

A COMPARATIVE ANALYSIS OF INSTRUCTIONAL TECHNIQUES
TOWARD LONG-TERM POSITIVE ERGONOMICS
TRANSFORMATION FOR THE EARLY
CAREER SONOGRAPHER

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ABSTRACT

The past two decades have demonstrated sonographer work-related musculoskeletal disorder (WRMSD) rates between 80.0 to 90.4%. A surprising revelation made by sonographers was that educators were not perceived as the primary providers of ergonomics instruction. For these reasons, a mixed methods study was performed, involving a causal-comparative component with a longitudinal perspective, a quasi-experimental element, and limited observations and interviews. The study followed four years of sonography graduates through the early career scan period, comparing transmissional, transactional, and transformational learning results.

The study's goal was to determine whether transformative ergonomics learning in a collaborative and reflective environment could demonstrate a significant difference in the reduction of negative scan habits associated with reported musculoskeletal disorders (MSDs), compared to transmissional and transactional learning. Testing revealed that a typical early career sonographer was unaware of the high percentage of musculoskeletal injuries (MSIs) in the field, nor readily perceived personal risks despite possessing knowledge of other injured sonographers. Nevertheless, nearly three-fourths of the study's subjects described work-related MSD complaints before the five year career period, with shoulders, neck, wrist, and back areas being most common among both general and cardiac sonographers. Determining early scan risk behaviors that coincide with early pain reports and working toward preventative corrective actions may, in fact, reduce the likelihood of such future WRMSD complaints.

Photoplethysmography (PPG) recordings during challenging maneuvers demonstrated additional benefit toward the reduction of negative scan behaviors; while transformational learning demonstrated significant benefit in both reducing negative scan behaviors and increasing positive behaviors. Transformational learners expressed more empowerment toward reducing personal risk susceptibility through collaborative recognition and corrective action planning measures. Transformational learners also cited positive attitudinal impact in peer collaboration, while demonstrating a noticeable change in MSI personal risk ratings at the conclusion of learning.

The study also revealed that, despite ergonomics learning, early career sonographers did not respond as readily to corrective feedback until personally experiencing an MSI. However, transformational learners demonstrated much greater responsiveness to corrective feedback than did the other learning classifications. This higher transformational level of learning provided evidence toward reduction of WRMSDs among sonographers through responsiveness of corrective action planning.

DEDICATION

To my parents, Joe and Ginny Love – I dedicate the result of this educational effort to you because, for the very short time you were here to influence my life, you dedicated yourselves to me and dedicated me to the Lord. As a late life child, I was privileged to understand why Tom Brokaw dubbed you among *The Greatest Generation*. As direct products of the Great Depression and World War II era, and as dedicated educators and coaches, you both instilled in me a strong work ethic, a rich sense of greater purpose, and an insatiable desire to better myself and my world in ways that materialism simply cannot satisfy. Consider this, then, a true labor of love.

Thanks, Mom, for instilling in me an unquenchable curiosity about the world that has made my time here more exciting. And thanks, Dad, for teaching me that my curiosity still needed to reside within reasonable bounds, even while living in the presence of a superhero who yanked me from midair as my bike plummeted over a rock wall. Together, you two began preparing me for the necessities of life's research. We'll just consider those two broken noses as empirical data collection.

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“...be transformed by the renewal of your mind, that by testing you may discern...what is good and acceptable...” (Romans 12:2, English Standard Version).

How does one even know where to begin when expressing gratitude to all those who have had any small part in assisting with the preparation, serving, and then digesting of what feels like a platter full of elephant? It only seems appropriate to begin with my professors and dissertation committee members associated with the University of Tennessee at Chattanooga and the profession of sonography who have become an integral part of this journey.

Thank you, Dr. David Rausch, for keeping my eye on the goal, my nose to the grindstone, my brain on task, and my rear in gear. I'm not sure your title should be that of Chair – unless it's the office kind with casters, for you are always on the move. Dr. Hinsdale Bernard, you are surely the most incredible advisor and methodologist any doctoral student could ever hope to have. You taught me to ask better questions. I thank you for your continual encouragement and insight that kept me believing the demands of this project, and my time spent on it, were all worthwhile. Dr. Jennifer Ellis, you remind me of Glinda, the Good Witch of the North, a compass pointing out that I had the tools I needed all along. Where would this project have been without your ability to help me conceptualize what I was attempting to conceive - and without your generosity in acquiring and sharing *iPads* for the transformative portion of this research? Dr. Felicia Toreno, sonographer extraordinaire, beyond your tremendous expertise in our field, I am most grateful for your wonderful sense of humor and adventure, especially in reminding me that, in the end, it's all about the hat!

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librarians at UTC, Dr. Beverly Kutz and Mrs. Chapel Cowden, patiently guiding me through the trials of retrospective EndNote referencing. There were Drs. Lee Casson and Matthew Johnson, whose calls and text messages of stick-to-it-tiveness renewed my energy on days when I felt less inspired to move forward. Despite slight setbacks, many of these moments reminded me of why I love this work. This dissertation is not solely my own, but the culmination of many people's contributions. There was a comical brainstorming session with Mrs. Leesa Ross, from which the term for talon grip arose (probably in lieu of the *Thriller* dance move hand). There were numerous clinical sites, sonographers, and other far-off friends, hosting me during the many months and miles of travel across five states, as I gathered my final data. And, of course, there were my family members, church members and at-home friends, all who were (fairly) patient and understanding about the many hours (months...okay, years) in which I had to be separated from activities with them in order to complete this comprehensive task. Even to the many sports fans - both acquaintances and strangers - who tolerated and even offered ample space for me to spread books and papers across all seasons of bleachers: know how very grateful I am, and always was, for your good-natured curiosity and understanding. I would be remiss not to say that, for all of these moments and more, each of these individuals contributed some part of themselves to this portion of my project's completion. So to my fitness friends at D-1, who have faithfully spurred me on, waiting for me to answer a key question for them for the past few years...Yes, I'm done!

Truthfully, this research is yet to be completed. From here, I'm still left with many unanswered questions, as well as many questions I don't yet realize I even have. Because of this, I feel the need to extend some impending gratitude to those who might assist in continuing to find future ergonomic answers, with or without me, for the betterment of our profession.

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LIST OF ABBREVIATIONS

ABCD Method, systematic objective-producing mnemonic, signifying Audience, Behavior, Condition and to what Degree

ARCS, acronym for Keller's model of motivational design, signifying Attention, Relevance, Confidence and Satisfaction

ASSURE, acronym for instructional model to signify Analysis of learners; Stated objectives; Selection of methods, media, and materials; Utilization of methods, media, and materials; Requirements of learner participation; and Evaluation and revision of plans

CAAHEP, Commission on Accreditation of Allied Health Programs

CTD, Cumulative Trauma Disorder

DSM, Directional Susceptibility of Movement

HBM, Health Belief Model

HIPAA, Health Insurance Portability and Accountability Act

IQ1-IQ10 – Pre-Instructional Interview Questions 1 through 10

IRB, Institutional Review Board

JCAHO, Joint Commission on Accreditation of Healthcare Organizations

JRCEDMS, Joint Review Commission (on Education) in Diagnostic Medical Sonography

MSD, Musculoskeletal Disorder

MSI, Musculoskeletal Injury

NIOSH, National Institute for Occupational Safety and Health

OBP, Optimal Body Positioning

OSHA, Occupational Safety and Health Administration

Padcam, Apple *iPad* camera (for both video and still imaging)

PHI, Protected Health Information

PPG, Photoplethysmography (blood flow study)

PPP, Personal Prevention Plan

RMI, Repetitive Motion Injury

RSI, Repetitive Stress Injury

SDMS, Society of Diagnostic Medical Sonography

TOS, Thoracic Outlet Syndrome

V-KL, Visual and Kinesthetic Learning

VMA, Video Mirroring Adjustment (survey)

WRI, Work Related Injury

WRMSD, Work Related Musculoskeletal Disorder

WRMSI, Work Related Musculoskeletal Injury

LIST OF SYMBOLS

- + , used in Table L.2 to represent either reported MSI-related complaint by subject, or to designate a repetitive or sustained categorical scan risk behavior observed with at least 20% proportional incidence
- ++ , used in Table L.2 to designate a repetitive or sustained categorical scan risk behavior most commonly observed, but with less than 70% proportional incidence
- +++ , used in Table L.2 to designate a repetitive or sustained categorical scan risk behavior observed with greater than 70% proportional incidence
- T₁-T₆ , subjects' scan tasks in numerical order of observation, as described on observation checklist

CHAPTER I

INTRODUCTION

“Practice does not make perfect.
Practice makes permanent”
(Quote attributed to various coaches).

It has been rumored in the healthcare imaging profession that sonographers are notorious for believing they are good poker players. After all, one of the very first lessons taught to a novice sonographer while sitting next to a patient and scanning for diagnostic concerns is that the patient is just as closely scrutinizing the sonographer's face for any signs of trouble as that sonographer is scrutinizing the imaging screen for the same. Thus, students in this imaging health care profession are taught to practice their poker faces from the very start, so as not to cause alarm among patients. Over the years, sonographers generally become quite adept in their development of this first lesson related to poker. Unfortunately, these patient caregivers appear to be as inept at mastering the next lesson, which is that, in order to remain in the game, one must keep the hand very close to the body at all times. No matter how convincing one's facial expression might be when trying to bluff others, if the arm is allowed to travel too far from the body, with the hand maneuvered in the wrong position, the game is eventually going to become costly.

Background to the Problem

The most current formal professional survey has reported pain and injury rates among sonographers at approximately 90.0% (Evans, Roll, & Baker, 2009). The Joint Review Commission on Accreditation of Healthcare Organizations (JCAHO) (2006) also reported that of the “[m]ore than 80% of sonographers who perform...vital diagnostic scans [while working] in pain..., 20% of these health care professionals eventually experience an injury that ends their career” (p. 6).

In the work of scanning patients, primary sonographer musculoskeletal pain sites involve the arm from both the shoulder to the wrist (Murphy & Russo, 2000; Philips Medical Systems, 2007), but also include the spine, particularly the neck and lower back (Coffin & Baker, 2007; W. Davis, 2006; Evans et al., 2009; Freiherr, 2003; Friesen, Friesen, Quanbury, & Arpin, 2006; Murphey & Coffin, 2002).

In her April 2000 testimony before the Occupational Safety and Health Administration (OSHA of Washington), Joan P. Baker, MSR, RDMS, RDCS, FSDMS, director of global marketing for Sound Ergonomics (Kirkland, Wash), identified the activities that tend to aggravate pain: applying pressure, abducting the shoulders, twisting the neck/trunk (sustained and repetitive), performing studies at the patient’s bedside, and holding the transducer. (W. Davis, 2006, p. 1)

Industry Impact

As far as the costliness of sonographers being taken from the proverbial game, W. Davis (2006) quoted Jody Hancock, director of the Diagnostic Medical Sonography Program at Chattanooga State, stressing that, beyond the individual health cost to the sonographer, “...healthcare organizations simply cannot afford to lose their presently trained and certified sonographers to careless, ergonomically related incidences” (p. 1). Jerry Gervais with the

JCAHO (2006) also expressed concern that “[t]here’s a personnel shortage to begin with, and it’s getting critical as more and more sonographers are unable to continue working” (p. 6).

Coffin & Baker (2007) disclosed that “[work-related musculoskeletal disorders (WRMSDs)] account for 56% of work-related illnesses reported to OSHA, cause 640,000 lost workdays, and account for most of the Worker’s Compensation costs” (p. 78).

According to W. Davis (2006), Baker estimated workers’ compensation at \$29,000 to \$32,000 annually per injured employee, without the included costs of hiring and training replacements or without any associated administrative costs. Kaiser (2007) has quoted Baker explaining “...that the absence of a full-time sonographer amounts to an estimated \$21,000 loss of billable revenue in just one work week” (p. 16). Horkey & King (2003) have examined costs from several perspectives, pointing out that

[a]n injured sonographer can cost an employer over a half million dollars each year through: 1) loss of revenue - \$52,000 per year chargeable revenue per injured sonographer, 2) workers’ compensation - \$32,000 per injury per year, 3) replacement staff - \$60,000-\$80,000 per year, and 4) medical bills - \$20,000 per year (does not include surgical treatment). (p. 207)

Instructional Considerations

W. Davis (2006) cited Phyllis King, a university occupational therapy chair at the University of Wisconsin, on the importance of adding ergonomics principles to the sonography curriculum as “...an effective approach to reducing musculoskeletal disorders in sonographers” (p. 2). Ergonomics instruction is, then, another essential lesson that should be introduced to sonographers early in the career, so minds and bodies can learn to reduce risks for assuring one’s longevity in the game (i.e., the sonography profession). Evans et al. (2009) made a surprising finding, revealing that “sonography educators are not listed [by sonographers] as the primary

method for learning about ergonomics adjustments” (p. 296), thereby inferring this instructional consideration to be a possible key point of intervention. M.N. Friesen et al. (2006) have come to the same conclusion, expressing that “[i]njury prevention training and ergonomic intervention...[are] critical in reducing WRMSD” (p. 36). These researchers further suggested future studies to focus upon specific interventions within the field.

In response, from Fall 2009 through Summer 2012, IRB-approved ergonomics instructional events were conducted, with lesson components on transmissional, transactional, and transformative learning emphases within the Chattanooga State Community College Diagnostic Medical Sonography Program. The sonography program director obtained these ergonomics data toward gaining professional insight on potential instructional methodologies that might ensure positive attitudinal, and thus behavioral, changes in response to such learning events. If evidence can be garnered toward such change, then an argument can be made for greater instructional potential in positive work-related outcomes for the reduction of future musculoskeletal injuries (MSIs) in the field.

At the beginning of a scan career, a typical sonography student likely has no idea of the high percentage of sonographers reporting MSIs or having difficulty performing duties due to work-related injuries or pain. The researcher of this study was concerned with the number of scan years each of these early sonographers might actually have remaining before repetitive motion injuries (RMIs) threaten career livelihood; thus, the researcher desired to determine the most appropriate ergonomics instruction to provide to these students toward reducing risks to prevent such injury and to prolong career longevity potential. This researcher posited that the best time to develop positive lifelong habits was early in a sonographer’s career, prior to development of detrimental habits, and that by intentionally reducing negative scan actions

throughout early career exposure, positive formative habits would more likely result through a transformative learning event.

In researching such a position, the intent of this study has been to compare the effects of three instructional techniques, presented to various participant groups in tiered levels of instruction, with learning progressions, classified as transmissional learning, transactional learning, and transformational learning events. Though the research definitions for each of these learning types are addressed later in Chapter I, and Chapter II will discuss literature findings concerning the theory behind these learning categories, a brief comparison is made here for the benefit of the reader.

Taylor (2008) explained that Mezirow's Transformative Learning Model was introduced in 1978 as a means of encouraging learners to build upon the frames of reference that influenced their thinking, beliefs, and actions. Mezirow (2000) believed events could be designed for learners to "...negotiate and act upon [their] own purposes, values, feelings and meanings rather than those [they had] uncritically assimilated from others" (p. 8), to assure deeper meaning toward habitual transformation. In contrast, the base level of instruction, classified as transmissional learning, simply addresses information that is transmitted for the learner to passively access and to either accept within a personal frame of reference for benefit or to reject toward personal application. The mid-level of instruction, classified as transactional learning, provides for a higher level of interaction, with learner engagement within an authentic work environment (Grabinger & Dunlap, 1996). Though a change in behavior may be more likely based upon a less passive learning opportunity, according to Mezirow, the identification of habitual transformation is not the learning expectation at this stage.

Transformational learning, then, was the highest level learning event of this study, in which learners were to take on a longer term, active and participatory role that included self and peer reflection and assessment. The beliefs and values of the individuals thus were to become more deeply ingrained into a community (or organizational) frame of reference. Taylor (2008) mentioned this relational frame of reference as part of a holistic approach to the transformative process. In this reference, the learners gain identities as key stakeholders through a continuous feedback loop of dialogue and evaluation, which Morrison, Forbes, and Wilkinson (2006) described as a strategy for gaining commitment and success within the framework of organizational (not merely individual) transformation. Allowing key stakeholders to assist in determining key purposes through active participation in individual and community adaptation, through a feedback mechanism, should allow for the greatest growth potential and purposeful impact toward long-lasting change (Wheatley, 1994). Davis, Key & Newcomer (2010) explained that organizations achieve long-term transformation by creating environments that focus on learning and sustainability. Taylor encouraged fostering active social reflection as a part of perspective transformation to achieve a sustainable society. Concerning the problems that have been addressed, this research sought to offer a solution, within the scope of ergonomic learning, for sonographers as both individuals and as a conglomerate profession.

Statement of the Problem

Over one decade ago, awareness of the impact of ergonomic injuries was introduced to the sonography community, with a devastating 81.0 to 87.0% statistical incidence of MSIs reported among sonographers (Baker, 2009; Friesen et al., 2006; Kaiser, 2007; Philips Medical

Systems, 2007; Ransom, 2002); in some individuals, injuries were significant enough to prevent continued practice in this chosen career field. One of the recommendations made by the Society of Diagnostic Medical Sonography (SDMS) (2003) was the inclusion of WRMSD prevention within the educational curriculum for sonographers. That same year, in 2003, the CAAHEP-accredited Chattanooga State Sonography Program voluntarily added formalized instruction in ergonomics awareness, implementing reflective feedback as part of this instruction, whereby each student was asked to develop a personal prevention plan (PPP) at the conclusion of the learning event.

Approximately one decade after MSI statistics were first widely disseminated in the sonography profession, Baker (2009) again reported that 87.0% of sonographers were still suffering from musculoskeletal disorders (MSDs), exactly the same percentage reported by the Canadian Society of Diagnostic Medical Sonographers in 1999 (Ransom, 2002), a full decade earlier. Research evidence appeared to demonstrate no statistical reduction in the incidence of MSDs, despite:

- manufacturer adjustments to equipment (Freiherr, 2003),
- availability of ancillary devices to the sonography community (Evans et al., 2009),
and
- some level of ergonomics instruction being provided by equipment clinical applications specialists, as reported by 90.4% of the 3,243 general and vascular sonographers, who claimed to have been exposed to this type of learning in the Evans et al. cross-sectional study that had an impressive 57.0% response rate.

Relative to ergonomics instruction, two important points should be noted from the Evans et al. (2009) study in consideration of this research. First, the percentage of sonographers who

had received at least transmissional ergonomics learning (90.4%) was exactly the same as the percentage of sonographers who indicated that they were scanning in pain (90.4%).

Secondly, though 90.4% of respondents documented some level of ergonomics learning, only 54.5% reported ever being shown how to personally manipulate equipment for ergonomics adjustments, which would, by definition of this current research, be classified as a more active type of learning than merely transmissional in nature. The Evans et al. study did not specify the percentage of responding sonographers graduating from formal ultrasound programs or whether such programs had any level of ergonomics instruction within the curricula.

Lack of Ergonomics-Related Instructional Impact Data

The extent of ergonomic educational opportunities is unknown among various program offerings at the time of the Baker (2009) or Evans et al. (2009) surveys because musculoskeletal injury awareness was not an established curricular standard of the Commission on Accreditation of Allied Health Programs (CAAHEP) (2011), in cooperation with the Joint Review Committee on Education in Diagnostic Medical Sonography (JRCDMS), until 2011. Therefore, this researcher had no means by which to report the influence of learning, or lack thereof, on the pain and injury findings among sonographers. However, according to Parhar (2004), the SDMS released a benchmark survey in 2000 that stated "...on average, within 5 years of entering the profession, sonographers experience pain while scanning" (para. 1). Horkey & King's (2003) study agreed with this finding, stating "[t]he average length of time a sonographer is working in this profession before experiencing pain is about 5 years" (p. 207).

This information, at the very least, offered a timeline in which to conduct this study, suggesting that awareness of the problem with enhanced learning outcomes very early in a sonographer's scan career could provide a means for documenting any post-instructional reduction in negative scan behaviors, thus having the potential toward musculoskeletal injury reduction throughout the sonographer's career. Philips Medical Systems' (2007) training module tended to agree that instructional influence can make an impact, citing training issues related to ergonomic scanning techniques as one of the primary causes of MSDs that have been reported among sonographers, though no techniques or guidelines were provided.

Need for Ergonomics-Related Instructional Impact Data

Two of the most obvious features that were hoped to have noticeable positive impact in the sonography field were adjustments to ultrasound equipment that would allow for increased ergonomics utilization (Freiherr, 2003; Murphey & Coffin, 2002; Murphy & Russo, 2000; Philips Medical Systems, 2007), and education to promote sonographer awareness regarding injury risk factors toward reduction in reported MSIs (Friesen et al., 2006; Martin & Tew, 2006). Comparative percentages of reported injuries over the past decade have failed to demonstrate improvement in the incidence of injuries despite documented equipment adjustments, ancillary additions (Evans et al., 2009), and reports of increased sonographer awareness of the problem (Evans et al., 2009; Horkey & King, 2003; Orenstein, 2009b). Such findings suggest that these ergonomic changes have either not been developed properly, are not being utilized effectively, or not enough time has elapsed to demonstrate a significant level of impact since CAAHEP (2011), in conjunction with the JRCEDMS, changed the educational standards.

This researcher posited that perhaps there was a related problem beyond simple awareness and anticipated response, more likely connected with value expectancy (Atkinson, 1957; Chen & Liu, 2009; Sennott-Miller, 1994) within the reference of the Health Belief Model (Becker, 1974; Edburg, 2010; Glanz, Rimer, & Viswanath, 2008; Rosenstock, Strecher, & Becker, 1988; T. P. Ross, Ross, Rhaman, & Cataldo, 2010). Likely, awareness cannot fully be achieved nor positive action habitually taken until a firm belief pattern has been established for participants to solidify an affirmative and active transformation.

Purpose of the Study

The National Institute for Occupational Safety and Health (NIOSH) (2011, 2012) has funded surveys and has readily acknowledged that musculoskeletal injuries exist within the sonography community (National Institute for Occupational Safety and Health, Department of Health and Human Services, 2006). Dr. Kevin Evans (personal communication, March 4, 2010), former president of the national Society of Diagnostic Medical Sonography, believed that NIOSH was most concerned with future research that would suggest how to reduce these injuries, rather than more research to document that such injuries exist. Evans further believed the profession would benefit from an analysis of sonographers at the professional entry point (Orenstein, 2009a). According to Horkey & King (2003), the next steps to be considered toward reduction of sonographers' excessive musculoskeletal concerns (beyond simply acknowledging the existence) included determining specific causes of the symptoms and, more importantly, identifying intervention measures. The SDMS (2003) targeted instruction as an essential intervention.

In 2003, the Chattanooga State Diagnostic Medical Sonography Program added formalized instruction in ergonomics awareness in response to the circulation of professional injury concerns. The program director designed this learning event to actively promote sonographer awareness of musculoskeletal risk factors, consisting of an informative instructional module (J. A. Hancock, 2002) and a participatory laboratory assessment exercise (J. A. Hancock, 2003; Martin & Tew, 2006), as well as a reflective personal prevention plan to be developed by each student. Over a multi-year period, IRB-approved data have been collected and research instruments have been formulated toward assessment of ergonomics work habitus based upon comparing transmissional, transactional, and transformational learning techniques.

The purpose of this study was to compare these instructional methods to assess whether transformative ergonomics learning in a collaboratively participatory and reflective environment could demonstrate a significant difference in the reduction of negative ergonomic scan habits associated with reported MSDs through early career sonographer adoption of learned principles as reinforced practice within the work habitus frame of reference. This study incorporated quasi-experimental and causal comparative components, as well as qualitative aspects by questioning sonography students about beliefs and understanding of personal risk factors following targeted observation periods and experimental blood flow studies, with assessment of written reflections. The intent of analysis was twofold: to assess subject data for any significant impact in value expectancy through the results of student-developed personal prevention plans, and to determine if behavioral changes could be documented in association with attitudes expressed by the learners.

Rationale of the Study

Since researchers in the field first published that approximately 80.0 to 86.0% of sonographers had reported MSDs (Baker, 2009; Coffin & Baker, 2007; Evans et al., 2009; Murphey & Coffin, 2002; Philips Medical Systems, 2007; Sound Ergonomics, 2008), educational seminars and other passive learning opportunities have existed for sonographers. Well beyond a decade of professional awareness of the problem, researchers have continued to report injuries, with incidences growing toward 86.0 to 90.4% (Baker, 2009; Coffin & Baker, 2007; Evans et al., 2009; Sound Ergonomics, 2008). However, studies do not readily exist within the scope of educational endeavors promoting the awareness of injury risk factors (Friesen et al., 2006), especially concerning the resultant reduction of risk behaviors. There now exists an abundance of ergonomics-friendly ultrasound units and ancillary equipment, along with educational resources on the topic of MSD prevention in the work place, but this researcher believes there may not exist sufficient opportunities for early career sonographers to become actively engaged in a transformational learning process toward injury reduction. Otherwise, in the event where such opportunities have been made available, early sonographers may not have had appreciable levels of value expectancy to develop positive work habitus frames of reference toward lasting transformation.

Significance of the Study

“The increasing loss of sonographers due to WRMSDs exacerbates the existing shortage of sonographers in the workplace and decreases patient access to this important healthcare service” (Society of Diagnostic Medical Sonography, 2003, Background section, para. 2). If

documentation could be made for evidence of transformational behavioral changes, in the form of sustained reduction of negative scan habits, within the first five years of a sonographer's scan career, then an argument could be made toward greater instructional potential in creating transformative learning events for development of positive work-related habits from the beginning of the scan career. If positive work habitus behaviors could be sustained, transformational learning would thereby have the prospect of prolonging individual sonography graduates' scan careers. Such improvement could expand into positively impacting the industry as a whole, through the reduction of musculoskeletal injury potential.

Research Questions

The central research question was: What differences in learner attitudes and behaviors can be determined within the ergonomics work habitus frame of reference when comparing transmissional, transactional, and transformational learning events for the early career scanning sonographer?

To this end, a number of additional, more precise research questions were considered within the scope of this particular study.

Research Question 1

How closely did sonographers' pre-instructional scan complaints and risk behaviors correspond with final musculoskeletal complaints and risk behaviors of prior published professional injury rates?

Research Question 2

Did having transmissional knowledge of other sonographers' injuries and statistical injury risk rates influence early career sonographers' beliefs of personal susceptibility to injury?

Research Question 3

Could differences in musculoskeletal injury (MSI) perceptions and risk behavioral changes be detected at the transactional post-instructional stage based upon learners' participation in the photoplethysmographic (PPG) diminished blood flow quasi-experiment?

Research Question 4

Did observed scan behavior incidences demonstrate an impact toward positive work habitus among study subjects, particularly those within the transformational group, due to ergonomics instructional intervention?

Research Question 5

How were student attitudes impacted by the interactions and reflections of the formative self and peer assessment process during the transformational learning stage?

Research Question 6

What patterns of responsiveness regarding injury awareness and prevention feedback were evidenced among program graduates at the time of final observation?

Terms

Terms have been divided in this section to represent definitions as used to convey ideas and components of this study, followed by operational definitions of the study to specify how particular theories, models and concepts were applied by the researcher. More detailed methodological descriptions have been included in upcoming chapters, as necessary, to further depict the use of instrumentation or considerations in testing.

Definitions of Terms within the Study

Directional susceptibility of movement (DSM): “the impairments of soft tissues induced by repeated movements and sustained postures [that eventually cause] a joint to develop a susceptibility to movement in a specific direction...” (Sahrman, 2002, p. 4). The expert observer (and, later, any peer observer) was asked to assess categorical descriptions of DSM according to criteria that were established and defined within the Observation Protocol Guide (Appendix F) and on the observation form.

Ergonomics: developed from the Greek words, "ergon" (meaning work) (Collins English Dictionary, 2012) and "nomos"(meaning law) (Encyclopaedia Britannica, 2012). Thus, the science of ergonomics is the study of how laws of nature affect the worker in his or her work

environment. “The goal of ergonomics is to reduce stress and eliminate injuries and disorders associated with the overuse of muscles, bad posture, and repeated tasks” (National Institute for Occupational Safety and Health, 2012, para. 1), specifically in this study as related to the sonographer during the performance of scan duties.

Health Belief Model (HBM): - “a conceptual framework that describes a person’s health behavior as an expression of health beliefs” (Mosby's Medical Dictionary, 2009). The HBM was used not only as a conceptual template within this research to explain ergonomic behaviors as expressed through sonographer beliefs regarding risk factors and personal susceptibility to MSIs, but also as a visual model associated with the value expectancy theory to demonstrate the addressed components toward adoption of a positive work habitus through transformational ergonomics learning for the sonographer.

Musculoskeletal injury (MSI): damage of the muscular and/or skeletal system(s), most often due to strenuous activity, usually of a repetitive or awkward positioning nature, particularly affecting joints and surrounding tendons (Ransom, 2002). The U.S. Department of Labor’s Occupational Safety and Health Administration (OSHA) (2010) has listed similarly related injury terms abundant in the literature, commonly to include:

- Musculoskeletal Disorders (MSDs), though it should be pointed out that a disorder could be present without being the result of an injury;
- Work-Related Injuries (WRIs);
- Repetitive Motion Injuries (RMIs);
- Repetitive Strain Injuries (RSIs);
- Cumulative Trauma Disorders (CTDs); or
- Work-Related Musculoskeletal Disorders/Injuries (WRMSDs, WRMSIs).

Of the above designated terms, the MSI term was most often presented to the study participants in this research (e.g., Please rate your perceived MSI susceptibility); while the WRMSD term was most often used as related to the literature review findings.

Optimal body positioning (OBP): an ergonomic description of appropriate posture and maneuvering to reduce risk factors of specific body parts for general overall enhancement of one's health (Sahrman, 2002). Murphy & Russo (2000) stressed that “[a]wareness of how to achieve an optimal posture...is vital to [a sonographer's] healthy [career] survival...” (Murphy & Russo, 2000, p. 13). Within this study, the expert and peer observers were asked to note the frequencies in which the subjects conducted scanning using OBP, or, conversely, when the subjects did not practice OBP while scanning.

Transmissional learning: In a transmissional learning event, information is simply conveyed (or transmitted) to the learner, suggesting a more passive learning role (J. Mezirow, 2000). The learner will either accept the information or not. For the purposes of this study, this category was considered to be the first order learning technique, of which all participant groups were involved as part of the online ergonomics learning module. Group A's transmissional learning event was not designed to extend into any evaluative feedback beyond the grading and return of the participants' personal prevention plan reports, thus was given the lowest tiered learning level designation.

Transactional learning: In a transactional learning event, the learner takes a more active role through identification with personal experience and some form of interaction. Learners become engaged in an active and authentic environment (Grabinger & Dunlap, 1996). A change in behavior may take place during the learning event, but habitual transformation is not sought for identification thereafter (J. Mezirow, 2000). For the purposes of this study, the transactional

categorical designation was considered to be the second order learning technique, in which meta-cognition in relation to ergonomics learning was anticipated to be enacted, based upon promotion of content and authentic interactive experiences. The learning for Group B did not, however, extend assessment related to the learning event beyond a short-term period, defined within the scope of one school semester, still focusing primarily on expert evaluative feedback, with the late induction of learning participant self-reflection (but no opportunity for later ergonomic adjustment feedback).

Transformational (transformative) learning: For the purposes of this study, this was considered to be the third, or highest, level of learning technique, which has been defined by Mezirow (2000) as:

the process by which we transform our taken-for-granted frames of reference (meaning perspectives, habits of mind, mind-sets) to make them more inclusive, discriminating, open, emotionally capable of change, and reflective so that they may generate beliefs and opinions that will prove more true or justified to guide actions. (p. 7)

Lessons of this level were conducted so that Group C study subjects extended learning beyond both the transmissional and transactional tiers to take on an active and participatory evaluation role, both of self and peers, throughout active scanning. These reflective-assessment exercises extended throughout a longer time period within the sonographers' formal learning experience and consisted of multiple peer collaborative and critical reflective opportunities following self-adjustment. It was the researcher's expectation that longer term perception transformation of attitudes and beliefs, through fewer observed negative behaviors, would more readily be identified beyond the learning event due to the active and participatory nature of this critical reflection.

Value expectancy theory (or Expectancy-value motivation theory): "postulates that motivation can be achieved when perceived values in an activity override perceived cost of the

activity derived from the effort of achieving” (Chen & Liu, 2009). In the instance of ergonomics, the literature has suggested that the value of reducing sonographers’ risk factors for developing MSIs should override the cost of preventing such injuries, such as time away from work, treatments, and possibly the eventual loss of a career (Society of Diagnostic Medical Sonography, 2003; Wihlidal & Kumar, 1997).

Work habitus: Bourdieu (as cited in Clark, 2002) built upon Mauss’ interpretation of habitus by stating “[it] governs practice as a socially produced recurrent action pattern” (p. 72) and that practical activities assist in constructing related patterns, as do influences who align learner thoughts and actions with the context and conditions. A work habitus, then, consists of practices constructed within the authentic work environment context. For the sonographer, adoption of a positive work habitus would include displaying less directional susceptibility of movement (DSM) during scan motions considered to be high risk for repetitive MSIs. In exchange for these negative behaviors, the sonographer would exhibit healthier OBP, as well as personal lifestyle patterns to function more effectively as a patient health care provider and, ultimately, increase career longevity.

Operational Definitions for the Study

Risk factors indicative of work-related musculoskeletal disorders (WRMSDs): were considered as repetitive or sustained movements or positions which have been cited to create or aggravate musculoskeletal injuries, e.g., hyperextension of the neck, torsion of the back, or hyper-angulation of the wrist or shoulder. Specific participant risk factors for WRMSDs were reviewed by the expert observer through the estimation of angles and actions that appeared to

displace the participant from OBP during real-time observation. Timed frequencies were established according to the observational assessment instrument. Some still images or video recordings were produced as sonographer study participants were scanning in the learning stages. The expert observer was thereby able to identify specific positions and/or types of scan maneuvers, anticipated or otherwise, which appeared to create an environment that could produce higher risks for WRMSDs.

Short-term adoption of positive ergonomics learning habitus: was measured through comparative pre- to post-observation of the study participants in Groups B and C, and in narratives within the personal prevention plan (PPP) for all groups. Positive work habitus was established when participants were recorded displaying less DSM during scanning motions that would be considered high risk for repetitive MSIs to occur in those specifically designated risk areas. Short-term adoption of positive work habitus was represented by results gathered at the end of the first semester of learning for the early career sonographer, whether involved in the transmissional, transactional, or transformational instructional group.

Long-term adoption of positive ergonomics learning habitus: was measured through comparative pre- to post-observation of the study participants in all groups following graduation, at a two to five year post-learning time period, as have been the majority of longitudinal studies on transformative learning or related concepts, as cited by Taylor (2007). Long-term adoption could not be measured in terms of career longevity due to the time limitations of this study. Rather, this concept was defined at the two to five year post-learning observation stage, in which an expert observed retained subjects within each participant's personal work setting and interviewed participants in regards to prolonged WRMSD complaints. Long-term positive work habitus can only be established when longer term subjects are recorded displaying fewer DSMs

over longer sustained periods than the shorter timeframes that were examined here. Nevertheless, compelling longer-term findings may still be discovered within the two to five year timeframe beyond when participants were actively engaged in formalized instruction.

Participants' value expectancy associated with transformative learning: was determined by comparisons of OBP considerations between the pre-interview observation and the post-interview scan observation for Groups B and C, as well as through comparison of perceived risk by those participating in the photoplethysmography (PPG) quasi-experiment. A final, post-graduate scanning observation was also conducted among all study groups to compare behavioral frequencies which may have differed once graduates were within sustained work environments. Lastly, a comparison was made between all sample group scores on PPPs, in which all study participants were provided with a rubric containing the important influencing value expectancy factors associated with the Health Belief Model. The various groups' scores and narrative theme findings were compared based upon exposure to either the transmissional (Group A), transactional (Group B), or transformational (Group C) learning tools and instructional techniques.

Assumptions of the Study

During the research development phase, study assumptions were made and have been categorized according to:

- learners' awareness levels of injury risk rates within the sonography profession,

- collaborative peer assessment measures for longer-term transformational learning, and
- the relationship between learners' beliefs and behaviors.

Sonography Student Awareness and Perception of Interventional Need

As earlier stated, the SDMS (2003) made a recommendation for sonographers to attend formal programs of study that included MSI preventative measures within these programs' curricula. Baker (as cited in Kaiser, 2007) explained part of the WRMSD problem as "...ergonomics [having] been part of equipment design for only about 10 years [so] most sonographers operating the equipment do not know how to take advantage of the ergonomic features" (p. 16). The researcher of this study, then, was making the assumption that early career sonography students had little idea of the rate of musculoskeletal injuries (MSIs) within the sonography profession or awareness of ergonomic interventions without such formalized instruction; and, furthermore, that such awareness could positively influence the participants' responses.

In considering such assumptions, an earlier study conducted by Horkey & King (2003) among cardiac sonographers was reviewed by the researcher, since two of the study's listed purposes were to determine whether sonographers perceived a need for ergonomic intervention measures and to determine sonographers' level of awareness of such interventions. The study revealed some interesting findings. First, the Horkey & King study provided evidence that sonographers did not implement an intervention if they were not aware of it. Though that may seem a sensible finding, the study also revealed a couple of disturbing ones. Though the majority

of the study's sonographer respondents were aware of most ergonomic interventions mentioned in the study, researchers found that the majority of respondents did not report implementing them. One of the ergonomic interventions discussed by Horkey & King was to provide preventative education measures, which should serve to assist sonographers in awareness of risk factors and better techniques toward risk reduction. Fifty-six percent of the active career respondents in the survey denied the need for such measures, citing reasons such as "not my responsibility" or "not considered important" (p. 214). These findings suggest negation of personal responsibility for well-being or possible denial concerning personal risk by at least a certain portion of sonographers.

Anne Jones (as cited in Orenstein, 2009b), past president of the Society of Vascular Ultrasound, summarized the concern about awareness, in and of itself, stating, "while we thought that with increasing awareness and action over the last few years we would see an improvement in the health of those scanning, it's been the exact opposite - the numbers being injured are rising" (p. 24). This researcher, then, made the assumption that awareness, on the basis of simply knowing of a problem, was likely not going to be sufficient to create a noticeable transformative reduction of WRMSDs within the profession.

Peer and Self-Assessment Opportunities for Longer Term Impact

For utmost effectiveness of an ergonomics program to make a longer-term impact, "[l]earners should be directly involved in developing, implementing, and evaluating learning experiences to encourage critical reflection between teachers and learners, and realignment of programs" (Franz, 2007, p. 1). The main instructional premise of transformative ergonomics

awareness translating to personal implementation was to take student assessment from the instructors' hands and physically place it into the hands of the students. It was the intent of the researcher to introduce peer assessments and self-assessments into the longer term instructional activities for the transformational learning participant study group (Group C). Though the concept of self-awareness through self-evaluation was introduced at the end of the transactional instructional process, with the intent to diminish the threat of having an expert evaluate and judge the sonographer's behaviors as being adequate or not (J. A. Ross & Starling, 2008), the addition of the on-going peer assessments in the late transformative learning segment could have potentially reintroduced that threat.

The assumption was that the activity of peer assessment would be performed in a non-threatening environment, with self-assessment also included as part of that process and without the learners' emphasis on pleasing the instructor (Strobino, Gravitz, & Liddle, 2002; Venugopal & Kakani, 2002). Rather, the facilitator's intent was to make these peer sessions positive in nature. Through a continued self-assessment process, the instructional objective was for participants to openly recognize and admit poor scan technique and to pinpoint personal issues that could continue to be refined, thus promoting the transformational learning process. Transformational participants were given the opportunity to reflect, not only on ergonomic issues, but also on perception of threat or helpfulness of peers during the ongoing surveys.

Transformative Beliefs Recognized Through Recorded Behaviors

An overriding assumption to this research was that learner beliefs could be determined based upon observed behaviors. The premise of transformation included both active learning and

critical reflection components based upon the assumption that reflection would advance the learner developmentally, both in discourse and action (Brookfield, 1995; J. Mezirow, 2000). Eisen (2001) addressed emerging changes identified in peer-based professional development participant interviews as “(1) change in practices, through the application of new skills or ideas to their work or life; (2) change in self, through a process of internalization; and (3) change in perspective, through a process [called] crystallization” (pp. 35-36).

Schein (2010) proposed addressing three levels of culture when considering movement of a previously established equilibrium (frame of reference) toward achievement of organizational transformation, which included both observations (visible artifacts) and beliefs (espoused beliefs and values). Moving deeper into underlying assumptions required purposeful reexamination of issues generally unspoken (e.g., how one truly perceives personal risk) to achieve desired change (e.g., a reduction in personal risk behaviors).

Furthermore, the James-Lange theory (Cannon, 1927) supported the assumption that practiced changed behavioral patterns could influence learners’ beliefs. According to Burke (2011), this theory has suggested that leaders set expectations that first require desirable actions that have been defined for successful transformation. The literal enactment of newly aligned behaviors, with support of learners’ mastery development, should eventually assist in forming new cognitive maps for transformed values aligned with transformational actions. The Value Expectancy Theory that was an overriding theme within this research builds upon these ideas of cognitive processing to form lasting impressions based upon the value placed on the learner’s experiences and expectations that preventive injury actions will create positive personal benefit to the learner (Becker, 1974).

Where Mezirow (1990) proposed that transformative learning involved deep, powerful beliefs that would ultimately be evidenced in the learners' actions; and where the James-Lange theory proposed that actions, themselves, assist in forming such beliefs (Burke, 2011; Cannon, 1927); Sennott-Miller (1994) pointed out that "in order to make a decision to adopt a preventive behavior..., one must connect the consequences of these changes with reduced personal risk" (p. 810). The value expectancy theory incorporates this socio-psychological interface between beliefs and behaviors. Reflection on developing behaviors assists to encourage positive benefit beliefs. Lasting impressions are cognitively formed based upon the value placed on the experiences and expectations.

Delimitations of the Study

Rather than attempt to utilize several ultrasound schools with varying ergonomics instructional techniques, this causal-comparative study was limited to data collected from three types of ergonomics instructional events conducted in the Chattanooga State Sonography Program, comparing outcomes based upon these varying techniques represented by the designated study groups. In this manner, reliability of the assessment instruments was increased, though overall generalizability of the study may have been limited.

Another important delimitation, for validity purposes, was for the researcher to assess specific risk-related areas. Of primary interest, according to the literature review, was the sonographer's neck, shoulder and wrist angles, as well as back torsion during the scanning portion of the examination (Coffin & Baker, 2007; W. Davis, 2006; Evans et al., 2009; Freiherr, 2003; Friesen et al., 2006; Hospital Employee Health, 2007; Murphey & Coffin, 2002; Murphy

& Russo, 2000; Nordander et al., 2009). The researcher made comparisons of the observed scan behavior incidences among the study participants and compared these findings with the most common areas of cited concern in the literature. In this manner, the researcher was better able to determine if the most commonly cited areas were readily observed from the initiation of a sonographer's scan career.

Subjects in Group A were not assigned expert pre-observational data, as that was not part of the designed transmissional instructional methodology; therefore, comparisons of changes in behaviors from pre- to post-observational periods were not made for this group. Nevertheless, attitudinal comparisons were made for all groups through the personal prevention plan (PPP) scores and narrative themes, and post-graduate behavioral frequency comparisons were made between all instructional groups.

Final long-term expert post-observations of all regional study participants, as program graduates, were conducted in various healthcare work settings. Videotaping was not feasible due to the privacy ruling of Protected Health Information (PHI) by the Health Insurance Portability and Accountability Act (HIPAA) (2009), to prevent patients from being unintentionally identified. The expert observer used the observation instrument only to document live findings, with no opportunity for formal imaging reassessment with participants or other researchers. Conversely, the videotaped segments performed in the campus scan laboratory environment included only study participants who signed an agreement for the purpose of shared findings among sample Groups B and C, as part of the transactional and transformational instructional methodology segments. At the time of the final expert post-graduate assessment, subjects were no longer engaged with an instructional purpose in mind. Rather, the gathering of final research data toward outcomes was the specific purpose of that observational segment.

This study did not quantitatively assess some of the problems described by NIOSH (2011) as contributing factors to WRMSDs, such as torque pressure on the joints or specific heights of the sonographers (Horkey & King, 2003; National Institute for Occupational Safety and Health, Department of Health and Human Services, 2006). Pressure compression due to patient obesity or equipment adjustments due to sonographer reach (which could be height related) may have qualitatively been cited as perceived related concerns in the observer or participant notations. The researcher may have recorded some other limited constructs listed by NIOSH, such as sonographer gender and age (Horkey & King, 2003; National Institute for Occupational Safety and Health, Department of Health and Human Services, 2006) within the study demographics; however, the sample groups had little variance among or within them concerning these variables, as the 61 subjects originally consisted of 53 females (86.9%), with a range of 21 to 50 years of age ($M = 27.52$, $SD = 7.28$), with the 40 retained study subjects at the final observation consisting of 37 females (92.5%). The sample of males in the study was far too limited for any gender comparisons, as were the aforementioned age range outliers for related comparative purposes within this research study. Moreover, the Evans et al. (2009) study demonstrated no significant difference in the percentage of scan pain reported based upon respondents' ages.

Limitations of the Study

The type and extent of ergonomic educational opportunities was unknown among any sonography program offerings within the 2009 published surveys (Baker, 2009; Evans et al., 2009), where sonographers had approximated 90.0% pain and injury rates. Though highly

suggested as part of a formal sonography program process (Society of Diagnostic Medical Sonography, 2003), musculoskeletal injury awareness was not an established JRCEDMS curricular standard until 2012 (Commission on Accreditation of Allied Health Programs, 2011); thus, the researcher had no generalized comparative means by which to report the influence of learning, or lack thereof, on the reported pain and injury findings among sonographers.

Within this study, there were issues to consider in the research proposal toward integrity and authenticity. First, although the Health Belief Model (HBM) provided a framework for perceptions related to a wide range of health behaviors, T.P. Ross et al. (2010) believed the model lacked clarity of operational definitions concerning constructs of variables toward any prediction in behaviors. Thus, the researcher attempted to formulate specific operational definitions in terms of sonography and ergonomics for the constructs considered within the value expectancy framework based upon this model, but must acknowledge that findings do not necessarily have any generalizability.

Based upon the literature review, a bias must be acknowledged that may limit the perception of any ergonomics related research in the field. As acknowledged by Evans et al. (2009), “the data are potentially biased toward only capturing responses from the portion of the population that has discomfort” (p. 296). In other words, error was expected within the survey samples, with an expectation that sonographers impacted by injuries would be more interested in reporting data than would be those non-impacted sonographers. Nevertheless, generalized research does support that many sonographers do have MSIs, so the data were still highly compelling.

A full picture of the extent of the WRMSD problem may never be obtained without following a large representative sample of sonographers through entire career spans. This study

was not able to fully address the issues of lifelong career patterns or career longevity, due to certain constraints. This research was conducted with time limitations, as well as limited availability of early career sonographer subjects, due to low annual class volume within a highly specialized program and field of study. Conversely, a limited number of subjects did allow for incorporation of some amount of qualitative data to be collected succinctly in narrative form. The obvious time constraints of the study were related to the researcher's dissertation and degree completion stipulations in consideration of time frames associated with documentation of extended long-term transformation.

Baker (2009) revealed that the highest reported incidence of WRMSDs occurred in sonographers who had been scanning in excess of 22.6 years, with rapidly elevated reports beginning at the 16 year period. The longevity aspects of transformation for this research study were reasonably encased within a much shorter period, while still addressing a timeframe that could be researched beyond immediate short-term effects. To assist in meeting a mid-term longevity that coincided with Horkey & King's (2003) and Parhar's (2004) five year average of sonographers reporting pain associated with scanning, and the two to five year time frame of the majority of longitudinal transformative studies (Taylor, 2007), while completing the research within a reasonable dissertation timeframe, data were collected on four contiguous years of program students throughout three empirically-based, IRB-approved analyses pertinent to the research topic. In this way, the researcher had the ability to include longitudinal study data of retained subjects within a limited number of experiential scanning years of one another for post-graduate career assessment. Since these sonographers could not reasonably be assessed over a 16 year career period, the goal became to study whether negative behaviors could be more proficiently identified and controlled through a learning environment, and ultimately reduced

beyond graduation into the work environment, within the literature's average five year period prior to commonly cited pain and injury reports (Horkey & King, 2003; Parhar, 2004). If so, then the hope was, and still is, that WRMSD reports can be reduced among sonographers in the future based upon assuring transformational learning techniques during the early instructional career phase.

According to Taylor (2007), who has conditionally limited longitudinal studies on transformational learning to a period of two to five years, "[t]he challenge for the longitudinal studies is separating out what is related to transformative learning and what is not a product of normal development of the individual and/or socio-cultural change..." (p. 176). On this basis, the researcher saw some benefit in measuring behaviors within a shorter time limitation, following the instructional period, rather than over the course of a sonographer's full career.

Of course, perhaps the most practical limitation consideration among participants in the final, post-graduate observation stage involved access to those graduates within each sample group following program completion. Some study participant graduates were difficult to locate or difficult to access by consent at particular healthcare facilities. Though accessible by contact, others were not actively working in the field at the time of the final long-term observation event. Such limitations, along with the small number of subjects in the original sample groups, restricted the researcher in data gathering attempts, with the study finally coming to an end based upon the law of diminishing returns.

Organization of Dissertation

Chapter I provides an introduction to the background of the problem related to sonographer ergonomic injury rates and the resultant impact on the healthcare industry and sonography professionals. The issue has been presented from the perspective that, after well over a decade of awareness of the problem with attempts at intervention, the MSI rate has not decreased and may, in fact, be increasing. The chapter further provides the study's purpose in terms of instructional considerations at the earliest intervention point with sonographers entering the field through formalized educational programs; a rationale for this approach; significance of evidence that might be gathered within this study; questions guiding the research process; related terms and operational definitions; and considerations regarding assumptions, limitations and necessary delimitations that would need to be made.

Chapter II presents a comprehensive literature review that investigates the various learning methods and connected instructional premises, as well as specific theories considered as essential to the formation of this research study, particularly Transformative Learning Theory and Value Expectancy Theory. Peer assessment and reflective design for the transformational sample group have been encompassed with the instructional design as specifically described through the ASSURE model.

Chapter III more specifically addresses the research design and methodology, including research questions and hypotheses, along with considerations of study variables, validity, reliability, and bias considerations. A brief explanation of IRB considerations for this study has also been included. The population and sample groups have been described, most especially in the determination of the various research designations by instructional approaches. Descriptions of data collection considerations for statistical analyses have also been proposed and reviewed.

Chapter IV provides quantitative analyses and results relating to the proposed hypotheses, in which findings suggest whether null hypotheses should be retained or rejected. Further test descriptions and discussions have been included to assist in the understanding of these results as addressed to the value of the instructional premise.

Chapter V includes qualitative descriptions and results, classifying patterns of behavioral and attitudinal discoveries, whether anticipated or unanticipated, to add understanding and meaning to quantitative results or to build upon empirical study data.

Finally, Chapter VI provides a review of findings for each of the research questions, summarizing the study's findings to include the most compelling key points. This final chapter makes implications about the sonography profession and even other healthcare providers, based on these findings. The researcher provides recommendations for the sonography industry, sonographer employers and employees of the work setting, sonography education, and future research. In conclusion, study participants offer transformational statements to those within the sonography profession.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Due to the high percentage of repetitive motion injuries (RMIs) among sonographers and an average time period of five years for the reporting of WRMSDs or associated pain in this career field (Horkey & King, 2003; Parhar, 2004), an instructional designer might reason that the most effective ergonomics training should begin as early as possible within a sonographer's career and should focus on developing positive lifelong scan habits with the potential to reduce work-related risks. Thus, transformation of sonographers' early career-related actions into a lasting, positive work habitus should require considerations of transformative learning, thereby also enacting personal belief values along with a cognitive model for conceptualizing behaviors that might otherwise seem ambiguous to learners without active participation and reflection upon personal beliefs and behaviors. Such was the premise of this research and, to that end, the focus of this literature review.

This review investigated the instructional premise of participatory (active) and critical reflective learning techniques within the transformative perspective, versus the simple transmission of information, toward the effectiveness of sonographer adoption of learned principles as practiced within the work habitus frame of reference. This review also investigated models associated with such behaviors and conceptualization. As any literature relating to various instructional techniques for ergonomics learning may be greatly limited, this information

was used for development and comparison of the various implemented approaches in this study. As such, this study used some elements of grounded theory in assessing long-term behavioral changes associated with a positive work habitus for the reduction of WRMSDs.

Instructional Techniques

Transformative, or transformational, learning is an adult education theory originally introduced by Mezirow (2000), who hypothesized there was a difference between transmissional, transactional, and transformational education. To more fully appreciate the meaning and scope of transformative learning, as well as the instructional techniques utilized for this study, a summary of each learning type has been included in Table 2.1.

Table 2.1 Comparison of Cognitive Learning Categories

Transmissional Learning	Transactional Learning	Transformational Learning
Information is conveyed (Freire Institute, 2013).	Event is designed for learner to personally identify with the experience (Knowles, Holton, & Swanson, 2011).	Event is designed with conceptual promotion, with critical reflection toward adjustments (Eisen, 2001; J Mezirow, 1997; 2000; Phillipi, 2010; Taylor, 2007).
Suggests a more passive learning role (Phillipi, 2010).	Learner assumes a more active learning role, with an opportunity for application (Grabinger & Dunlap, 1996; J. Mezirow, 2000).	Learner's role is highly participatory for a longer time period (Brookfield, 1995; Imel, 1998).
Learner will or will not accept information to act upon it (J. Mezirow, 2000).	Change in behavior may take place, but habitual transformation has not been identified (J. Mezirow, 2000).	Actions result in evidence of habitual change (J. Mezirow, 2000).

Transmissional Learning

As explained in Chapter I, the transmissional learning event was the first order among the three instructionally tiered categories enacted in this study. Transmissional signified that information was simply conveyed, and the learner either accepted it as so or not (J. Mezirow, 2000), as well as that information might be applied in the future or not. Freire Institute's (2013) banking concept of knowledge expressed the idea behind transmitting instruction as "knowledge [being] bestowed by those who consider themselves knowledgeable upon those whom they considered [to know] nothing" (p. 1). In other words, the teacher has delivered knowledge as an expert to learners who are believed to possess no prior understanding of the introduced concept. Merriam (2001) explained the particular problem with such a limited educational scope as this, especially for the adult learner:

...[T]he learning process is much more than the systematic acquisition and storage of information. It is also making sense of our lives, transforming not just what we learn but the way we learn...with the context in which learning occurs [taking] on greater importance. (p. 96)

"If the [learner] is involved only in banking knowledge, critical thought and decision skills cannot develop" (Phillipi, 2010, p. 45). Knowles (as cited in Knowles et al., 2011), who first introduced the concept of adult learning, or androgogy, identified the need for such learning to be performance-based, rather than merely subject-based, as a primary assumption of the adult learner.

Transmissional learning is defined by the conveyance of information, with an assumption that knowledge is to be acquired. The study's use of this learning classification as a lower level tier was not meant to suggest that base knowledge does not hold importance for learning to take place. Rather, Mezirow (1997) explained that, within adult learning, base information merely serves as one resource, meant to be built upon while developing autonomous meaning. Even if

the information has been acquired, the Knowledge category, in and of itself, has instructionally been considered the lowest functioning level of learning in Bloom's Taxonomy (Bloom, 1953, as cited in Baker College, 2005; Seddon, 1978). "Surface level learning [rather than deep learning only has occurred] when students do not progress past the first or second level..." (Baker College, 2005, p. 3).

Transmissional learning, then, has historically been planned through classical types of teaching (declarative and/or procedural knowledge) in which the student has been passive in the learning process, void of the critical elements of active or interactive learning (Oxford Center for Staff Development, as cited in Baker College, 2005). This type of instruction also has tended to assume that all learners have the same base knowledge on a subject when it is introduced into the learning environment. This notion may not have generally been true for the sonography professional within the scope of ergonomics. Differences may exist in early career sonographers introduced to the topic in a strictly didactic setting with no experiential knowledge, as compared to others who may have exposure through a strictly clinical environment.

Yorks & Sharoff (2001) believed "a change in a habit of mind [involved] more critical reflection on one's pre-given premises and suppositions" (p. 24). Such shared reflection between learner and facilitator at the career entry level served to remove instructional assumptions about base knowledge, so cooperative learning could begin based on the learner's expressed beliefs. Based on Cogan's (1953) definition of profession, Maudsley & Strivens (2000) posited that "[p]rofessionals must...be able to apply more than this conventionally acknowledged knowledge base, i.e. be able to exploit knowledge-in-action and reflection-in-action (thinking what they are doing while they are doing it)" (p. 536). The transmissional learning technique has not been designed with such immediate utilization in mind.

Transactional Learning

Stolovitch & Keeps (2011) defined the two classical knowledge types as being either declarative or procedural in nature. Whereas transmissional learning would be defined by the receipt of declarative information in classical instruction; “procedural knowledge can be best gained by doing” (2005). Stolovitch & Keeps maintained that “...what [learners] learn declaratively cannot readily be transformed into procedural knowledge unless [learners] already possess similar procedural knowledge” (p. 38). This is where the importance of the concept of the learner gaining experience through interaction within a meaningful context has received instructional emphasis.

In a transactional learning event, the learner has been positioned to take a more active role through identification with personal experience and some level of interaction (Baker, 2009; Grabinger & Dunlap, 1996; Knowles et al., 2011; J. Mezirow, 2000). Transactions allow the learner to process through cultural experience, as was the intent of Kolb (1984, as cited in Maudsley & Strivens, 2000) in creating knowledge opportunities that included people-environment transactions. The transactional learning event component of this study was designed to build upon this transactive experience proposition by incorporating:

- an emotional element (of the learner personalizing the potential of MSI risk) that Dirx (as cited in Merriam, 2001) believed served to facilitate the meaning-making process;
- presentation of the information within the professional context through videotaped self-assessments prior to reflective development of the personal prevention plan - an element which Merriam believed was essential toward transformation, but Taylor

(2007) stated was “...historically overlooked in Mezirow’s conception of transformative learning theory” (p. 184);

- the beginning of Schon’s reflective practice in action (Kaufman, 2006), as well as procedural and transactional beginnings to develop relative experience through laboratory work station evaluations and self-assessment of ergonomic practices via videotaped observation (Kolb & Kolb, 2005; Maudsley & Strivens, 2000); and
- an introduction to certain components of Rotter’s social learning theory, as the learners (in the interview process and in the post-observation reflection) were asked to consider factors related to behavior potential and expectancy (Craighead & Nemeroff, 2004).

The transactional learning process, as defined within this research study as the second order learning technique, enabled the instructional facilitator to open a pedagogical entry point “...where students [might] consciously [engage] their personal dilemma...” (Taylor, 2007, p. 183). This transactional entry point was created as the pre-instructional interview, where students were first introduced and questioned on personal susceptibility to MSI risks. The post-instructional creation of each learner’s personal prevention plan (PPP), with the affective component introduced within the learning event, provided an analytical means for learners to journal experiences, thereby identifying and constructing personal values (Cohen, 2004, as cited in Taylor, 2007). Finally, each subject of the transactional process was individually observed and later allowed to observe oneself through videotaped analysis and to reflect upon those findings. Learners were capable of experiencing the realization, within a work environment context, that actions could be adjusted and outcomes were within the learner’s control (Baker College, 2005; Knowles et al., 2011; Merriam, 2001; Taylor, 2007).

The transactional learning event, as defined in this study, was designed to develop self-awareness and promote self-efficacy, as described through:

- modeling behaviors (both positive and negative, using personal videotaped sessions with expert observer feedback for critical reflection);
- a clearly defined goal of improved ergonomics practice with corrective feedback (again, provided by the expert observer); and
- the ability of the learner to reflect upon negative ergonomic behaviors in self-evaluation of videotaped segments toward completion of the PPP at the conclusion of the learning event (Baker College, 2005; Kaufman, 2006). “Critical reflection, awareness of frames of reference, and participation in discourse become significant elements in defining learning needs, setting educational objectives, designing materials and methods, and in evaluating learning growth using non-traditional methods...” (J Mezirow, 1997, p. 11), such as the design of the study’s personal prevention plans and other reflective activities.

As with transmissional learning, transactional learning concepts may have been adopted and brought about some level of change, yet change did not necessarily bring about identified transformation of the learners’ belief systems and/or actions as part of an adopted habitus (J. Mezirow, 2000). A transactional learning event allowed a level of self-evaluation and reflection within a simulated work environment context, but not necessarily the impetus to carry this knowledge forward beyond that learning event.

Toward achievement of long-term transformation, developing and adjusting frames of reference were necessary within an emotional or deeper, more holistic context (Merriam, 2001; Taylor, 2008). Such frames of reference have usually been considered to be cumulative in

experience, developing more gradually over time (Eisen, 2001; J Mezirow, 1997; 2000; Phillipi, 2010; Taylor, 2007). Though the transactional experience may have assisted in beginning an epochal (meaning epoch, formational) event toward transformation (Eisen, 2001), Mezirow (1997) believed that epochal changes occurred less commonly and were more difficult to achieve. Transformative learning theory described a longer, habitual process composed of various and building frames of reference, termed perspective transformation (Brookfield, 1995). “Anecdotal and testimonial reports have long supported the notion that people can be profoundly changed through [such] learning” (Merriam, 2001, p. 94).

Transformational Learning

Transformational learning theory posited that a habitual change would take place as a result of a participatory and continued reflective learning role, in which actions display a transformative change in the learner on a longer-term basis. Of mention,

Mezirow did not agree that transformative learning always [led] to visible action. While he did agree that action was usually the last step in transformational learning, the action may be a decision rather than a measurable change in behavior. Ideally, transformative learning in healthcare will lead to action. (Phillipi, 2010, p. 46)

Learners must be engaged in constructing personal knowledge, with a learner-centered approach, for a change in beliefs to take place before a habitual change in behaviors will ever be noticed (J. Mezirow, 2000, 1990; Phillipi, 2010; Taylor, 2007). Prior meanings must be renegotiated for new meanings to be made (Kitchenham, 2008). For this to be accomplished, Mezirow (2000) believed a disorienting dilemma must take place to broaden existing schemes of meaning. In a critical dialogue with Dirkx, Mezirow (as cited in Dirkx, Mezirow, & Cranton, 2006) explained the importance in making meaning as awareness transformation through new frames of reference

to assist in "...[generating] beliefs and opinions that [would] prove more true or justified to guide action" (p. 124).

Taylor (2007) incorporated Knowles' assumptions of androgogy by stating that transformative learning was "...uniquely adult, abstract and idealized, [and] grounded in the nature of human communication" (p. 175). In proposing that transformative learning involved deep, powerful beliefs that would ultimately be evidenced in the learners' elective actions, rather than merely instructionally planned ones, Mezirow (1997; 1990) also discussed processes of learning to help reframing take place. Mezirow (2000) believed discourse was essential among adult learners to establish frames of reference and meaning for any future actions to be guided.

The four processes of reframing were (1) to elaborate an existing point of view; (2) to establish new points of view; (3) to transform learners' points of view; and (4) to become aware and critically reflect upon one's points of view. Such an autonomous approach was meant to allow for a potential shift in perspective (Brookfield, 1995). Though perspective transformation consists of the three dimensions of psychological, convictional and behavioral classifications, the behavioral dimension of this transformation was the one which signified a legitimate change in the learner's lifestyle, and thus adaptation of the learning as a formed habitus, according to Mezirow (2000). Taylor (2007) admitted that perspective transformation was an elusive concept to define, but any change in this frame of reference relied upon the beliefs of irreversibility, sustainability, meaning scheme change, and epistemological change.

Imel (1998) maintained that transformative learning theory placed the learner in a key participatory role. As such, the learner should be encouraged to engage in critical reflection as part of that participation for sustainable transformation to truly take shape (Brookfield, 1995; Garrison, 1992). Philippi (2010) stressed that critical reflection was integral in shaping health

behaviors, which was the intent of this study in assisting health care professionals to assess personal actions toward musculoskeletal health. Furthermore, incremental frames of reference should be structured within an educational environment and given time for development of conceptualization to occur (Eisen, 2001; Phillipi, 2010).

Also of importance to this study, the researcher did not wish to overlook the components of social learning theory in discourse (Craighead & Nemeroff, 2004; J. Mezirow, 2000; Phillipi, 2010); emotive responsive components (Dirkx et al., 2006; Taylor, 2008); or experiential learning in repetition, reflection, conceptualization and experimentation (Baker College, 2005; Kolb & Kolb, 2005; Maudsley & Strivens, 2000). The combination of these mechanisms have been proposed in Mezirow's primarily rational theory toward achievement of greater success in long-term transformative instructional efforts (Boyd & Myers, 1988; Dirkx et al., 2006).

Taylor (2007) stressed the importance of implicit memory attention to the transformational development of attitudes and habits, in which repetitive experience is essential and must be considered within the instructional planning process. Pugh (2002, as cited in Taylor, 2007) stated that "[i]ndividuals undergo transformative experiences when they actively use a concept, find that it allows [learners] to see aspects of the world in a new way, and personally value this way of seeing" (p. 180). Taylor more specifically cited three approaches to fostering transformative learning. The first of these was providing direct, engaging, and stimulating experiences for learning; the second was to vary the medium to include expressions of both internal critique and external dialogue; the third was to recognize (or create) a pedagogical entry point, "...developing an awareness of students who are at the edge of their knowing, as well as helping them become self aware..." (p. 183). Taylor also believed that the significant role of context in the development of awareness was historically overlooked as it related to

transformative learning theory. The transformational learning elements of this research were designed with work context in mind.

Boyd & Myers (1988) and Dirkx (1997, as cited in Dirkx et al., 2006) each described meaning in the transformative learning context through more than the reason and logic approach of the original theory, looking upon the process as more holistic, being emotional and psychosocial in nature. Dirkx' view of transformative learning incorporated much more subjective soul work (or inner work), in which the learner "...reflects the intellectual, emotional, moral and spiritual dimensions of our being in the world" (Dirkx et al., 2006, p. 125). Notwithstanding the discrepancies, all of these theorists have agreed on the need for the learner to construct personal meaning through reflection and interaction. The proposals of reflection in action as well as reflection on action have been attributed to Schön, whose theory of reflective practice was proposed to challenge the learner to apply past experiences to new learning, as well as to think back on past actions for readjustment of future actions (Kaufman, 2006). Such repetitive reflection opportunities were included as part of the student mirroring and assessment conceptual exercises within the transformational learning group design of this study.

Since ergonomics instruction has been available throughout the past decade, yet the incidence of reported WRMSDs has not reduced according to published professional data, the researcher of this study believed that transformative learning has not been enacted on a widespread basis throughout the profession based on any recognizable changes in behavior. A newly developed frame of reference has not been demonstrated through any evidence of actions that have changed ergonomic behaviors to the point of reducing MSI rates. Mezirow (as cited in Dirkx et al., 2006) explained that these frames of reference involve "...a mind-set or worldview

of orienting assumptions and expectations involving values, beliefs, and concepts - by assessing...epistemic assumptions” (p. 123).

The simple transmission of information concerning ergonomics principles and MSIs may be causing transformation to take a backseat in sonography due to professional productivity demands and perceived patient needs within the work environment. Else, transmissional learning simply may not be an effective instructional technique for sonographers to establish adequate value expectancy to actively practice positive work behaviors. From the time initial information has been transmitted, learning should be intentional in providing the disorienting dilemma that Mezirow felt was essential to reorganize meaning (Kitchenham, 2008; J. Mezirow, 2000). Phillippi (2010) stressed that “[c]hanges in health status act as a disorienting dilemma for many adults” (p. 48) and, as in the case of what the profession’s MSI statistics actually represent to individual sonographers in terms of career loss, that “[a]dults must know about their health to effect changes in their behaviors and health status” (p. 40). Any change in behaviors that may lead to reduced MSIs among sonographers will unlikely happen without an individual’s personal examination of assumptions and beliefs, as well as what value might be perceived from any reframing in meaning.

Value Expectancy Theory

Greenberg (2001, as cited in Phillippi, 2010) made the observation that when healthcare issues were rushed, there was “...little time for deep thought and discussion” (p. 44) to take place. Sonographers are often rushed within the clinical environment to fulfill a crowded patient schedule, with thoughts more often on patient diagnostic concerns, rather than personal safety.

Belated career decisions to engage in positive work habitus behavioral changes, without time for critical reflection once immersed in busy daily schedules, will be less likely to occur. “When people critically reflect on their health, they evaluate their current behaviors and make decisions about changes” (p. 44). Such reflection should be arranged within a transformational learning event, so positive work habitus will be developed that will not require conscious reframing of thoughts in the midst of other duties. By the time actions are repetitive, reframing needed to have already taken place. Furthermore, Quick (1988) emphasized that “...people will choose the behavior...that will result in their getting the more valuable output or reward...” (p. 30). If sonographers, as health care providers, view the reward beyond personal career longevity to the daily delivery of patient care services, then positive behaviors should also yield an opportunity for more patients to receive care over extended career longevity. This researcher has posited that value lies not only in personal attainment of financial and career goals for early career sonographers, but in overall professional attainment of employer patient care goals. Injured sonographers do not scan patients productively, if at all (Coffin & Baker, 2007; Kaiser, 2007; National Institute for Occupational Safety and Health, Department of Health and Human Services, 2006; Society of Diagnostic Medical Sonography, 2003).

For true transformation to more permanently take place in sonographers’ actions, belief patterns from reframing perspectives must become firmly established (Brookfield, 1995; Taylor, 2007; Yorks & Sharoff, 2001). Sennott-Miller (1994) posited that adoption of preventive behaviors would only come through a connection of consequences that ultimately demonstrated a reduction in personal risk because of those changes. The threat of a health status change has served as a trigger in past adult learning transformational experiences (Phillipi, 2010). The socio-psychological theory explaining this process, of cognitively deciding to form lasting impressions

based upon the value placed on experiences and expectations that preventive actions will create positive benefit, has been termed value expectancy theory (Becker, 1974; Edburg, 2010; Glanz et al., 2008; Rosenstock et al., 1988).

Atkinson (1957) developed the expectancy-value theory of achievement motivation, postulating that one's behavior was based upon both the value of the outcome to that individual and the expectation that such an outcome could actually be attained through the performance of said behavior. Maehr & Sjogren (1971) later placed this theory within the context of academic motivation, rather than a more risk oriented behavior pattern. In other words, a learner, in essence, will engage in particular behaviors based upon an acceptable level of expected achievement toward a desired outcome motivation. Transformational study participants were provided with the opportunity to become engaged in experiences and to reflect upon personal beliefs throughout learning to gain realization of benefit from behavioral choices through value expectancy.

Value expectancy theory has been explored in numerous health behavior studies, often in relation to the Health Belief Model (HBM). Mosby's Medical Dictionary (2009) defined the Health Belief Model as "a conceptual framework that describes a person's health behavior as an expression of health beliefs" (p. 1). The HBM has been attributed to Rosenstock (1966) while studying behavioral responses in the treatment of illnesses. However, Hochbaum (1956) had previously described this phenomenon when performing a study on public participation in seeking health services. Stephen Kegels also researched this interest, but none of this work was publicly addressed until Rosenstock. Of importance to the proposed transformative learning discussion, Rosenstock believed the emotional component held greater importance than did the intellectual in determining changed behaviors.

Ivanov & Blue (2008) credited Lewin with the idea that “[b]ehavior is a function of the subjective value of an outcome and the subjective expectation that a particular action will achieve that outcome” (p. 256). Rosenstock et al. (1988) stated the HBM hypothesized that action would depend upon sufficient motivation, belief in personal susceptibility, and “[t]he belief that following a particular health recommendation would be beneficial in reducing the perceived threat, and at a subjectively-acceptable cost” (p. 177). Since the HBM was established, the model’s uses of prediction have continued to be revised by Becker (1974), among others.

Rather than simply defining HBM for avoiding negative consequences, Becker (1974) posited that individuals were motivated to make healthier decisions, thus resultant actions, on the basis of positive benefit. An internal locus of control, or an appropriate outcome expectation, within Rotter’s social learning framework (Nowicki, Adame, Johnson, & Cole, 1997), along with self-efficacy, or the belief that a change in these actions can affect the outcome, were also cited by Rosenstock et al. (1988) to have importance within this frame of perception. Rosenstock et al. and Glanz et al. (2008) categorized the Lewinian concept of assigning subjective value as value expectancy theory, pointing to the importance of the factors of perception in decision making and behaviors related to health concerns. Nowicki et al. (1997) , in a study on physical fitness, put it simply as “[p]eople are more motivated to work hard for something they value highly” (p. 556). Rosenstock et al. expanded on the pairing of values with behavior by incorporating Bandura’s social cognitive theory into the learning concept of the HBM, stating that “...learning results from events (termed “reinforcements”) which reduce physiological drives that activate behavior” (p. 175).

In combining these theoretical approaches of value expectancy and social cognitive theory toward activation and maintenance of desired behaviors within the transformative context,

Taylor (2007) discussed the importance of ontological change through “...understanding one’s mission or call in life [to help] shed light on...[the purpose of engaging in transformative learning]” (p. 181). If defining one’s call in life helps shed light, and if patient care is viewed as the early career sonographer’s calling or purpose, then could that person’s belief for patient care, if larger than for personal safety, take precedence to reduce MSI risk potential, or will the desire for career longevity be enough? Though this study was not designed to answer those specific questions, such ideas may assist in reframing meanings through dialogue. Figure 2.1 demonstrates Hancock’s Ergonomics Injury Belief Enhancement Model, which modifies and applies the motivational layers of the Health Belief Model associated with value expectancy theory to the early career sonographer within the ergonomics context.

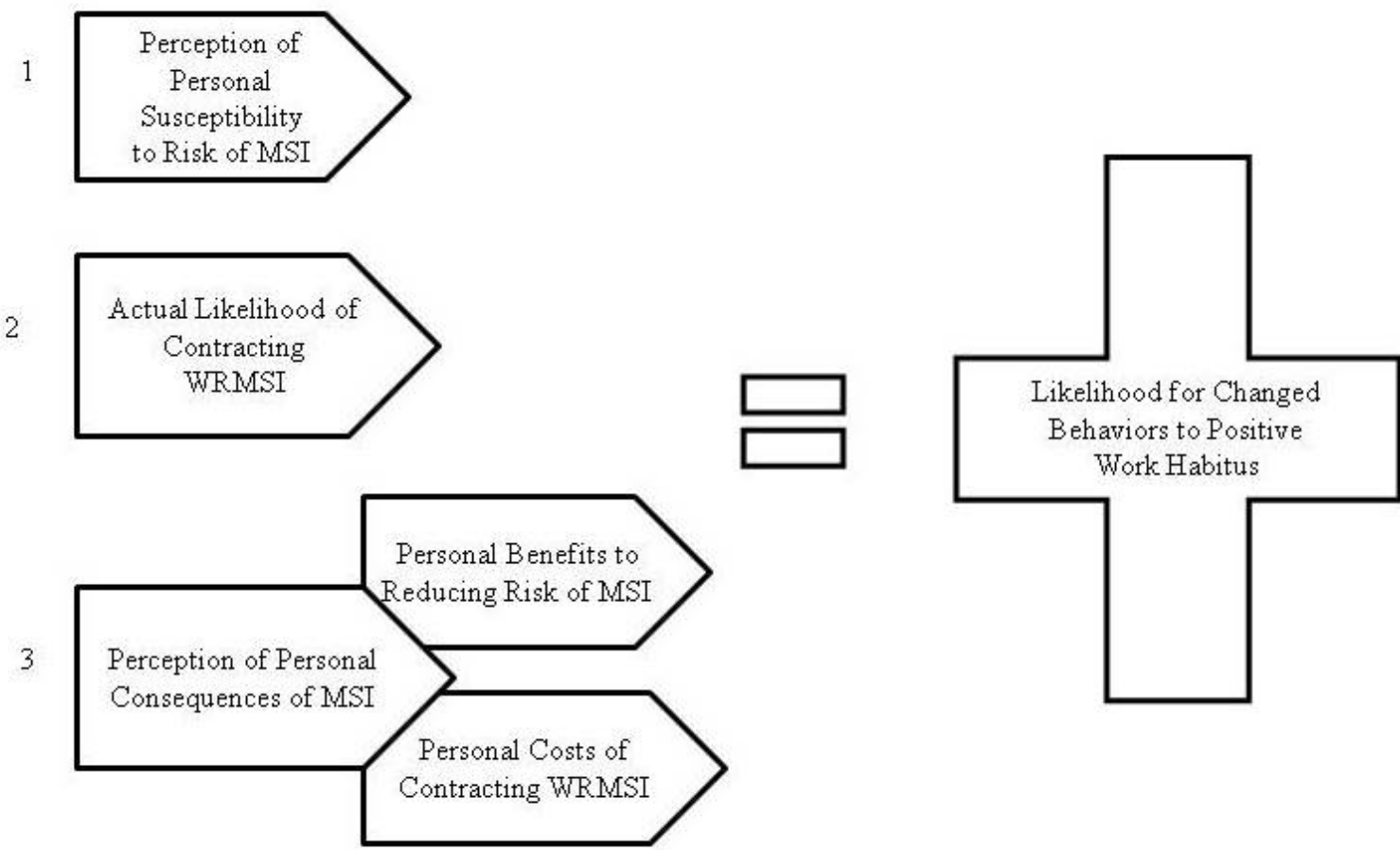


Figure 2.1 Hancock's Ergonomics Injury Belief Enhancement Model

Tanner-Smith & Brown (2010) found the HBM to fall short in predicting perceptions of risk, with considerations of contextual constraints as the primary reason. Rosenstock (1966) explained that there was a gray area that existed for many health behavior learners who could admit to having a statistical risk toward an illness or injury, but would not concede to the likelihood of personally obtaining a particular illness or injury. Critical reflection on visualized personal behaviors was viewed as a necessary component of the transformational learning event to help shed light in assumptions to the learner, so that self-efficacy might be established toward greater success in outcomes, without the contextual constraints that contribute to denial patterns (Phillipi, 2010).

Also of important consideration was that value expectancy, when viewed as a singular theory within the Health Belief Model construct, would likely not be of theoretical value within this study without the transformative learning theory structure, as the HBM does not necessarily consider repeat behaviors (Tanner-Smith & Brown, 2010). Phillipi (2010) deemed that long-term care patients could gain "...incremental implementation of new behaviors and skills" (p. 44) because there would be more time to critically reflect on the information within a learning community, supporting the longer incremental participation period surrounding the designated transformational learning principles in the design of this particular research study. Lastly, although the HBM provided a framework for perceptions related to a wide range of health behaviors, specific steps had to be considered within an ergonomics frame of reference, as the model otherwise "...[lacked] clear operational definitions for the proposed constructs, and [did] not specify how variables should be combined...to predict behavior" (T. P. Ross et al., 2010, p. 30).

Rosenstock (1966) listed the four interrelated variables of the HBM as perceived seriousness, perceived benefits of taking action, barriers of taking action, and cues to action. Important influencing factors listed for this model and considered in this research in reference to value expectancy theory as an extension of the HBM included:

- the participant's perception of susceptibility to the risk of MSIs;
- the likelihood of contracting a WRMSD (which can be introduced through published statistics of the profession);
- the participant's perception of severity of consequences related to contracting an MSI; and
- the participant's perception of benefits or barriers to achieving behaviors that can reduce the risk of MSIs.

Perceptions are created within the affective realm, where attitudes and beliefs reside. As has been discussed, the expression of those inner perceptions can often be viewed in external behaviors. Neuroscientists believe that mirror neurons within the brain assist in the interpretation of behaviors, while schema (patterning) activation in the brain assists in developing understandings that may have not yet been personally encountered in one's own behavior.

Mirror Neuron Theory

Uddin, Iacoboni, Lange, & Keenan (2007, as cited in Javanbakht, 2011) emphasized the importance of mirror neurons functioning as a bridge between interactions involving oneself and others. Javanbakht posited that "...pattern completion is involved in estimation of the intention behind motor movements which are recognized through utilization of the mirror neuron

system”(p. 249). Rizzolatti et al. (1996, as cited in Burns, 2008) unexpectedly realized this phenomenon associated with the firing of what became termed as mirror neurons through behaviors that occurred in primates as a result of a desire for objects while observing the movements of humans with those objects (e.g., the primate pretending to peel an imaginary banana in response to viewing the human peeling an actual one). If, then, mirror neurons fire during the observation of others’ actions and even drive emotions toward the development of new cognitive patterns, how much more effective might conceptualization be if learners purposefully engaged in a process this researcher has termed as mirroring adjustment technique within a social learning activity? Within this construct, learning peers were instructed to intentionally capture actions using a video device as a mirror display of actions to demonstrate personal scan behaviors to partnered subjects within the transformational learning group. In doing so, these subjects could visualize personal scan performance and make behavioral adjustments through both cognitive social reflection and individual emotional attitude associated with value expectancy toward such change.

Viale (2011) posited that with mirror neuron theory, “[c]ognitive simulation and empathic identification are the necessary premise to understand an action and generalize it into an ideal type representing aggregate social behavior or a social phenomenon” (p. 319).

Javanbakht (2011) explained that mirror neurons assist in development of a cognitive model for schemas that can be

...used to complete ambiguous aspects of future experiences...in relation to the self or the outside world when a pattern with unknown...aspects is encountered.... This process is to help the observer acquire a better understanding of the environment or the self. (p. 243)

Sonography students have chosen to engage in an imaging field which requires visual understanding; consequently, the researcher believed a visual learning preference existed for the

majority of these individuals, which was confirmed through orientation learning preference activities. To properly support the mirror neuron theory, the development of cognitive patterns for self-transformation of ergonomic habits, via the interjection of visual learning stimuli of students' own actions for reflective assessment, was deemed an appropriate pedagogical strategy. This strategy created a learning environment that allowed the transformational learning group to view, first hand, actual personal scan behaviors as compared to those identified as desired, through a video recorded mirroring method. By each learner actively identifying risk behaviors, while affectively and logically reflecting upon these behaviors for oneself, the researcher was able to search for evidence to support whether the transformative learner more readily developed a cognitive schema toward greater positive (and fewer negative) ergonomic adjustments at a future time, as compared to the transmissional or transactional learning groups.

Peer Transformative Assessment Approach

Phillipi (2010) stated that “[c]ritical reflection is an integral part of shaping health behaviors” (p. 44). O’Donnell & King (1999) have explained that the principles behind a Vygotskian perspective require social structure in learning to obtain higher reasoning and critical thinking. Taylor (2007) concluded that ongoing critical reflection upon oneself and others resulted in authenticity, listing enthusiastic support as an essential component in fostering authentic transformation. Eisen (2001) explained the peer learning partnership as being the support mechanism necessary for such fostering through “...a nontraditional approach that incorporates several dynamic learning methods into an integrated professional development strategy aimed at fostering learning and change through reciprocal reflection and praxis” (p. 31).

Eisen went on to define the peer learning partnership success on the basis of the experience being voluntary in its problem-posing approach, having a commonly related objective, and based upon interacting individuals sharing a comparable status. The learning emphasis was on incremental development as an ongoing assessment, rather than a point of definitive evaluative outcome. Eisen recommended that the peer learning process should purposefully be designed as highly visible and interactive for the learners.

Popham (2008) specifically identified the need for learners to be actively and substantially involved in a formative assessment process, also stressing the importance for such assessments to be instructionally supportive toward critical reflection within changing the learners' frames of reference. Popham clarified this need for formative assessment as part of a transformative process, explaining it as "...a planned process in which teachers or students use assessment-based evidence to adjust what they're currently doing" (p. 6). Yorks & Sharoff (2001) posited that

[p]roviding opportunities for dialogue into the meaning of [a learner's] emotional responses to various clinical experiences [facilitated] the development of alternative meaning perspectives that [would] empower the [healthcare provider's] ability to participate in his or her own healing as well as the healing process of another. (pp. 24-25)

This type of learning setting provides the autonomous and collaborative environment that Mezirow (1997) stated was essential within the assessment realm for the goal of transformative learning.

The transformational design component of this ergonomics study incrementally built upon the methodology of peer transformative assessments. Recognizing the instructional magnitude of behavioral conditioning through repetition (Skinner, 1957, 2012; Tolman, 1938) and social learning reinforcement (Bandura & McDonald, 1963), Hancock & Ellis (2012) developed a model for student mirroring adjustments. The design of this instructional model

consisted of peer assessment during skills-based scan labs, with directed feedback using an observation survey tool and *iPad* cameras (padcams) available to students in the laboratory setting. Working in pairs or a small group setting during scanning laboratories, learners were able to engage critically and cooperatively at the three key reflective points designated in Figure 2.2. A student assessor could use the observation tool to record quantitative assessments of a peer's scanning performance according to ergonomic behavioral concerns. Peers could then reflectively collaborate through the sharing of photo and video archives available on the padcam while searching out reasonable adjustment solutions using visual cues provided on posters at each scan station. The final survey conducted on the *iPad* allowed for self-reflection following peer discussions concerning personal adjustment goals for the next scan session. Each of these three reflective points (peer, collaborative, and self) combined to achieve student mirroring adjustment behaviors.

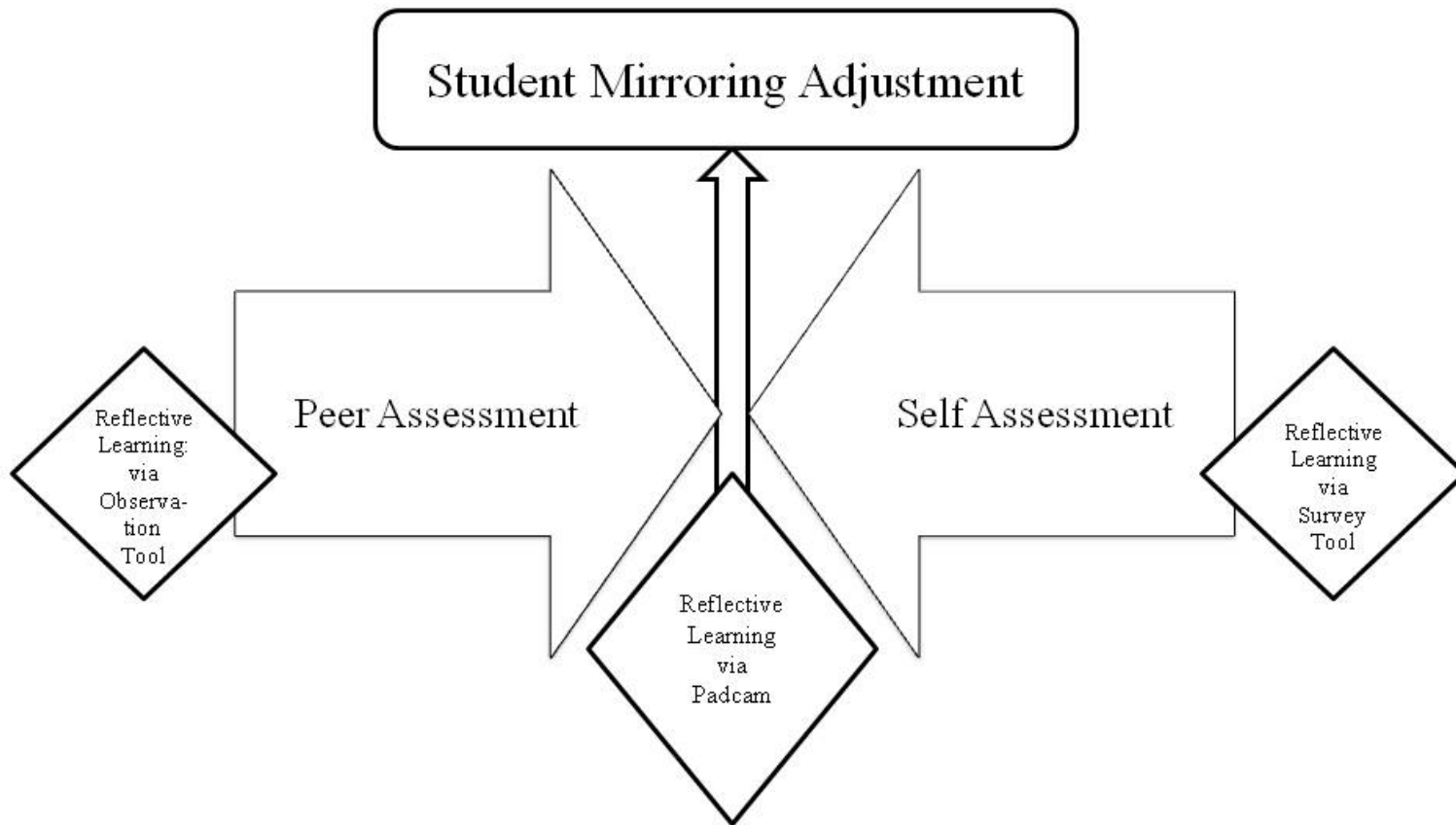


Figure 2.2 Reflective Engagement Points within Hancock-Ellis Student Mirroring Adjustment Model

Sivan (2000) expressed the importance of involving learners in peer assessment within an active learning environment toward furthering development of critical reflection skills. Sivan furthermore expressed that “[the] gradual [incremental] introduction of the method into the curriculum and the importance of building on student experience was also found to be effective in relation to student engagement in the assessment criteria” (p. 206), as documented within multiple studies on peer assessment. Multiple student mirroring sessions throughout later semesters, after learners had been introduced to assessing personal ergonomic concerns, allowed each learner to become one’s own model, with the ability to share in personal and peer assessment of scan behaviors recorded on the padcam. In this way, collaborative critical reflection was available to assist in determining appropriately reasonable adjustments based upon visual cues provided by instructional posters (Figure 2.3) available at each transformational scan station within the laboratory setting. These visual cues served as repetitive reminders of the experiences the learners had already undergone, thus were designed to further build confidence, as evidenced to be of great importance in Sivan’s research.



Figure 2.3 Visual Cues via Poster of Ergonomic Scan Behaviors and Corrective Measures

The interactive collaboration among peers brought together many of the other planned instructional concepts toward prediction of transformed learner behaviors, based upon the four main components of Rotter's social learning theory: behavior potential, expectancy, reinforcement value, and the psychological situation (Craighead & Nemeroff, 2004; Nowicki et al., 1997).

ASSURE Instructional Design Model

Designing interactive, collaborative lessons that enhance learners' visual and conceptual understanding can be effectively done via integration of instructional technology tools such as

iPads using the ASSURE model (J. L. Hancock & Ellis, 2012). Williams (2012) was one of many educational trend analysts suggesting that modern students are geared toward tactile and technologic interaction in the learning environment. With this in mind, ergonomic learners can be provided with tools for developing new cognitive schemata which include self-assessments through honest reflection toward improvement, rather than feeling threatened or resentful that someone else is assigning grades based upon that other individual's perception of such improvement (J. A. Ross & Starling, 2008). Strobino et al. (2002) are among many academicians pointing to the tension and stress students (and faculty) experience over such assessment issues. Venugopal & Kakani (2002) expressed concerns of students' propensity to temporarily please the instructor or to select less rigorous course work with the learners' focus being on the grade outcome over the outcome related to the long-term application of learning. Changes induced by external forces traditionally are not perceived by learners in a positive light nor are these changes necessarily long-lasting, which, then, negate the learning from being truly transformational at all.

The ASSURE model was developed to serve as a procedural planning tool that could be used by an instructor when desiring to incorporate technology into the design of the learning environment (Smaldino, Russell, Heinich, & Molenda, 2005). ASSURE is an acronym for an instructional design model, which describes the use of the first letter of each of the six steps that guide the model: Analysis of learners; Stated objectives; Selection of methods, media, and materials; Utilization of methods, media, and materials; Requirements of learner participation; and Evaluation and revision of plans. The decision to use technology may be made as part of a broader instructional development model; yet Smaldino et al. have highlighted that the ASSURE model's greatest benefit is its ease of use by an individual for implementation of systematic and

effective instruction without necessarily having the benefit of expert analyses and prototype piloting that is often built into more ambitious models.

The steps of the ASSURE model have been individually addressed within Appendix C to be specific within the scope of the ergonomics assessment plan, based upon the aforementioned components of transformational learning, value expectancy, and peer and reflective assessments. The main instructional premise was to enhance longer-term adoption of transformational habits by removing the component of learner assessment from the instructors' hands and physically placing it into the hands of the students in a collaborative learning environment. The first two steps of the ASSURE model played essential roles in determining that the selected technology of *iPads* would provide a reasonable means by which to achieve the longer-term, incremental transformative instructional goals.

Summation of the Literature Review

The significance of evaluating the usefulness of expressed value expectancy within a transformative learning ergonomics module is that most early learners within the field will be working with sonographers who possess greater amounts of work experience and who also have authority over learners within the clinical settings. If more experienced sonographers have not personally transformed prior ergonomics methodology, thus being at greater individual risk toward MSDs, student sonographers may also easily dismiss the value of positive ergonomic techniques addressed in transmissional learning, primarily because of a poor transactional experience within the clinical environment. Thus, identifying an educational protocol design - one in which early sonographers may begin to transform personal ideas of protective scanning

versus productive scanning using the Health Belief Model pattern - might greatly serve in achieving personal value expectancy based upon positively influenced adopted beliefs. The findings of this study might also be of great importance to NIOSH in offering additional information on best practices in education for transformational adherence to suggested professional ergonomics guidelines, in hopes of reducing MSDs among sonographers, in general.

In transmissional learning events, a learner is provided with information but may not choose to apply it. In transactional events, active learning may demonstrate that a change in behavior has taken place, but habitual transformation has not been identified. By comparison, transformative learning events are designed to enhance the value of instruction by encouraging learners to continue practicing positive habits as part of a longer-term belief pattern development as a result of progressive learning events, as well as to begin to formulate continued assessment of those patterns throughout both self and peer progression. In the case of ergonomics instruction and assessment, student mirroring allows the subject to become one's own model, to assess personal behaviors that have been recorded through the peer's padcam to determine appropriately reasonable adjustments based upon visual cues provided in an active instructional setting (J. L. Hancock & Ellis, 2012; Sivan, 2000). The interactive collaboration among peers brings together many of the other planned instructional concepts toward predicting transformed student behavior, based upon the four main components of Rotter's social learning theory: behavior potential, expectancy, reinforcement value, and the psychological situation (Craighead & Nemeroff, 2004).

Based upon the literature review, causal-comparative learning groups were established using a quasi-experimental approach according to categorized tiers assigned within progressive instructional events. These will be further delineated in Chapter III, but were based upon the tiers

and learning progressions that have been described as part of the ASSURE Model detailed in Appendix C. The steps of the ASSURE model were addressed within the scope of the transformative ergonomics plan of the study, as each played an essential role in determining that the technology of *iPads* provided a reasonable means by which to achieve the longer-term transformative learning goal and through which instructional tools and methods could either be used, modified, or created to achieve both expert and learner formative assessments.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY OF THE STUDY

Introduction

Chapter III describes and explains the inferred population and samples studied, the research design through learning progressions, and methodological procedures with instrumentation tools and variables used to collect and analyze the research data. Approval by the Institutional Review Boards (IRBs) at the University of Tennessee at Chattanooga and at Chattanooga State Community College was sought and granted for the use of all data collected during prior instructional analyses (Appendix A) and during the graduate observation stage, from which final data were garnered as part of this constructive research analysis for comparative assessment among all designated learning groups. The intent of observation was explained to each scanning participant with prior consent obtained (Appendix B). Such research procedures were put into place to assure the protection of human subjects.

Within this chapter, the general overview of the research design listed various instructional techniques incorporated within this study, including the comparative instruments used to complete each instructional stage and learning progression tier, along with the final expert observational assessment to fulfill this research study's intent. This was a quasi-experimental, causal-comparative study of the three instructional methods defined and referred to as transmissional, transactional, and transformational. The study's purpose was primarily to assess whether transformational ergonomics learning, in a reinforced reflective and collaborative

environment, could demonstrate a significant difference in ergonomic scan behaviors associated with reported musculoskeletal disorders (MSDs).

Research questions have been addressed individually and in order in this chapter, together with any assigned hypotheses, designated instrumentation and planned methodology within the research design, and all associated variables – independent, dependent, and extraneous. Related discussion includes the approach for analysis, whether by quantitative or qualitative means, identifying associated descriptive findings, statistical testing, and further narrative input. In this manner, the reader should be able to logically progress through the study, especially in relation to later research chapters.

Description of the Population and Study Subjects

The inferred population consisted of those sonographers entering the field early in the scan career who had not yet been broadly exposed to an understanding of the risk factors associated with work-related musculoskeletal disorders (WRMSDs) within the profession, and who were likely unaware of the published repetitive injury rates among sonographers. The most specific population of this study, however, encompassed the students of the Chattanooga State Diagnostic Medical Sonography Program, through which three ergonomics learning categories were compared – transmissional, transactional, and transformational – as employed within an educational setting for each of the sample groups. Sample instructional methodology groupings for study comparisons were made among four graduating classes, as described in Table 3.1.

Table 3.1 Study Subject Designations

Group	Instructional Technique	Class Designation	<i>n</i>
A	Transmissional	Classes of 2009, 2010	35
B	Transactional	Class of 2011	14
C	Transformational	Class of 2012	12

Research Design

Just as Taylor (2003) conducted a longitudinal study of belief changes based upon behavioral patterns, and Taylor (2007) later concluded that most of the longitudinal studies addressing transformative learning took place over a time period of two to five years, the data from this study were gathered from the same approximate period among three comparative sample groups (A, B and C). The researcher employed a mixed methods approach involving a causal-comparative component with a longitudinal perspective, a quasi-experimental element, and observational descriptions and narrative themes as part of the qualitative segment.

The research design combined information from identified ergonomics instructional events to assess for value expectancy adoption through expressed beliefs related to injury risk factors and through positive work habitus ergonomics practices. Planned learning events occurred within a transmissional module for Group A, extended to transactional events until the end of the first semester for Group B, and continued through the program year with reflective and collaborative exercises toward longer term transformation for Group C. The design of these learning level progression tiers has been depicted in Table 3.2, with groups designated within the

instructional stage column to demonstrate the end of each group's progressive learning, along with instructional and research assessment tools for each.

Table 3.2 Research Design by Learning Progression Tiers among Sample Groups

Sample Group	Instru- ctional Stage	Learning Progression Tier Description	Assessment Instrument	
C - Transformational	A - Transactional	Online Presentation and Study Notes	Pre-Assessment	
		Online Self-Assessment Game (PowerPoint)	Post-Assessment	
		Learner Workstation Inventory Assessment for Ergonomics Compliance	Workstation Inventory Checklist	
		Learner Self and Peer Scan Assessment for Ergonomics Compliance	Self and Peer Scan Check sheet	
		Personal Prevention Plan (PPP) - Learner Reflective Applicability Report	PPP Rubric (Appendix D)	
	B - Transactional	Pre-Instructional Expert Scan Observation (for behavioral frequencies)	Observation Guide (Appendix F)	
		Pre-Instructional Learner Interview	Interview Questions (Appendix E)	
		Post-Instructional Expert Scan Observation with Self-Assessment (for behavioral frequencies)	Observation Guide (Appendix F) Video of Personal Scan Behaviors	
		Photoplethysmography (PPG) Quasi-Experiment for ½ Learners: Compression Blood Flow Demonstration	PPG Reading (Appendix F)	
		PPG Quasi-Experiment for ½ Learners: Compression Blood Flow Demonstration	Post-PPG Interview (Appendix H)	
		Likert Scale Designation of MSI Risk Factor for Post-Instructional Comparison of Quasi-Experimental PPG and Control Groups	Likert Scale (Figure 3.1)	
			Self and Peer Scan Evaluation compared to Expert Evaluation (for comparison of behavioral frequencies and discussion related to pre-assessment for mid-term learning progression)	Observation Guide (Appendix F) Video of Personal Scan Behaviors
			Multiple Peer Observation Student Mirroring Adjustment Laboratory Sessions (frequency of observed behaviors)	Observation Guide (Appendix I)
			Multiple Collaborative Ergonomic Adjustment Sessions with Self and Peer Assessment	Video Mirroring Adjustment (VMA) survey (Appendix I)
	All Groups		Post-Graduate Expert Scan Observation (2 to 5 years of scan experience) – Retained Subjects	Observation Guide (Appendix F)

Transmissional Learning Progressions

As denoted by the instructional stage column of Table 3.2, all sample groups were given access to the same transmissional ergonomics learning module. This module was located online and designed for self-progression from the tenth program week until the end of the first semester, to include:

- 1) an overview with an ergonomics learning goal;
- 2) specific learning objectives to be accomplished;
- 3) key ergonomic terms;
- 4) a suggested schedule for module completion;
- 5) introductory comments on the importance of the topic;
- 6) a pre-assessment survey for the learner to self-assess knowledge of ergonomic issues;
- 7) responses to pre-assessment questions posted to the class discussion board, asking the learner to describe a physical setting of a personal scan work station, to explain whether physical exercise has any relation to one's work as a sonographer, and to identify if the learner was experiencing any new aches or pains in the past few weeks and, if so, any perceived cause;
- 8) a formal instructional PowerPoint presentation which: defined the ergonomics term; related the term to the sonography scan environment; identified general causes, risks, symptoms, and common injury locations and rates of injuries; discussed OSHA goals and standards; demonstrated corrective measures (both personal and equipment-based) and exercises toward prevention; and provided a WRMSD assessment checklist;
- 9) an interactive outline to create personal study notes during the presentation;

- 10) an elective gaming PowerPoint for additional practice at identifying poor scan behaviors;
- 11) a post-assessment, designed as a multiple choice computer-based exam, in which the learner must have achieved an 80.0% mastery level to signify satisfactory completion;
- 12) an evaluation for self-assessment and peer-assessment of scan behaviors (in the form of answering questions through an abbreviated scan observation check sheet);
- 13) a work station inventory (in the form of answering questions on an evaluation checklist); and
- 14) completion of a personal prevention plan (PPP) report developed by the learner, guided by a supplied grading rubric (Appendix D) and due by the end of the first semester.

The transmissional ergonomics information was comprehensive by professional standards, but this was where formal ergonomics instruction ceased for Group A's learners beyond behavioral corrections suggested by instructors during further scan laboratories and clinical site visits. Although the course instructor was available to answer any questions related to the module and became involved in the online group discussion component, learners progressed independently according to the semester schedule. Though there were limited components in which learners interacted, such as the discussion forum, scan evaluations, and the work station inventory exercise, these elements were not defined within the scope of transactional learning for the purposes of this study. Similarly, although the personal prevention plan (PPP) allowed for learner reflections to the extent that the subjects may have accepted at least some portion of information that had been transmitted for reflecting upon laboratory and

clinical transactions, this segment of learning was not defined as a transformational learning progression element within the scope of this study.

Quantitative analyses were made among the three learning groups and among other sub-groups based upon learner scores on the PPP from this initial learning stage. Additionally, qualitative analysis was made of learner reflections on the PPP in search of any pertinent themes among instructional groups related to this study's purpose. Lastly, some transmissional components were identified within the pre-instructional transactional interview process for Groups B and C, whereby methodology was devised for testing certain variables of those elements.

Transactional Learning Progressions

Group B's learners engaged in all transmissional learning progression tiers, in addition to those continuing transactional progressions of Table 3.2. The goal of the transactional stage was to begin a confrontational interaction between the instructor and the learner, creating an environment in which the learner could begin to reflect upon personal beliefs and associated behaviors, could be assessed on those scan behaviors, and might consider knowledge gained through transactions with other sonographers in the field toward individual risk meaning. These learning progressions included:

- 1) a pre-instructional scan assessment conducted by the expert observer, using the observation guide (Appendix F) to identify early scan behaviors (defined by categorical frequencies) that were or were not conducive to a positive ergonomics work habitus;

- 2) a pre-instructional learner interview, using interview questions from Appendix E and ending with a review of the results from each learner's scan observation;
- 3) all components of the ergonomics instructional module (as previously described within the transmissional learning progressions);
- 4) a quasi-experimental photoplethysmographic (PPG) blood flow study (Appendix G), in which only a portion of the learning group was engaged (while the others became members of the control group);
- 5) a post-PPG interview (Appendix H), in which only the quasi-experimental portion of the learning group was engaged;
- 6) a post-instructional scan assessment conducted by the expert observer, using the same observation guide of Appendix F to reassess scan behaviors;
- 7) a personal viewing session of the post-instructional observation video, in which the learner used the observation guide to first perform a self-assessment of behavioral frequencies and then to compare these results to the expert observer's results; and
- 8) a personally designated MSI risk factor, on a Likert scale of 1-10 (Figure 3.1).

On a Scale of 1-10, with 1 designating essentially no risk of developing an MSI and 10 designating absolute risk of developing a future MSI, rate your own perceived ergonomics risk level. (Please do so without viewing any other participant's response.)

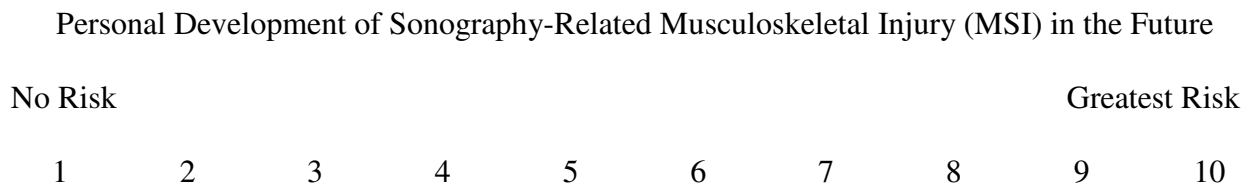


Figure 3.1 Likert Scale of Personal MSI Risk Perception

The objective within the study was for the learner to have engaged in all additional learning progression tiers of the transactional stage prior to formulating the PPP. However, since the transmissional components of the ergonomics module were self-progressive, the potential existed for the learner to complete the individualized PPP prior to reflecting upon all transactional learning components. This factor may be considered as a study limitation, having had the potential to impact statistical test results.

The scan observation instrument allowed the researcher to collect quantitative behavioral frequencies that could be compared in various ways, such as:

- pre-instructional to post-instructional periods for behavioral differences within a group;
- post-instructional behaviors between Groups B and C;

- behavioral changes between the PPG and control groups of the quasi-experimental phase; and
- post-graduate behaviors between all major learning groups.

These various comparisons have been specifically addressed, along with the instrumentation and methodology of the appropriately associated hypotheses, within the bounds of related upcoming research questions.

The pre-instructional interview allowed for some additional transmission of information concerning sonographer incidences and risks, but did so in a transactional manner between instructor and learner. This interview also allowed for transaction of the learner with oneself when viewing and attempting to objectively analyze one's own beliefs and behaviors. Interview questions were designed to primarily gather qualitative responses of learners' beliefs, to search for recurrent narrative patterns and themes related to the study's purpose, and to enhance understanding of responses. The interview format also allowed for quantitative coding of certain responses, as addressed within designated methodology segments of this chapter.

The PPG segment was a quasi-experimental sub-study on blood flow analysis during scan maneuvers (Appendix G) with an additional post-interview segment for those sampled subjects (Appendix H). This experiment included quantification of blood flow volume on a strip recorder for each learner to assess with the instructor prior to an additional transactional interview segment, where differences between baseline blood flow volume and volumes during each of the scan maneuvers could be analyzed. The added interview questions allowed the instructor to qualitatively gather enhanced meaning of learner beliefs within this progression.

Learners' beliefs were further quantified at the end of this transactional learning stage, after subjects had viewed personal ergonomic videos using the observation tool and after the

PPG experiment was conducted. This additional quantification was accomplished through personal MSI susceptibility ratings placed on the Likert scale of Figure 3.1. The researcher analyzed these ratings for differences in beliefs within groups, and among groups and sub-groups, as further addressed within the methodology of various segments of this chapter.

Transformational Learning Progressions

Group C's learners engaged in all transmissional and transactional learning progressions, in addition to an enhancement of the video viewing segment, along with additional learning progression tiers that extended during three laboratory scan sessions spread throughout the remainder of the program year. The goal of this transformational learning stage was to allow for enhanced opportunities of self-reflection and transactional collaboration with peers over an extended learning timeframe. The researcher postulated that such conditions might allow for improved belief patterns concerning awareness and health to evolve toward solidified behavioral patterns with a longer-term positive work habitus response. These progressions also removed the responsibility of behavioral evaluations from the instructor, transferring these duties to the learners to reinforce collaborative practice in identifying concerns and developing solutions.

Additional learning progressions included:

- 1) an enhancement of the personal viewing session of the post-instructional observation video at the end of the first semester (also designated as the end of the transactional learning stage), in which the learner used the observation guide not only to first perform a self-assessment of behavioral frequencies and then compare findings to the

- expert observational results, but did so in conjunction with one or two peers who also performed a peer assessment and reflected upon one another's results;
- 2) three laboratory scan sessions, with learners using *iPads* at each scan station to input ergonomics behavioral frequencies of a scan partner, while using the padcam application for video or still image mirroring to record both positive and negative behaviors for peers to visualize and, ideally, make immediate adjustments, if necessary;
 - 3) three collaborative sessions to reflect upon laboratory scan attitudes and behaviors of both self and scan partner, and to develop corrective action plans for each group member, using the video mirroring adjustment (VMA) survey.

As mentioned by Taylor (2007) when describing such transformative instructional benefits, “the video [helped] with the challenge of remembering reflective moments and [provided] a medium to stimulate reflection...” (p. 179), while “the use of writing as a medium when promoting transformative learning [was] significant...providing students a place to interject their own voice and a tangible product of the educational experience” (p. 182).

Final Observation Stage Progression for All Learning Groups

The final expert observation evaluation was performed at no less than two years and no greater than five years of post-graduate scanning experience among all retained study subjects. Quantitative data were gathered from the behavioral frequencies logged on the observation guide, which were compared among and between groups as specified within the methodology of the upcoming research questions. These graduates were also provided with an opportunity to

express beliefs in regards to personal scan injury risk and preventative measures associated with the work environment. This information was assessed for themes related to the purpose of this study.

Graduates were asked to identify whether there were any personal WRMSD concerns at the two to five year scan period, whereby these data were also gathered for further understanding of findings within the scope of this research. Upon determining that graduates had varying attitudes regarding MSI risk susceptibility at such time, the researcher coded related responses. The variable of responsiveness was first compared to whether the graduate had or had not reported an injury, and then compared to the retained subjects' learning group designations.

Research Questions and Hypotheses

The central research question directing this study was: What differences in learner attitudes and behaviors can be determined within the ergonomics work habitus frame of reference when comparing transmissional, transactional, and transformational learning events for the early career scanning sonographer?

The corresponding primary research hypothesis (H_a) was: Transformative ergonomics learning for the early career sonographer can demonstrate a significant difference in long-term behaviors associated with reported musculoskeletal disorders (MSDs) through adoption of positively reinforced reflection and collaborative practice within the work habitus frame of reference, compared to transmissional and transactional learning practices.

The primary null hypothesis (H_0) was: A comparative analysis of instructional techniques toward long-term positive ergonomics transformation for the early career sonographer will reveal

no significant difference in long-term behaviors associated with reported MSDs among transmissional, transactional, or transformational learning practices.

Though different variables were addressed among the various research questions, with Appendix K providing a comprehensive listing of these variables by type, level, scale of measurement, and statistical tests conducted, the primary independent variables were based upon whether the learner engaged in the transmissional (first order thinking), transactional (meta-cognitive process during interaction), or transformational (beliefs transitioning to actions) learning technique (Holistic Education Network, 2011).

A number of additional research questions, many with corresponding hypotheses (Appendix J), were considered within the scope of this particular study to incorporate several elements of consideration toward answering the central research question. Due to the large number of additional questions and hypotheses used to resolve the posed research problem, each procedural question will form the upcoming headings of this chapter, with any associated hypotheses, methodology, and procedures for data analyses serving as sub-headings within each of those sections. It may be of interest to the reader that the sixth procedural question was added during the final data collection stage, upon discovery of an essential unanticipated finding that the researcher believed should be measured.

Research Question 1

How closely did sonographers' pre-instructional scan complaints and risk behaviors correspond with final musculoskeletal complaints and risk behaviors of prior published professional injury rates?

The data collected in this study allowed for gathering of descriptive statistics toward comparison of results; however, this question could not be adequately tested through a null hypothesis.

Cross Tabulations

Descriptions were categorized and addressed by:

- 1) pain concern areas of the early general sonographer sub-group based upon proportions of incidences reported;
- 2) pain concern areas of the early cardiac sonographer sub-group based upon proportions of incidences reported;
- 3) proportions of negative scan behavior categorical observations made in the early general sonography sub-group;
- 4) proportions of negative scan behavior categorical observations made in the early cardiac sonography sub-group;
- 5) pain concern areas of all retained subjects at two to five years of scan experience based upon proportions of incidences reported;
- 6) proportions of negative scan behavior categorical observations made during the final observation at two to five years of scan experience among the study's retained graduate sonographers; and
- 7) comparisons between those early reports and observations to reports and observations made at the two to five year final observation period among the study's retained graduates.

These tests made available proportions through which comparisons could be made among and between established sub-groups. Results of these reports and observations were discussed both in relation to one another and in relation to published categorical career sonographer injury rates.

Methodology for Comparisons

The researcher collected reported areas of pain and discomfort from the subjects during both the early career sonographer scan period and later at the final post-graduate observation stage, while also collecting frequencies of observed negative scan behavior incidences at the early career period for Groups B and C and among all retained subjects at the final observation stage.

Data were collected on reported and observed incidences for the early general and cardiac sub-groups, as well as for the retained graduate sonographers. Comparisons were made both between and within these sub-groups, meaning that the proportions of reported pain in specific body areas were first compared to proportions of observed negative scan behaviors in those same areas for both the early general sonographers and the early cardiac sonographers. Additionally, the researcher made proportional comparisons between both reported and observed incidences between early general and cardiac sonographers, to assess for any differences. Lastly, such comparisons could be made among the 40 retained subjects at the time of final observation, in which reported work-related musculoskeletal disorder (WRMSD) categorical proportions were compared to longer-term observed behavioral proportions. Finally, a graphic display was developed for visual comparison of each retained subject's early and late categorical reports compared to early and late categorical negative risk behaviors. In all instances, the researcher

also interjected literature-cited sonographer injury proportions for comparison. More specific methodology will be further discussed specific to the instrument(s) used to collect the associated data.

Variables for Research Question 1

Subjects' early and final reported pain locations (divided into the categorical areas of neck, back, shoulder, and wrist) and early and final observed negative risk behaviors (classified by these same categorical locations) comprised the variables that were analyzed for association with one another in this segment of the study. Reported discomfort areas that subjects related to scanning during the early learning period were compared to categorically observed risk behaviors logged by the expert observer in the early career stage. Reported WRMSD concerns reported by subjects at the final observation stage were also categorically compared to both earlier reported discomfort locations and expertly observed categories of risk behaviors in both the early learning stage and the later post-graduate stage to determine any apparent association.

In regards to the variables of reported pain or discomfort locations in the pre-instructional stage, self-reporting posed a study limitation with the possibility of subjects either over-reporting soreness, where muscle memory of a new activity had not yet been established; or subjects under-reporting discomfort based upon learner denial of health related concerns, as addressed in the review of the health belief model. In regards to WRMSD reports during the final observation stage, subjects' complaints were, again, self-registered without evidence of medical reports of injury. In some rare cases (e.g., navicular cysts, shoulder injury), medically documented evidence did exist. The researcher sought to confirm with all other reporting subjects that any

registered complaint had a perceived association with scan activities and/or was further aggravated by conditions within the sonographer's work environment, rather than any resultant likelihood from extraneous factors or activities (e.g., a non-work related injury). No pain levels were established, nor did the researcher have any means of establishing one subject's pain tolerance level as different from another's.

The independent variables of observed negative risk behavior categories were assessed using frequencies logged in each subject's observation guide, as will be further described within the dual methodology in the upcoming Instrumentation for Data Collection of Observed Negative Risk Behaviors section. Briefly, depending upon the use of the variables, these frequencies were recorded as either present or absent for the purposes of proportional incidences within the frequency charts; or were recorded as categorical proportionalities in a comprehensive comparison of reported and observed findings, based upon the number of incidences observed within each category versus that particular category's potential total. Each of these methods has been described in greater detail in the following sub-headings of this chapter and will also be described within each related segment of Chapter IV, as well as in Appendix L, for the benefit of reader methodological comprehension. The most probable relationships of the variables associated with categorical pain reports and behavioral observations have been visually delineated in Figure K.1 within Appendix K.

Instrumentation for Data Collection of Reported Pain or WRMSD

The primary instrument for recording early reported pain or discomfort areas by learners from Groups B and C was through self-reporting during the pre-instructional interview

(Appendix E), in which the first question inquired if the subject was experiencing any areas of pain or discomfort associated with scanning and, if so, was asked to identify the location(s). No further data were procured from this instrument for the purpose of responding to this research question. The primary instrument for recording later WRMSD complaints among the retained subjects of Groups A, B and C at two to five years of scan experience was by notation of the expert observer on the final observation form, according to self-reporting by the subject in an informal interview process. The researcher did seek clarification, at the time of such WRMSD declaration, that the subject perceived the injury to either be directly related to scan duties or further aggravated by work related activities. In each instance, reports were taken by the researcher according to categorized body areas and noted as either present or absent within each.

Instrumentation for Data Collection of Observed Negative Risk Behaviors

The primary instrument for recording frequencies of observed ergonomic scan behaviors was the observation guide (Appendix F), used in both the pre-instructional and post-instructional observation periods for Groups B and C; and during the final expert observation stage for all retained graduate subjects. The observation tool was developed to record frequencies of associated risk factor behaviors according to negative direction of susceptibility in movement (DSM) in specified categories (e.g., shoulder, back, neck, wrist, elbow, etc.), or according to positive protective maneuvers designed to reduce ergonomic risk factors (e.g., resting the forearm, adjusting the monitor, taking microbreaks, etc.). For the purposes of Research Question 1, only negative DSM categorical observations were recorded, as will be more thoroughly described in the upcoming paragraphs.

Methodology 1: Observed behavioral concerns versus proportions in literature. For the purposes of this particular section of the study, in calculating the most commonly observed negative behavioral frequencies and comparing these behaviors to injury areas cited in the literature, the use of data collected from the observation instrument (Appendix F) was greatly simplified. A negative behavior was logged as taking place within a DSM category only when repeated more than once and when sustained each time for a period designated in the guide (e.g., 15 seconds or longer). Based on these criteria, the behavior was recorded as either present or absent.

Methodology 2: Reported versus observed concerns comparison between early learners and graduates. The observation guide (Appendix F) listed five (5) protocol tasks for the sonographer to complete on a laboratory scan volunteer, whereby each ergonomic movement could be assessed by the expert observer during that task period. To standardize the observation results for quantitative analysis, the researcher set a five-task time limit, with a mentor assigned in the early stages to work with the entry level sonographer on this set of 5 given scan tasks that were estimated to take approximately one minute each to accomplish. The researcher became an inconspicuous non-participant observer, making behavioral assessments based upon the observation guide while each learner scanned. The observation form was designed so that the participant received no greater than one mark in each task category for any event being observed within that one minute period of time, with a maximum of 5 potential marks within each risk category (due to the five assigned tasks within the five minute period). Standardization was achieved through setting potential minimum and maximum frequencies per category, with each

participant unable to receive more than 5 negative behavioral marks during the 5 tasks (or 5 minutes) within a DSM categorical description.

One anatomical area of concern, however, might contain a greater number of incidences than another, depending upon the number of concerns or descriptions that existed for that categorical area. For instance, hyperabduction of the shoulder could only occur in either the scan shoulder that was extended toward the patient (for a maximum of 5 times in a 5-minute period) or the non-scanning shoulder that was extended toward the ultrasound unit (for a maximum of 5 times in a 5-minute period). The maximum number of shoulder incidences, then, could have only equaled 10; whereas the wrist was assessed for three DSM activities - hyperflexion, dorsiflexion, or lateral flexion – within those same 5 minutes, creating the potential for 15 recorded negative wrist actions. To standardize interpretation, the researcher calculated proportions for citing observed incidences of these categorical behaviors. Table 3.3 provides a condensed example to assist the reader in understanding the behavioral frequency logging toward proportional interpretation technique, formulated for comparison of variables in Chapter IV's final comprehensive table for Research Question 1, in which the reader may visualize each subjects' early versus post-graduate reports and observations (Appendix L, Table L.2).

Table 3.3 Abbreviated Record of Observed Scan Risk Behaviors

Categorical DSM	Task 1	Task 2	Task 3	Task 4	Task 5
Scan Shoulder	X		X	X	
Non-Scan Shoulder		X		X	X
Wrist Hyperflexion			X		
Wrist Dorsiflexion	X				
Wrist Lateral Flexion					

In the example of Table 3.3, the subject demonstrated six DSM behaviors among the two descriptions for both shoulders during the five tasks, or $P = .60$ (representing 6 reports among 10 potential task behaviors, or 60.0%). In the case of wrist behaviors, the subject only demonstrated $P = .13$ (representing two DSMs of 15 potential task behaviors, or 13.0%). Even though the probabilities were not numerically displayed in the final graphic representation, these probability values were important for visually recording the most highly observed incidences that compared early reports and observations to later ones. Symbols were used in the place of numbers, based upon threshold levels that are further delineated with the corresponding table's legend (Legend Explanation for Table L.2) in Appendix L.

Additional Observation Considerations Concerning Instrumentation

Because the nature of ergonomic risks involves prolonged and repetitive behaviors beyond those which may have been expected, both anticipated and unanticipated findings of

sonographers' scan positions were recorded on the observation guide. Anticipated observational categories in which subjects could have received negative behavioral findings included:

- 1) maintenance of optimal body positioning (OBP), whereby criteria varied according to whether subjects were in the standing or sitting scan position;
- 2) neck – cervical spine hyperflexion, hyperextension, rotation, or lateral extension;
- 3) shoulder – scan and non-scan hyperabduction;
- 4) back – lateral flexion and spinal torsion;
- 5) scan wrist – joint hyperflexion, joint dorsiflexion, lateral flexion; and
- 6) elbow – pronated hyperextension, supinated hyperextension.

Anticipated observational categories in which subjects could receive positive behavioral frequency findings included:

- 1) making appropriate height adjustments to the scan table and/or monitor;
- 2) resting one's forearm on the scan table, arm rest, or patient;
- 3) taking microbreaks; and
- 4) requesting patient movement to assist in preventing sonographer's directional susceptibility of movement (DSM).

Furthermore, a consent form (Appendix B) was signed by learners who were recorded through video or still image format in the scan laboratory for instructional observation sessions, as well as for any subject engaged in the final observation stage within the work setting, at which time images and videos were not used in order to assure HIPAA (2009) compliance regarding patient privacy measures within the authentic work setting. In the simulated laboratory learning environment, the combination of the video with the observational tool served not only as a benefit for the expert observer's reliability in review, but also for the benefit of the transactional

subjects (Group B) in visualizing observational feedback; and for the transformational subjects (Group C) to compare expert observational feedback to self-assessments and peer assessments, while also becoming more familiar with the ergonomics observational instrument to be used by those same learners during future scan laboratories.

Statistical Data Analysis for Research Question 1

The data collected in this study allowed for gathering descriptive statistics toward comparison of results, categorized by:

- 1) early reported concerns of both general and cardiac sub-groups;
- 2) early observations made in both the general and cardiac sub-groups; and
- 3) comparisons between those early reports and observations to reports and observations made at the two to five year final observation period.

First, actual frequencies of early career general and cardiac sonographers' most highly reported pain or discomfort locations related to MSI risk factors after the first several weeks of scanning were logged, with proportions recorded among both sonography sub-groups. Additional comparison was made to assess whether early career general and cardiac subjects exhibited similar proportions of reported pain locations.

Risk behavior incidences were then logged for both the general and cardiac sub-groups, with proportions again identifying the most commonly recognized negative behaviors within each of these. Moreover, the subjects' reported proportions of discomfort areas were compared to the observed proportions of negative scan risk behaviors within each group. Additionally, comparison was made to assess the differences in observations between the two sub-groups.

Reported WRMSD complaints and observations of negative scan risk behaviors were later recorded in retained graduate subjects at the two to five year period, comparing proportions of reports and behaviors to published categorical career sonographer injury rates. Essentially, all reports and observations from the early career stages were discussed in relation to one another and in relation to published categorical career sonographer injury rates.

Lastly, the researcher sought to more comprehensively consider the observations of post-graduate work habitus ergonomic behavioral concerns compared to behavioral concerns at the onset of the learning experience, as well as reported concerns during both the early career period and at the time of the final observation. To best convey such comparisons to the reader, all early and late pain reports and all categorical observations from both early and post-graduate stages were visually displayed in table format with descriptive proportions provided on key research elements that the researcher considered most pertinent to the study's intent.

Qualitative Analysis for Research Question 1

The qualitative analysis associated with Research Question 1 included observational assessment of scan behaviors noted by the researcher as either common or unanticipated findings beyond those or in association with those that were already categorically identified and described in the observation instrument. Detailed findings have been addressed in Chapter V.

Research Question 2

Did having transmissional knowledge of other sonographers' injuries and statistical injury risk rates influence early career sonographers' beliefs of personal susceptibility to injury?

Research and Null Hypotheses 2a

H_a: Transmissional knowledge relayed to the early career sonographer regarding other sonographers' incidences of work-related musculoskeletal disorders (WRMSDs) demonstrated an increased belief in one's own personal musculoskeletal injury (MSI) risk susceptibility.

H_o: Transmissional knowledge regarding other sonographers' incidences of work-related musculoskeletal disorders (WRMSDs) demonstrated no relationship to belief patterns held by early career sonographers regarding personal risk perception of musculoskeletal injuries (MSIs).

Testing Methodology at the Transmissional Stage - Hypothesis 2a

A transmissional mechanism occurred in the beginning stages of the transactional ergonomics instruction for Groups B and C that could be tested. The interview instrument in Appendix E was designed to transmit some additional or reinforced learning information to the study's subjects while gauging early career beliefs, or even to allow the learners to transmit knowledge of any known sonographer injuries back to the interviewer. Hypothesis 2a was quantitatively assessed through the coding of narrative responses to questions 3 and 5 of this interview, to test the likelihood of success in what the literature review revealed as the most common instructional ergonomics practice - that of transmitting information to increase

awareness of risk (Evans et al., 2009; Pratt, 2002). Under the instructional premise of transmissional knowledge being deemed as a successful learning technique, then being made aware of others' injuries should have reasonably resulted in an increased belief of the learner's own personal risk factor.

Variables for Hypothesis 2a

There was one independent and one dependent variable identified for testing this sub-hypothesis. The independent variable was derived from the pre-instructional interview question 3 (Appendix E), which sought to identify the learner's personal knowledge (awareness) of sonographer injury(ies), with three potential coded categories of response related to the stated level of awareness:

- (0) = unaware of sonographer MSIs;
- (1) = aware of at least 1 sonographer's MSI;
- (2) = aware of 2 or more sonographers' MSIs.

The dependent variable related to pre-instructional interview question 5 (Appendix E), which sought to identify the learner's personally perceived MSI risk factor following the transmission of personal sonographer injuries, with three potential coded categories of response:

- (0) = learner did not express belief of presently being at personal risk;
- (1) = learner was uncertain if presently at personal risk;
- (2) = learner expressed belief of presently being at personal risk.

Instrumentation for Data Collection – Hypothesis 2a

The interview guide (Appendix E) was developed to pre-instructionally assess each learner's understanding of and attitude regarding MSI risk factors in the sonography profession. The interview was conducted with participants after the initial expert observation, but prior to formal instruction on ergonomics and risk factors. Information that the researcher targeted during this portion of the interview was related to the participants' awareness of any personally developing habits or associated consequences relative to lack of optimal body positioning (OBP) as a potential risk factor to MSIs. Interview questions were also posed to gauge each participant's attitude of personal significance to other sonographers' injuries in comparison to one's own potential risk factor for MSIs. The researcher began each interview by emphasizing that there were no correct or incorrect (right or wrong) responses to these questions; the researcher was simply in search of the participant's candid opinion, according to one's own understanding and experience. Qualitative coding was performed on the specific questions, based upon interview responses, to allow for quantitative data analysis. Qualitative themes were otherwise searched out.

Statistical Data Analysis for Hypothesis 2a

The comparison of categorical awareness and learner beliefs, both nominal classifications, lent themselves best to chi-square testing. A cross-tabulation with descriptive proportions was made between Interview Question 3, personally being aware of sonographers with WRMSDs, and Interview Question 5, the participants' belief of personal susceptibility for MSI development.

Qualitative Analysis for Hypothesis 2a

Beyond coding qualitative responses for quantitative analysis, the researcher reviewed all narrative responses from the pre-instructional interview to assess for prominent, recurrent themes. As well, key remarks that provided further understanding of learners' beliefs at the pre-instructional transactional stage of learning have been presented with Chapter V in relation to the study's intent.

Research and Null Hypotheses 2b

H_a: Transmissional knowledge relayed to the early career sonographer regarding other sonographers' published rates of work-related musculoskeletal disorders (WRMSDs) demonstrated an increased belief in one's own personal musculoskeletal (MSI) risk susceptibility.

H_o: Transmissional knowledge regarding other sonographers' published rates of work-related musculoskeletal disorders (WRMSDs) demonstrated no relationship to belief patterns held by early career sonographers regarding personal risk perception of musculoskeletal injuries (MSIs).

Testing Methodology at the Transmissional Stage – Hypothesis 2b

Similar to the methodology of Hypothesis 2a, Hypothesis 2b also derived data from the pre-instructional transactional interview, in which qualitative responses were coded so that statistical analysis could be performed between pre-instructional Interview Questions 7 and 8.

This portion of the interview was also designed for transmissional purposes, to assure all subjects in Groups B and C were informed of the approximated WRMSD rate among the sonography population. The interview gauged learner responses to this information once all subjects had been informed of the rate. Responses by the subjects after receiving (or confirming) this transmissional information were compared to any change in subjects' own personal beliefs of susceptibility to MSIs.

Variables for Hypothesis 2b

The independent variable for this sub-hypothesis was derived from Interview Question 7 of the interview instrument (Appendix E), which sought to identify the learner's awareness of the published professional rate of sonographer MSIs, with three potential coded categories of response related to the level of awareness:

- (0) = unaware of published rate (did not attempt a guess, or made an uninformed estimate below 50%);
- (1) = attempted an uninformed estimate above 50%, but was incorrect;
- (2) = knew the published rate of MSIs (within a response range between 80.0 and 90.0%).

The dependent variable related to Interview Question 8, which provided the learner with an opportunity toward reconsideration of personal injury susceptibility after receiving, or confirming, the sonography population's approximated proportion of MSI incidence, with two potential coded categories of dependent variable response:

- (0) = learner did not cite any change in perception of MSI susceptibility;

(1) = learner cited an increased risk belief based on knowledge of the population statistic.

Statistical Data Analysis for Hypothesis 2b

As with Hypothesis 2a, the categorical learner perception of Hypothesis 2b, combined with the identified categorical independent variable, best lent themselves to chi-square testing. A cross-tabulation with descriptive proportions was made between Interview Question 7, awareness of the published WRMSD rate among sonographers, and Interview Question 8, the participants' reconsideration of personal susceptibility belief for MSI development.

Qualitative Analysis for Hypothesis 2b

Beyond coding qualitative responses for quantitative analysis, the researcher reviewed all narrative responses from the pre-instructional interview to assess for prominent, recurrent themes. Learners' quotes and belief patterns have been presented with Chapter V in relation to the study's intent.

Research Question 3

Could differences in MSI perceptions and risk behavioral changes be detected at the transactional post-instructional stage based upon the learners' participation in the photoplethysmographic (PPG) diminished blood flow quasi-experiment?

Research and Null Hypotheses 3a

H_a: The photoplethysmographic (PPG) flow study participants' mean self-susceptibility rating for MSI risks was greater than for those who did not participate in the quasi-experimental study.

H₀: The photoplethysmographic (PPG) flow study participants' mean self-susceptibility rating for MSI risks was the same as for those who did not participate in the quasi-experimental blood flow study.

Testing Methodology at the Transactional Stage – Hypothesis 3a

Of the 26 subjects originating from the transactional learners (Group B) and the transformational learners (Group C), 11 were engaged in a quasi-experimental PPG study at the transactional learning stage, in which those participants viewed personal blood flow recordings in each subjects' own fingertips while using both neutral and negative scan maneuvers to assess for diminished flow. The remaining 15 subjects served as the control group.

The quasi-experimental study was performed to assess whether any predictive value could be placed upon learners' attitudes within a personal transactional experience in which one's own blood flow was diminished based upon challenging scan technique and poor scan positioning. Participants of both the experimental and control sub-groups of Groups B and C were each asked to provide a numerical designation of one's personally perceived MSI risk factor following the transactional learning stage, which not only included the PPG experiment with the limited subjects, but feedback from the initial expert observation provided to all learners within Groups B and C.

Variables for Hypothesis 3a

The independent variable was whether or not the learner was engaged in the quasi-experimental PPG study, in which participants viewed personal blood flow recordings in the subjects' own fingertips while using both neutral and negative scan maneuvers to assess for diminished flow. There were two potential coded categories:

(0) = control group (a subject who did not participate in the PPG study);

(1) = quasi-experimental PPG group participant.

The dependent variable included the learner's personal perception of MSI risk rating on a Likert scale of 1-10, with 1 designating the least perceived risk and 10 designating the greatest perceived risk.

Instrumentation for Data Collection – Hypothesis 3a

Experimental subjects participating in the PPG flow study were provided with the handout located in Appendix G, explaining the concept of thoracic outlet syndrome (TOS) in regards to positioning, blood flow determinations, and possible long-term nerve or muscle damage. These subjects then assessed individually charted blood flow under the instructor's supervision, comparing the established baseline flow with any flow changes recorded during the two scan maneuvers.

Baseline neutral blood flow volume, as determined through the use of photoplethysmography on the scanning index finger, was first established and charted. Scan Maneuver 1 was described as the participant in a standing position with the scan shoulder in a somewhat neutral position of less than 20 degrees, while compressing a tissue phantom at an

oblique angle (similar to either a subcostal hepatic hilar approach for the general sonographer or a subcostal cardiac approach for the echocardiographer). A 2 cm depth was marked on the phantom as the compression goal, while the participant was timed for 15 to 20 seconds of compression, to simulate similar pressure and time applied when scanning an obese or difficult patient. Scan Maneuver 2 was described as the participant in a sitting position with the scan shoulder hyperabducted to approximately 80 degrees, while performing the same amount of compression over the same period of time as described for the prior maneuver. Blood flow changes were calculated through percentage comparisons made according to the original baseline value.

Following the PPG study and observation of the expert feedback from the primary observation, participants were asked to use the 1-10 Likert scale in Figure 3.1, in which 1 designated the least likely perception of personal MSI susceptibility and 10 designated the greatest perception of personal MSI susceptibility.

Statistical Data Analysis for Hypothesis 3a

Descriptive quantitative data were included for the learners' assessments during the PPG blood flow quasi-experiment that demonstrated differences in flow experienced between participants' baseline volumes versus the flow reductions recognized as a result of either challenging or risk-associated ergonomic techniques. The initial recording for the PPG study determined a baseline neutral blood flow volume, with Scan Maneuver 1 designed to place the participant in a neutral scan position with tissue phantom compression, and Scan Maneuver 2 designed to create directional susceptibility of movement (DSM) with compression. Quantitative

blood flow value comparisons were made for review with the participating early scan sonographers. Blood flow changes were calculated through percentage comparisons according to the original baseline value.

The hypothesis was then tested using the defined variables of MSI ratings provided by both the PPG and control group participants following this experiment. Due to the nominal nature of the independent variable combined with the interval nature of the dependent variable, the hypothesis was analyzed through a *t* test for mean difference of MSI susceptibility perceptions between the control and PPG quasi-experimental participants from the sub-groups of Groups B and C.

Qualitative Analysis for Hypothesis 3a

Four additional interview questions were asked of the PPG participants (Appendix H) in an attempt to discern any narrative response themes to signify reasoning of beliefs, as well as to offer the learner additional opportunity to reflect upon the results of the study. Qualitative narrative themes have been provided with Chapter V to add meaning to the quantitative analysis of this study.

Research and Null Hypotheses 3b

H_a: The photoplethysmographic (PPG) flow study participants' personal prevention plan (PPP) mean score was greater than the PPP mean score of those who did not participate in the quasi-experimental study.

H₀: No significant difference existed between the personal prevention plan (PPP) mean score of the photoplethysmographic (PPG) flow study participants and the PPP mean score of those who did not participate in the PPG study.

Testing Methodology at the Transactional Stage – Hypothesis 3b

As first explained in the learning progression tier discussion, all learning groups developed a personal prevention plan (PPP) at the conclusion of the first semester, regardless of the learning in which the learners were engaged. Learners were provided with the same grading rubric (Appendix D) to complete this task. Though the PPP scores were also used to test one additional hypothesis (4b) among all learning groups, Hypothesis 3b continued with the theme of comparing the experimental and control groups from the those learners within Groups B and C associated with the PPG flow study at the transactional stage.

Variables for Hypothesis 3b

The independent variable was again whether or not the learner was engaged in the quasi-experimental PPG study, in which participants viewed personal blood flow recordings in the subjects' own fingertips while using both neutral and negative scan maneuvers to assess for diminished flow. There were two potential coded categories:

(0) = control group (a subject who did not participate in the PPG study);

(1) = quasi-experimental PPG group participant.

The dependent variable consisted of the rubric guided, instructor graded PPP scores, with interval raw scores ranging from 0 to 100.

Instrumentation for Data Collection – Hypothesis 3b

Beyond the PPG data collection method which has already been described, the PPP scores were the main data components for this hypothesis. Grades were assigned on the learners' prevention plans based upon detailed guidelines provided, in advance, within the rubric of Appendix D. Learners were instructed, within the ergonomics module, to provide headings according to those listed in the rubric. Categories for personal reflection of ergonomic factors included:

- diet and nutrition,
- personal fitness,
- relaxation techniques,
- workloads and breaks,
- work environment evaluation (taken from the work inventory checklist within the ergonomics module),
- scan habits evaluation (taken from the self and peer assessment checklist within the ergonomics module),
- monitoring and reporting of MSI-related work concerns,
- report writing skills, and
- comprehension of ergonomics concepts.

Each categorical section was worth a maximum of 10 points, with scores ranging from 0 to 100 percent. The grade of 70.0 was designated as the assignment's pass threshold, though failing this assignment would not prevent a learner from progressing within the course.

Statistical Data Analysis for Hypothesis 3b

Due to the nominal nature of the independent variable and the interval nature of the PPP scores, the hypothesis was analyzed through a *t* test for a difference of mean PPP scores between the control and PPG quasi-experimental participants from the sub-groups of Groups B and C.

Qualitative Analysis for Hypothesis 3b

No qualitative analysis was conducted based upon the PPP scores. However, the researcher culled prevention plans from all learning groups (A, B and C) to search for learner responses that might provide additional insight to belief patterns related to scan attitudes and behaviors. Dominant narrative themes were discovered, particularly related to certain beliefs of the designated groups. These have been addressed with Chapter V, along with specific reflective quotes (Appendix M) to assist the reader in identifying the researcher's categorization of the prominent themes that were identified.

Research and Null Hypotheses 3c

H_a: The PPG flow study participants exhibited greater reductions in the frequencies of observed ergonomic risk behaviors from the pre-instruction observation stage to the post-instruction transactional observation stage than those who did not participate in the quasi-experimental study.

H₀: The PPG flow study participants exhibited the same frequencies of observed ergonomic risk behaviors from the pre-instruction to the post-instruction transactional observation stage, as compared to those who did not participate in the quasi-experimental blood flow study.

Testing Methodology at the Transactional Stage – Hypothesis 3c

An additional comparison was made between the 11 experimental subjects and the 15 control subjects of Groups B and C who had engaged in the transactional learning stage, which included the PPG experiment for some and the expert observation with feedback for all involved. This comparison was specifically for the reduction in negative scan behaviors from the initial expert observation during the pre-instructional period to the expert observation that took place at the end of the transactional stage, which was also the end of the first program semester. This test did not yet take into consideration any comparison with the transmissional learners of Group A, who were not involved in early instructional observation.

Variables for Hypothesis 3c

Once more, the independent variable was whether or not the learner was engaged in the quasi-experimental PPG study, in which participants viewed personal blood flow recordings in each subjects' own fingertips while using both neutral and negative scan maneuvers to assess for diminished flow. There were two potential coded categories:

(0) = control group (a subject who did not participate in the PPG study);

(1) = quasi-experimental PPG group participant.

The final dependent variable in this quasi-experimental set calculated differences among ergonomic risk behaviors, using frequencies from the pre-instructional to the post-transactional observation events.

Instrumentation for Data Collection – Hypothesis 3c

The PPG flow study handout (Appendix G), the interview questions designed for PPG participants (Appendix H), and the previously described PPG blood flow volume recording strips were all instruments used in this data collection, as was the observation guide (Appendix F) in tallying frequencies during the two observational stages. Data collection methods through these instruments have all been described, in detail, in prior instrumentation sections.

Statistical Data Analysis for Hypothesis 3c

The combination of the nominal independent variable with a frequency-based ratio dependent variable gave way to the use of an independent-samples *t* test to analyze the data.

Qualitative Analysis for Hypothesis 3c

Four additional interview questions (Appendix H) were asked of the PPG participants in an attempt to discern any strong narrative theme responses to signify reasoning of beliefs, as well as to offer the learner additional opportunity to reflect upon the results of the study. Qualitative narratives have been provided with Chapter V to add meaning to the quantitative analysis of this study.

Research Question 4

Did observed scan behavior incidences demonstrate an impact toward positive work habitus among study subjects, particularly those within the transformational group, due to ergonomics instructional intervention?

Though not to be assessed apart from all other findings when study conclusions were made, this research question most directly addressed the central research question of what differences in learner attitudes and behaviors could be determined within the ergonomics work habitus frame of reference when comparing transmissional, transactional, and transformational learning events for the early career sonographer.

Hypotheses 4a

As already determined in Hypothesis 3c, scan behaviors toward a positive work habitus not only included the potential for a reduction in negative risk behaviors, but also an increase in positive scan behaviors. The sub-hypotheses of 4a were tested on both merits, assessing

frequencies over a longer term for differences in habitual actions among the various learning groups in each regard. In expanding to this broader range of testing among the three main instructional groups, Hypothesis 4a-i first assessed for frequency differences in negative scan behaviors among the retained subjects of the three learning groups at the two to five year career period; then Hypothesis 4a-ii tested for differences in the frequencies of positive scan behaviors among these learning groups (A, B and C), also during the same final observation stage.

Research and Null Hypotheses 4a-i

H_a: The observed behavioral risk incidences recorded at the final observation event (post-graduation) were significantly reduced for negative scan behaviors in the transformational learning group (Group C) as compared to the other learning groups (Groups A and B).

H_o: The observed negative behavioral risk incidences recorded at the final observation event (post-graduation) were the same for the transformational learning group (Group C) as compared to the other learning groups (Groups A and B).

Research and Null Hypotheses 4a-ii

H_a: The observed behavioral incidences recorded at the final observation event (post-graduation) were significantly increased for positive scan behaviors in the transformational learning group (Group C) as compared to the other learning groups (Groups A and B).

H₀: The observed positive behavioral incidences recorded at the final observation event (post-graduation) were the same for the transformational learning group (Group C) as compared to the other learning groups (Groups A and B).

Testing Methodology at the Transformational Stage – Hypotheses 4a

These two sub-hypotheses were the most directly connected to the primary research question, with focus on the independent variable of learning engagement – whether of the transmissional (Group A), transactional (Group B), or transformational (Group C) type. The primary research hypothesis (H_a) stated that transformative ergonomics learning could demonstrate a significant difference in the long-term behaviors associated with reported musculoskeletal disorders (MSDs) through adoption of positively reinforced reflection and collaborative practice within the work habitus frame of reference compared to transmissional and transactional learning practices. Hypothesis 4a directly compared the final outcomes of overall scan behaviors, both positive and negative, among the three identified learning groups through expert observation at the two to five year post-graduate period. A research assumption was made that any detected behaviors would be more habitual in nature by the time these subjects were assessed following multiple years of career scan experience.

Variables for Hypotheses 4a

As already noted, the independent variable was listed as the type of learning engagement in which the learner was categorized. The potential instructional categorical responses, as

designated in Table 3.1 and coded for data input, were:

(0) = transmissional,

(1) = transactional, or

(2) = transformational.

The dependent variable was measured in ergonomic behavioral frequencies, separately for positive and negative behaviors, during the final (two to five year post-graduation) observation stage.

Instrumentation for Data Collection – Hypotheses 4a

Frequency tabulations from the observation guide (Appendix F) comprised a large portion of the quantitative data collected and analyzed in this study, not only with formative observational frequencies when identifying ergonomic scan behaviors categorically, but with comparisons between experimental groups (such as those in Hypothesis 3c from the pre-instructional to post-instructional reviews to assess for differences in behaviors among sub-study participants within Groups B and C). For the sub-hypotheses of 4a, however, the frequencies being tested were of the total negative and total positive scan behaviors that were logged during the final observation stage, with comparisons of the sums made among all of the learning groups. In this manner, the researcher could determine if any significant differences existed among the groups that had carried over into longer term behaviors associated with greater longevity within the work habitus.

Statistical Data Analysis for Hypotheses 4a

Because three classifications of a nominal independent variable were being compared based upon the dependent variable of a frequency ratio, a one-way analysis of variance (ANOVA) was initially conducted to evaluate the relationship between the frequencies of negative scan behaviors according to classification of learning types. A second ANOVA was then conducted to evaluate the relationship between the frequencies of positive scan behaviors based upon the classification of learning types. Post hoc tests were also conducted to evaluate pairwise differences among the means.

Qualitative Analysis for Hypotheses 4a

The qualitative analysis associated with Research Question 4 included observational assessment of scan behaviors noted by the researcher as unanticipated findings beyond those or in association with those that were already categorically identified and described in the observation instrument. Such findings have been addressed in Chapter V.

Research and Null Hypotheses 4b

H_a: The Personal Prevention Plan (PPP) scores were greater for the transformational learning group (Group C) as compared to the other study groups (A and B).

H₀: The PPP scores demonstrated no difference between the transformational learning group (Group C) and the other study groups (Groups A and B).

Testing Methodology at the Transformational Stage – Hypothesis 4b

According to the value expectancy theory, beliefs and behaviors are associated with one another (Becker, 1974). Beyond appreciable behavioral differences, the researcher wanted to determine if attitudinal variances were also significant among the learning groups, based upon scores on the reflective writing assignment that asked each participant to reflect upon one's personal plan toward ergonomics risk prevention (the PPP). Group A had only received transmissional knowledge concerning ergonomics injury at the time of this project; Group B had received the transmissional knowledge and had interacted in the interview process and by receiving observational feedback (as well as a sub-group engaging in the quasi-experimental PPG study). Group C had completed all of the components of Groups A and B, in addition to each participant viewing one's own observation video with at least one peer, using the observation tool to evaluate one's own behavior as well as a peer's behavior and comparing these learners' findings to those of the expert observer.

Variables for Hypothesis 4b

Once more, the independent variable included all of the learning groups, coded for data input as:

- (0) = transmissional,
- (1) = transactional, or
- (2) = transformational.

The dependent variable for sub-hypothesis 4b consisted of original raw PPP scores compared among the three instructional groups, with interval scores ranging from 0 to 100 percent.

Instrumentation for Data Collection – Hypothesis 4b

Again, the rubric for the personal prevention plan (PPP) was the tool used by the subjects to complete the assignment from which the score was derived. As a reminder, the PPP was the final product of the ergonomics learning module, due at the end of the first semester for all study participants (Groups A, B and C). Whereas Group A had only received transmissional learning information at such time, both Groups B and C had also undergone the transactional learning stage, with each Group C learner additionally reflecting upon one's own video and that of a peer engaged in the initial observation stage. The same grading rubric, located in Appendix D, was used for all learning groups, directing participants on all components that should be reflectively addressed, so that each student might have an opportunity to demonstrate an awareness of personal behavior patterns related to one's expressed personal risk habits and beliefs.

Statistical Data Analysis for Hypothesis 4b

Due to the nominal independent variable containing the three learning classifications, in conjunction with interval data in the dependent variable, an ANOVA was conducted to evaluate significance in the relationship between the personal prevention plan (PPP) scores and the classification of learning types addressed in this study.

Qualitative Analysis for Hypothesis 4b

No qualitative analysis was conducted based upon the PPP scores. However, the researcher culled prevention plans looking for learner responses that might provide additional insight related to belief patterns and scan behaviors. Dominant narrative themes were discovered, predominantly related to particular groups' beliefs, as have been addressed with Chapter V.

Research Question 5

How were student attitudes impacted by the interactions and reflections of the formative self and peer assessment process during the transformational learning stage?

Research Question 5a

Did learner self-reflections and collaborative peer reflections demonstrate a positive impact on learner attitudes concerning longer-term transformative assessment benefit?

A portion of Research Question 5 could not be statistically tested through a null hypothesis; however, descriptive statistics were published for consideration of learner perceived value. For consistency's sake, the researcher has designated this segment as Research Question 5a. Testing of Research Question 5 was conducted using Null Hypothesis 5b.

Testing Methodology at the Transformational Stage – Research Question 5a

This methodology was incorporated within the instructional progression of the research design, as depicted in Table 3.2, using the ASSURE model of Appendix C for the transformational learning group. Research question 5a was evaluated using descriptive data from the Video Mirroring Adjustment (VMA) survey, as part of the ASSURE design.

Instrumentation for Data Collection – Research Question 5a

Specifically, questions 1 through 5 of the VMA survey (Appendix I) were answered by the participants of the transformational learning group, and responses were included in the resultant descriptive data. The VMA was conducted three times during scan laboratories throughout the final two semesters of the program year by the 12 students designated as the transformational learning group, though only 10 to 11 participated in each lab, due to scheduling considerations. The transformational learners who engaged in VMA activities for the extended semesters were asked in VMA survey question 1 to identify the number of times using the *iPad* padcam within a laboratory session to demonstrate ergonomic issues.

Research question 5a was further evaluated using descriptive data from VMA survey questions 2 through 5, which asked for:

- (2) perception of personal benefit in receiving collaborative feedback of ergonomic behaviors;
- (3) perception of peer benefit in receiving collaborative feedback of ergonomic behaviors;

- (4) perception of enhanced visual benefit (through the use of the padcam) for demonstration and discussion purposes; and
- (5) perception that ergonomics adjustments could have as easily been described and made with verbal explanations (without the use of the padcam).

Variables for Research Question 5a

There were extraneous variables that applied only to Group C, as derived from the VMA Survey regarding learner beliefs and attitudes within the extended transformative learning event.

Participants within Group C were asked, in VMA question 1, to provide the number of times using the *iPad* padcam to demonstrate ergonomic issues. For this question, there were five possible grouped responses, designated as:

- (1) = none;
- (2) = 1-3 times;
- (3) = 4-6 times;
- (4) = 7-10 times;
- (5) = Over 10 times.

The majority of the VMA questions (2 through 5) used a Likert scale of 1 to 5 for responses, designated as:

- (1) = strongly disagree;
- (2) = somewhat disagree;
- (3) = uncertain;

(4) = somewhat agree;

(5) = strongly agree.

Statistical Data Analysis for Research Question 5a

The quantified information in the VMA survey simply provided a means by which to estimate the perceived value of the continued transformative learning stage, as assigned by the learners engaged in it. Descriptive statistics were used for this purpose.

Qualitative Analysis for Research Question 5a

Learners reflected within the VMA survey, collaborating with peers to develop individualized corrective plans of action to follow and adjust throughout the transformative scan laboratories. Both self-review comments and peer review comments have been categorized with Chapter V for each participant, with comparisons made between the two. As well, repetitive behaviors have been identified from one scan lab to the next, as well as assessed for any patterns of correspondence to later WRMSD complaints provided at the time of the final expert scan observation (among participants who were retained through the end of the study).

Research and Null Hypotheses 5b

H_a: The mean MSI risk ratings from the end of the transactional stage of learning to the end of the transformational stage of learning exhibited significant attitudinal differences among the transformational learners of Group C.

H_o: The mean MSI risk ratings from the end of the transactional stage of learning to the end of the transformational stage of learning exhibited no attitudinal differences among the transformational learners of Group C.

Testing Methodology at the Transformational Stage – Hypothesis 5b

Question 9 of the transformational group's video mirroring adjustment (VMA) survey asked the student evaluator of Group C to provide a personal MSI rating on the same Likert scale of 1 to 10 that had been used during the transactional learning stage, with 10 designating the greatest perceived risk and 1 designating the lowest perceived risk. Comparisons were made within Group C between the MSI risk ratings taken at the end of the transactional learning stage to those MSI risk ratings gathered at the end of the transformational learning stage. The researcher was interested in whether these transformational subjects would perceive the scan risk to be greater, due to the learning that had taken place; or less, due to the empowerment of not only awareness, but reinforced practice in a collaborative environment.

Variables for Hypothesis 5b

The independent variable was the stage of learning engagement (rather than the designated learning group) for the transformational (Group C's) learners only, designated as either:

- (1) = transactional stage, or
- (2) = transformational stage.

The dependent variable designated learners' personal perceptions of MSI risk ratings on a Likert scale of 1-10 as a dependent variable, with 1 designating the least perceived personal risk and 10 designating the greatest perceived risk.

Instrumentation for Data Collection – Hypothesis 5b

Group C subjects, representing the longer-term transformational group, were provided access to *iPads*, chosen as currently available and accessible video and survey technology, within scan laboratories to record and share findings during live peer scanning, so that OBP adjustments could be immediately made as part of the collaborative assessment and reflective process. With these devices, subjects performed peer assessments during the extended instructional laboratories using the observation form in electronic format, recording and sharing frequencies of specific behaviors, and engaging in reflective activities using the VMA survey tool (Appendix I). The researcher gathered the data from electronically submitted VMA surveys following three designated scan laboratories.

The MSI risk rating was the same tool previously used and displayed as Figure 3.1. This rating tool was used at various learning stages among and within Groups B and C, and among the PPG quasi-experimental sub-groups, in order to make comparisons in attitudinal changes.

Statistical Data Analysis for Hypothesis 5b

A *t* test for difference in means was conducted to test for any changes within the transformational groups' MSI ratings following the transactional stage of learning (at the end of the first semester) compared to the final rating at the end of the formal transformative stage of learning (the end of the program year).

Qualitative Analysis for Hypothesis 5b

Narrative information provided by learners during the collaborative correction action plan formation was considered and addressed with Chapter V, when providing additional understanding of learner progression within this instructional segment of the study. Comments from the PPG study, or comments made at the time of the learners' second video assessment, were also considered in relation to the reported MSI ratings.

Research Question 6

What patterns of responsiveness regarding injury awareness and prevention feedback were evidenced among program graduates at the time of final observation?

Research and Null Hypotheses 6a

H_a: Post-graduate sonographers who expressed concerns of work-related musculoskeletal disorders (WRMSDs) were perceived by the evaluator to demonstrate greater responsiveness to ergonomic feedback at the final observation stage than were sonographers who did not express WRMSD concerns.

H₀: Post-graduate sonographers who expressed concerns of work-related musculoskeletal disorders (WRMSDs) were perceived by the evaluator to demonstrate the same level of responsiveness to ergonomic feedback at the final observation stage as sonographers who did not express WRMSD concerns.

Testing Methodology beyond the Learning Stages

Graduates were asked at the final observation stage to report any areas of pain or concern associated with a WRMSD. Additionally, the evaluator assigned a responsiveness rating at the time of the final observation to signify each graduate's perceived level of interest in receiving feedback toward identifying problematic ergonomic behaviors and corrective measures. This research hypothesis tested the presence or absence of the graduates' WRMSDs in relation to responsiveness to ergonomics feedback.

Variables for Hypothesis 6a

The independent variable was based upon whether or not the graduate subject reported a WRMSD concern. These categorical responses were coded as:

(0) = denial of WRMSD concern, or

(1) = report of WRMSD concern.

Subjects' complaints were self-registered, most often without medically documented evidence. The researcher sought to confirm with all reporting subjects that any registered complaint was perceived as directly related to scanning or further aggravated by work habitus conditions.

The dependent variable was determined according to the evaluator's perception of the graduate's responsiveness to final observation feedback, rated on an interval scale of:

(0) = resistant,

(1) = ambivalent, or

(2) = responsive.

Graduate subjects defined as resistant either demonstrated no interest in the evaluator results or cited denial of any potential of a personal WRMSD in the future. For example, one graduate went so far as to demonstrate a high level of muscular flexibility in an attempt to convince the evaluator of the lack of any future personal risk potential. Subjects defined as ambivalent had to be asked by the observer if feedback information could be shared and expressed very little interest in the feedback received. Subjects identified as responsive were enthusiastic to offer information and receive feedback from the onset of the evaluation and/or were very reflective and became engaged when results were shared.

Instrumentation for Data Collection – Hypothesis 6a

An informal interview at the conclusion of the final observation was the method for collecting the data. The researcher noted a difference in attitudes between reporting sonographers

regarding interest in ergonomic feedback, as classified in the Variables section. By the evaluator's perception, sonographers who had WRMSD concerns appeared to offer reports without hesitation and also appeared to be more interested in the evaluator's outcomes than did those sonographers who denied the presence of any WRMSDs. This unanticipated discovery led to the testing of these data through this research hypothesis.

Statistical Data Analysis for Hypothesis 6a

The evaluator's perception rating was classified as interval data, while the WRMSD complaint status of the sonographer was considered to be categorical in nature. An independent-samples *t* test was conducted to evaluate the graduates' responsiveness levels related to WRMSD reports.

Qualitative Analysis for Hypothesis 6a

Additional qualitative analysis regarding graduate and supervisory feedback responses of work environment situations that may be pertinent contributors to attitudes or behaviors has been included with Chapter V's findings.

Research and Null Hypotheses 6b

H_a : A significant difference existed between the evaluator responsiveness ratings regarding final observation feedback based upon the learning classification (Group A, B or C) in which the graduates had been formally engaged while in school.

H_o : No difference existed between the evaluator responsiveness ratings regarding final observation feedback based upon the learning classification (Group A, B or C) in which the graduates had been formally engaged while in school.

Testing Methodology based upon Learning Engagement Type

In response to the central research question, the researcher was interested in knowing whether graduates responded differently to ergonomic feedback toward corrective scan measures based upon learning classification – transmissional, transactional, or transformational. Such findings might signify whether certain types of instruction were more successful in developing attitudes toward continual positive work habitus adjustment, particularly stemming from collaborative suggestions, as had taken place in the ASSURE instructional design for the transformational learners.

Variables for Hypothesis 6b

The independent variable was the type of learning in which the learner had been engaged. The potential instructional categorical responses, as previously designated in Table 3.1 and coded for data input, were:

- (0) = transmissional,
- (1) = transactional, or
- (2) = transformational.

The dependent variable was determined according to the evaluator's perception of the graduate's responsiveness to final observation feedback, rated as one of the following:

- (0) = resistant,
- (1) = ambivalent, or
- (2) = responsive.

Descriptions have already been provided for each interval rating within the Variables section of Research Question 6a.

Instrumentation for Data Collection – Hypothesis 6b

Again, as previously described for Hypothesis 6a, an informal interview at the conclusion of the final observation was also the method for collecting the responsiveness rating for Hypothesis 6b. Subjects were designated according to learning engagement within a database.

Statistical Data Analysis for Hypothesis 6b

The evaluator's perception rating was classified as interval data, with the three learning engagement types being categorical. Therefore, a one-way ANOVA was conducted to evaluate the relationship between the study graduates' assigned responsiveness ratings following the final

ergonomics observation according to the classification of learning type in which each graduate was involved.

Qualitative Analysis for Hypothesis 6b

Additional qualitative analysis regarding graduate and supervisory feedback responses of work environment situations that may be pertinent contributors to attitudes or behaviors has been included with Chapter V's findings.

Validity and Reliability Considerations

No known existing resources would have been specific to the needs of this study, based upon the criteria that had been established for observation and data collection purposes. Therefore, assessment tools were constructed by the researcher for instructional and research purposes. The primary tool was the observation guide, located in Appendix F. Validity of this expert observation instrument was initially established based upon the literature review comparisons. Reported incidences by the study subjects and expert observation findings in early pilot stages added to this instrument's validation. Using one expert observer throughout the entire research process served to increase reliability of responses, as did video recording the pre-instructional and post-instructional scan segments to assure a consistent environment for review when making determinations of ergonomic scan performances.

The researcher recognizes that inter-rater reliability of the observation instrument would have diminished when Group C's various learners were asked to conduct peer reviews. However,

a level of reliability of the observation instrument was still maintained through incorporation of the same observational categories and descriptions from the expert tool within the Ergonomics Peer Observation Checklist (Appendix I). Furthermore, student assessors were guided by visual cues of described categorical behaviors, along with suggested adjustments, by posters that were hanging above each scan station (Figure 2.3).

Whereas the first survey instrument used by Group C focused on monitoring peer behaviors, the second survey tool, the VMA reflection survey (Appendix I), was developed for guidance in critical reflection related to attitudinal perceptions and future behavioral considerations that could either contribute to or result from attitudinal transformation. Student in-services with practice of these survey instruments using the *iPads* were conducted prior to implementation of the mid-term transformative peer review and reflection activities to increase reliability of use. The collaborative and reflective VMA survey tool was also formatively developed, based upon the learning goal, the objectives, and, finally, feedback received during student orientations of the ASSURE learning activities (Appendix C). Some additional validity was established based upon the expertise of those developing the tool by theoretical understanding and empirical evidence gathered through the ASSURE model and earlier learning progression tiers.

As already mentioned, inter-rater reliability was anticipated to vary from learner to learner, due to lack of experience in the ergonomics observation technique. However, the learning event was designed to increase the capability of each learner's intra-rater reliability for identifying ergonomic concerns based upon the repetitive methodology of the study. Some learner inter-rater reliability had the potential of being tested through comparisons between the ergonomic plans of adjustment following collaboration among lab partners. Though these

comparisons were listed qualitatively with Chapter V's findings, testing measures were considered beyond the scope of this study's intent.

Bias Considerations

Concerning transformation and even ergonomic injuries, some bias may have been introduced into the study by reason that sonographers scanning longer at the time of the final observation would have had higher susceptibility to injuries and the consequences of poor form. The scan career span of two to five years was selected as introduced in the literature review concerning longitudinal studies (Taylor, 2007). Reasonably, because of this, some graduates had been performing for longer scan periods than had others at the final expert observation stage. In response to this concern, Kaiser (2007) stated that a study of 10,000 participants revealed an average time of at least five years in the profession before sonographers reported pain related to scanning. Horkey & King (2003) agreed with this finding, stating, "[t]he average length of time a sonographer is working in this profession before experiencing pain is about 5 years" (p. 207). Baker's (2009) study revealed that reported incidences of WRMSDs were of particular concern in sonographers who had been scanning in excess of 16 years; therefore, none of the participants who graduated within the five-year study span would fall into these classifications. Furthermore, the researcher was originally searching for a change in behaviors (or sustenance of changed behaviors) associated with adopted attitudes, rather than actual pain or injuries themselves.

The greatest concern involved the integrity of the data throughout the observation sessions. If participants were aware of the reason for observation, subjects could have easily succumbed to the Hawthorne Effect, a tendency for studied subjects to alter behaviors due to the

knowledge of involvement in observational research (Roethlisberger & Dickson, 1966, as cited in Anteby & Khurana, 2012). A reasonable assumption was made, however, that if the Hawthorne Effect was evidenced among participants of the study, then an equivalent bias should apply among all study subjects. Had the researcher entered the participants' domains without informing subjects of the study's intent, this practice could have represented an ethical violation, as appropriate consent could not have been obtained. The most suitable solution, as proposed and used in this study, was to openly inform the participants of the researcher's intent of the study, in writing with brevity, seeking participant cooperation and consent (Appendix B), then asking each participant to later perform a self-assessment following the pre-observation and interview period. In this way, the concept of self-awareness that was first introduced in the instructional segment on ergonomics continued to be utilized, with the benefit of diminishing the threat of someone else judging the sonographers' behaviors as being adequate or not. Through a continued self-assessment process, the researcher's goal was that participants would openly recognize and admit poor scan technique and pinpoint personal issues that should continue to be refined, thus building upon the transformational learning process. This step was also meant to assist in diminishing any threat of peer assessment for the transformational learning group, as was the design for the learner to reflect on such threats in the respondents' VMA surveys.

Peer assessment, especially, could have presented not only inter-rater reliability from one participant to the next, but could have introduced social bias. Bias should not have created a watered-down effect of response due to social-emotional concerns (e.g., hurting another learner's feelings; adjusting findings for a friend), as gathered quantitative data were not being graded on the learner's performance, but for the benefit of making helpful personal adjustments.

With a consistent expert observer, who also performed the data analysis and written work of this research, there became the danger of bias being inserted at the time of the final observations. Since the research observer decided upon the frequency of risk behaviors, the researcher had the capability of skewing the data toward a favored outcome. To minimize any unintended tampering of data, the researcher sought assistance in grouping all study participants according to region, rather than instructional methodology type, thus performing final observations over a determined three-month period using a geographical approach. The observer did not classify the subjects by learning groups until all data had been collected, wherein each subject's observation instrument was then matched by correct participant number and designated for data input.

Summary

This chapter provided an outline for the research study design and methodology, including six research questions and associated sub-questions and hypotheses, along with associated considerations of study variables, instrumentation, validity, reliability, and bias. Descriptions of data testing for statistical analyses were also proposed and provided for review. The population and sample groups were described, most especially in determining the various research designations by instructional approaches. A brief explanation of IRB considerations for this study was also included. Chapter IV will provide the quantitative analyses and results of these specified data sets. Chapter V will provide the qualitative narratives, wherever applicable to particular research questions or to gain additional insight into quantitative results or unanticipated findings.

CHAPTER IV

QUANTITATIVE ANALYSIS OF DATA

Introduction

The primary objective of this research study was to compare the three ergonomic instructional methods – classified as transmissional, transactional, or transformational – particularly to assess whether a significant difference could be demonstrated in the reduction of ergonomic risk behaviors associated with reported musculoskeletal disorders through early career sonographer adoption of learned principles as reinforced practice within the work habitus frame of reference. The researcher postulated that the greatest behavioral changes would be identified among those subjects in the transformational group, according to longer-term transactional behaviors within the learning environment, as well as additional opportunities toward sustained awareness and continued expression of beliefs through reflective exercises that transitioned from instructor-based assessments to self-assessments and peer-based assessments.

Table 4.1 classifies the 61 subjects analyzed in this research from the study's origin, from which Personal Prevention Plan (PPP) scores were obtained on all subject groups for study comparison, and through which the researcher's goal was to observe as many of the subjects as were accessible during the final observation stage. As expressed in Table 4.1, there was a 34.4% attrition rate that took place among all research groups by the final observation stage, allowing for data collection from only 40 of the original 61 subjects at the ending study period of two to five years of graduate scan experience.

Table 4.1 Retention of Study Subjects for Final Observation

Group	Instructional Technique Applied	Class Designation	Original Number of Study Subjects Identified	Study Subjects Available at Final Observation	Study Retention Rate (%)	Study Attrition Rate (%)
A	Transmissional	Classes of 2009, 2010	35	20	57.1	42.9
B	Transactional	Class of 2011	14	11	78.6	21.4
C	Transformational	Class of 2012	12	9	75.0	25.0
Totals Among all Groups			61	40	65.6	34.4

Reasons for study attrition were classified as:

- 1) The graduate was not working in the sonography profession at the time of the final observation. This included 11 of the 61 graduates (18.0%) who were either not working in any field, who were working in another field, or who may have been on a temporary leave of absence (e.g., surgical leave, maternity leave) from the sonography field with no reasonably established date of return.
- 2) The observer was not allowed access to the clinical site for observation with three of the 61 graduates (4.9%). In two of these cases, graduates cited that supervisors had objected to the observation request due to HIPAA violation concerns, even after the researcher suggested that a volunteer be used, rather than an authentic patient. One graduate refused access on the basis that the clinical site was too busy to allow for observation, even after the researcher explained that the observation should not

- interfere with scheduled duties. Of interest, all such refusals for access to observe at the final observational stage came from subjects designated within the transmissional learning group.
- 3) The observer was unable to coordinate a final observation with four of the 61 graduates (6.6%) due to lack of availability. Reasons for this designation included any instance in which a graduate had been contacted at least four times over the course of three months to attempt scheduling an observation, but the graduate repeatedly cited unavailability. Two of these responses originated from subjects designated within the transmissional learning group, while the other two responses originated from subjects of the transactional learning group.
 - 4) The graduate was inaccessible by means of reasonable geographic availability. The researcher traveled within a 300 mile radius among five states to collect the final observation data from graduates. Any site beyond 300 miles from the researcher's home base was considered to be out of range for the purposes of gathering data for this study. Such criteria encompassed two of the 61 graduates (3.3%) – one being classified as a transmissional subject; the other as a transformational subject.
 - 5) One graduate (1.6%) could not be located. In this case, the researcher made every feasible attempt at contact, according to information available or obtainable (e.g., postal mail, email, phone messages, social networking search, and surveying other graduates), without any response from the graduate or any additional means of contact. This subject originated from the transmissional learning group.

Study subjects unable to participate in the final observation stage have been classified by type, number and percentage in Table 4.2.

Table 4.2 Reasons for Study Subject Attrition

Group	Class Designation	Presently Not Working in Field		Refusal of Access for Observation		Inability to Coordinate with Graduate		Inaccessible by Location		Unable to Locate Graduate		Total Within Each Group	
		<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
A	Classes of 2009, 2010	8	22.9	3	8.6	2	5.7	1	2.9	1	2.9	35	44.0
B	Class of 2011	1	7.1	0	0.0	2	14.3	0	0.0	0	0.0	14	21.4
C	Class of 2012	2	16.7	0	0.0	0	0.0	1	8.3	0	0.0	12	25.0
Total Among All Groups		11	18.0	3	4.9	4	6.6	2	3.3	1	1.6	61	34.4

In the testing of research hypotheses, some quantitative data were analyzed on all 61 original study subjects (from extant data); some data on the 40 (65.6%) retained subjects; and, in specific analyses, only portions of data on subjects or limited sub-groupings of subjects were compared, depending upon the research question analyzed or hypothesis tested and the related data available or obtainable. Specific instructional groups and sub-groups were identified, by type and reason, within the methodology chapter and, where necessary, in the descriptive data or test analyses.

Research Questions

The research questions provided a framework through which the researcher could set out to resolve whether the type of defined instructional methodology, most particularly the transformational type, could make a significant difference toward the reduction of MSI risk behaviors in the early career sonographer. To that end, null hypotheses were considered, wherever appropriate, so that the researcher might be provided with neutral statements to test, using the identified independent and dependent variables. Descriptive statistics otherwise were used to provide some level of understanding in response to the questions.

In either case, responses to the following research questions were quantitatively analyzed in regards to learner attitudes or behaviors related to the three instructional techniques defined within this study. Each research question has been individually addressed in order in this chapter, together with any assigned hypotheses, testing, and analyses. In this manner, the reader should be able to logically progress through the study, conveniently relating the progression to the

methodology descriptions within Chapter III, any interrelated qualitative considerations in Chapter V, and the upcoming summary of research results in Chapter VI.

As a reminder, the primary research question directing this quantitative analysis was: What differences in learner attitudes and behaviors can be determined within the ergonomics work habitus frame of reference when comparing transmissional, transactional and transformational learning events for the early career scanning sonographer?

Research Question 1

How closely did sonographers' pre-instructional scan complaints and risk behaviors correspond with final musculoskeletal complaints and risk behaviors of prior published professional injury rates?

The data collected in this study allowed for calculating descriptive statistics toward comparison; however, this question could not be adequately tested through a null hypothesis.

Descriptions were categorized by:

- 1) early reported concerns of both general and cardiac sub-groups,
- 2) early observations made in both the general and cardiac sub-groups, and
- 3) comparisons between those early reports and observations to reports and observations made at the two to five year final observation period.

All reports and observations were also discussed not only in relation to one another, but in relation to published categorical career sonographer injury rates.

Early Reported Concerns versus Proportions in Literature

The primary instrument for recording early reported pain or discomfort areas by learners from Groups B and C was through self-reporting during the pre-instructional interview (Appendix E), in which the first question inquired if the subject was experiencing any areas of pain or discomfort associated with scanning and, if so, the subject was asked to identify the location(s). The researcher sought clarification, at the time of such pain or discomfort report, that the subject perceived the injury to either be directly related to scan duties or further aggravated by work related activities. In each instance, reports were taken by the researcher according to categorized anatomical areas and noted as either present or absent within each.

Early General Sonographers' Pain Reports

Initially, the actual frequencies of early career general sonographers' most highly reported pain or discomfort locations related to MSI risk factors after the first several weeks of scanning were logged and compared to literature findings for the most common injury categories among sonographers. Table 4.3 lists the areas of pain or discomfort that were most commonly reported by a sample group of 14 general sonography subjects during the pre-instructional ergonomics stage, along with the frequency of those complaint incidences. Note that a sonographer could report more than one area of pain or discomfort. Thirteen of the 14 subjects (92.9%) reported the 21 incidences depicted, with one subject (7.1%) declining to report any pain concerns.

Table 4.3 Reported Pain Frequencies among Early Career General Sonographers compared to Proportions of Sonographer Injuries Cited in Literature

Reported Pain Locations From New General Sonographers	Reported Frequency	Reported Proportion (%)	Actual Proportions from Literature* (%)
<i>n</i> = 21 (incidences)			
Shoulders (Scan or Non-Scan)	11	52.4	76.0
Neck	6	28.6	74.0
Wrist	2	9.5	59.0
Upper or Lower Back	2	9.5	58.0
Total	21	100.0	Will Not Equal 100.0**

*Source: Murphy & Russo (2000)

**Assumes the same sonographer could report multiple areas of pain

The most commonly reported pain and discomfort areas of these early general sonographers included the shoulders, wrist, neck, and back, also highly reported areas for MSI complaints among sonographers (Murphy & Russo, 2000). Specifically, the shoulders and neck received the greatest percentage of early general sonographer complaints (52.4% and 28.6%, respectively), also coinciding with the two highest proportions of injuries cited in the literature, as listed in Table 4.3. The reported wrist and back complaints were much lower in this sub-group (at 9.5% each), but were still categorically among the most commonly reported discomfort areas mentioned in sonography ergonomics literature.

Early Cardiac Sonographers' Pain Reports

Subsequently, the actual frequencies of early career cardiac sonographers' most highly reported pain or discomfort areas related to MSI risk factors after the first several weeks of scanning were compared to the most highly cited sonographer injury rates, as categorized within the literature. Furthermore, a comparative assessment was made between the early cardiac and early general sonographer subjects' results.

Table 4.4 lists the areas of pain or discomfort that were most commonly reported by the sample group of 12 early career cardiac sonographers, along with the frequency of complaint incidences. As a reminder, a subject could report more than one area of pain or discomfort; therefore, the nine incidences recorded should not be misconstrued as limited to one report per one sonographer. In fact, eight subjects (66.7%) reported the nine incidences depicted, with four subjects (33.3%) declining to report any associated scan pain concerns.

Table 4.4 Reported Pain Frequencies among Early Career Cardiac Sonographers compared to Proportions of Sonographer Injuries Cited in Literature

Reported Pain Locations From New Cardiac Sonographers	Reported Frequency	Reported Proportion (%)	Actual Proportions from Literature* (%)
<i>n</i> = 9 (incidences)			
Shoulders (Scan or Non-Scan)	5	55.6	76.0
Neck	2	22.2	74.0
Wrist	1	11.1	59.0
Upper or Lower Back	1	11.1	58.0
Total	9	100.0	Will Not Equal 100.0**

*Source: Murphy & Russo (2000)

**Assumes the same sonographer could report multiple areas of pain

The MSI concern areas of shoulders, wrist, neck, and back continued to be the most commonly reported areas of pain or discomfort among the early career cardiac sonography subjects, as had been the case among the general sonography subjects. Specifically, the shoulders (55.6%) and the neck (22.2%) received the greatest categorical pain and discomfort complaints, coinciding with the highest percentage of categorical injuries reported in the literature. Both wrist and back complaints were reported less frequently in the early cardiac subjects (at 11.1% each) than the other discomfort areas; yet still among the most commonly reported injury categories mentioned in sonography ergonomics literature (Murphy & Russo, 2000).

Comparison of Pain Reports between Early Career

General and Cardiac Sonographers

Of additional interest was whether early career general and cardiac subjects reported similar proportions in the most common pain and discomfort categories. The cardiac subjects performing adult echocardiography exhibited a similar proportion of reported shoulder pain (55.6%) in comparison to the general sonography subjects (52.4%), as well as similarity in neck discomfort reports, being 22.2% for the early career cardiac sonographers and 28.6% for the general sonography subjects. Reported wrist and back complaints for cardiac subjects (each being 11.1%) were also very similar to the wrist and back reports among the general sonographer sample group (9.5% for each category). Sample sizes were small, so comparisons should be repeated with larger sample numbers before applying any generalizations.

Regardless of whether the subjects were engaged as early general or cardiac sonography learners, pain and discomfort reports after several weeks of scanning were quite similar among

the two specialty sub-groups within this study. Though these statistical descriptions could be analyzed for the potential of early musculoskeletal warning signs that might denote future risk, the obvious limitation of subjects reporting any discomfort was whether there was any significance of meaning at such a limited time of scan experience in the work environment (as any new task may create some level of soreness prior to the onset of building muscle and gaining what is termed as muscle memory). The less obvious limitation of self-reporting was any potential denial on the part of the learner regarding health related concerns, as earlier addressed within either of the first two motivational layers of Hancock's Ergonomics Injury Belief Enhancement Model (Figure 2.1). Therefore, the researcher wanted to assess beginning habitual formations that might also be useful in delineating future injury concerns in the early scan stage.

Early Observed Concerns versus Proportions in Literature

Early behaviors could be objectively discerned through expert evaluation. Risk behavior incidences were logged based upon anatomical areas that had both been reported by early career sonographers and those that had been researched through the literature as the most common sonographer MSI locations. The researcher wished to make a comparison of categorical proportions that had been observed compared to the sonographer injury rates cited in the literature.

As a review of methodology to assist in the analysis of this additional data, the scan observation instrument (Appendix F) was constructed in pilot studies to allow the researcher to collect ergonomic behavioral frequencies within categorized areas of concern in a standardized manner. For the purposes of this particular section of the study, in calculating the most

commonly observed negative behavioral frequencies and comparing these behaviors to cited injury locations, the use of data collected from the observation instrument was greatly simplified. A negative behavior was logged as taking place within a DSM category only when repeated more than once and when sustained each time for a period designated in the guide (e.g., 15 seconds or longer). Based on these criteria, each behavior was recorded as either present or absent.

Observed Behaviors of Early General Sonographers

The researcher calculated actual frequencies of early career general sonographer subjects' most highly observed negative scan incidences related to MSI risk factors within the first few weeks of scanning, comparing these with the literature findings for the most common injury locations among sonographers. Table 4.5 displays the distribution of the 41 incidences exhibited among the 14 general sonographer subjects, all performing adult abdominal examinations using a right-handed scan technique during the laboratory observation protocol.

Table 4.5 Frequencies of Observed Incidences of Early Career General Sonographers compared to Proportions of Sonographer Injuries Cited in Literature

Observed Concern Locations of New General Sonographers	Observed Frequency	Observed Proportion (%)	Actual Proportions from Literature* (%)
<i>n</i> = 41 (incidences)			
Shoulders (Scan or Non-Scan)	12	29.3	76.0
Neck	13	31.7	74.0
Wrist	13	31.7	59.0
Upper or Lower Back	3	7.3	58.0
Total	41	100.0	Will Not Equal 100.0**

*Source: Murphy & Russo (2000)

**Assumes the same sonographer could report multiple areas of pain

As seen in Table 4.5, the most common negative behaviors of the early career general sonography subjects occurred in the shoulders, neck and wrist, with the back at a much lower proportion of observed negative behaviors. The observed proportions were all lower than the injury proportions cited in the literature, but still corresponded to the most highly reported categories within both this group (Table 4.3) and among career sonographers. Specific comparisons between general sonographers' pain reports and observed risk behaviors revealed that shoulder behavioral incidences (29.3%) were lower than reported shoulder discomfort (52.4%) in the early scan stage; however, observed risk behaviors of the neck (31.7%) were proportionally similar to reported neck pain (28.6%), as were negative back behaviors (7.3%) compared to reported back pain proportions (9.5%). Negative wrist behaviors (31.7%) were much greater than were the reports of wrist discomfort (9.5%) among these general sonography subjects.

Observed Behaviors of Early Cardiac Sonographers

The researcher then calculated the frequencies of early career cardiac sonographers' most highly observed negative scan incidences for comparison with these same MSI risk factors following these subjects' first several weeks of scanning. Table 4.6 displays the distribution of the 31 incidences exhibited by the 12 cardiac sonographer subjects who, incidentally, performed adult echocardiography studies using a left-handed scan technique during the laboratory observation protocol.

Table 4.6 Frequencies of Observed Incidences of Early Career Cardiac Sonographers compared to Proportions of Sonographer Injuries Cited in Literature

Observed Concern Locations of New Cardiac Sonographers	Observed Frequency	Observed Proportion (%)	Actual Proportions from Literature* (%)
<i>n</i> = 31 (incidences)			
Shoulders (Scan or Non-Scan)	1	3.2	76.0
Neck	10	32.3	74.0
Wrist	9	29.0	59.0
Upper or Lower Back	11	35.5	58.0
Total	31	100.0	Will Not Equal 100.0**

*Source: Murphy & Russo (2000)

**Assumes the same sonographer could report multiple areas of pain

As demonstrated in Table 4.6, the most common negative scan behaviors of the early career cardiac sonography subjects occurred in the neck, wrist, and back, with the shoulders registering a much lower proportion of observed negative behaviors. Again, in all categories, all observed proportions were lower than the injury proportions cited in the literature, but still

corresponded to the most highly observed problematic categories that had been reported by early career cardiac sonographers (Table 4.4). Shoulder DSM behavioral incidences (3.2%) were extremely lower than reported shoulder discomfort (55.6%) among the early career cardiac subjects. Conversely, observed negative behavioral incidences in the wrist (29.0%) were much greater than reports of discomfort to the wrist (11.1%), as were observed negative behaviors of the back (35.5%) in comparison to reported back complaints (11.1%). The closest proportion was the comparison of observed negative behaviors of the neck (32.3%) to proportions of reported neck pain (22.2%).

Comparison of Observed Behaviors between Early Career

General and Cardiac Sonographers

Also of interest was whether risk incidences observed among the cardiac sonography subjects would be similar to those observed in the general sonography subjects, since adult echocardiography and general abdominal exams require different scan protocols and approaches. The cardiac subjects performing adult echocardiography exhibited an obvious reduction in negative shoulder behaviors (3.2%) in comparison to the general sonography subjects' negative shoulder behaviors (29.3%). The cardiac subjects, however, exhibited a greater increase in negative back behaviors (35.5%) as compared to the general sonography subjects' observed back behaviors (7.3%). Observations of negative neck and wrist behaviors were quite similar between these two sub-groups. The neck behaviors were 32.3% for cardiac and 31.7% for general subjects; and the wrist behaviors were 29.0% for early cardiac sonographers and 31.7% for early

general sonographer subjects. Of mention once more, sample sizes were small, suggesting that larger samples should be assessed before forming any generalizations.

Reported WRMSD Concerns among Experienced Subjects versus Proportions in Literature

The researcher also wished to assess reported pain concerns among the subjects at the final observation period encompassing two to five years of graduate scan experience, making comparison to injury reports cited in the literature. A compelling reason to assess reported pain locations from these post-graduate subjects during this time period was because these sonographers were coming upon the profession's published threshold for reporting MSI concerns (Horkey & King, 2003; Parhar, 2004) and approaching one-third of the career period for the onset of highest reported pain incidences among sonographers (Baker, 2009).

Twenty-nine of the 40 retained subjects (72.5%) reported WRMSD complaints at the time of the final observation. Table 4.7 provides a view of these reports by frequency and proportions, along with the actual proportions of sonographer career injuries as cited in the literature. Disparate from the controlled, educational laboratory setting, the 43 incidences that were reported by the 40 general and cardiac sonographers represented work conditions in which these experienced sonographers performed various ultrasound examinations within a period of two to five years at various facilities, each using the scan protocols of those facilities along with personally adopted scan techniques.

Table 4.7 Reported Pain Frequencies among Retained Sonography Graduate Subjects with Two to Five Years of Scan Experience compared to Proportions of Sonographer Injuries Cited in Literature

Reported Complaints at Final Observation	Reported Frequency	Reported Proportion (%)	Actual Proportions from Literature* (%)
<i>n</i> = 43 (incidences)			
Shoulders (Scan or Non-Scan)	16	37.2	76.0
Neck	9	21.0	74.0
Wrist	5	11.6	59.0
Upper or Lower Back	13	30.2	58.0
Total	43	100.0	Will Not Equal 100.0**

*Source: Murphy & Russo (2000)

**Assumes the same sonographer could report multiple areas of pain

The most commonly reported WRMSD complaints included the shoulders, wrist, neck, and back, consistent with all prior commonly reported areas for MSI complaints among the early career sonography subjects, and as identified by Murphy & Russo (2000). At this more experienced scan time of the final observation period, shoulders (37.2%) and backs (30.2%) received the greatest percentage of complaints, with neck concerns being reported at 21.0%, and wrists encompassing 11.6% of the complaints.

Though the proportions of WRMSD complaints at two to five years of scan experience were lower than the career injury proportions among sonographers, these results point to some alarming statistics that the researcher would like to emphasize in this section where data have been calculated and are more readily accessible.

- 1) Nearly three-fourths (72.5%) of the subjects in this study reported WRMSD complaints before or exactly at the five year threshold period designated in the literature review as the commencement of sonographer MSI concerns (Horkey & King, 2003; Parhar, 2004). This proportion, then, was already nearing the approximated 80.0% to 90.0% career injury rate that has been cited among various sonography sources (Baker, 2009; Coffin & Baker, 2007; Evans et al., 2009; Friesen et al., 2006; Murphey & Coffin, 2002; Murphy & Russo, 2000; Philips Medical Systems, 2007).
- 2) The study subjects' shoulder and back complaints, at less than or equal to five years, had already reached nearly one-half of the proportions reported among sonographers for career-long MSIs in these DSM categories, as cited by Murphy & Russo (2000).
- 3) The study subjects' neck complaints at or less than five years of scan experience had reached nearly one-third of the proportion reported in the literature (Murphy & Russo, 2000), while reported wrist complaints were less prevalent at approximately one-fifth of the cited career injury proportion.
- 4) There may or may not have existed predictive value in early reports or early observations versus later WRMSD complaints, as the proportions varied somewhat between groups and among individuals. This will be further addressed in the following two sections.

Observed Behavioral Concerns among Experienced Subjects versus Proportions in Literature

The researcher further conducted observations to determine the most common negative scan behaviors among the retained graduate subjects during the final observation stage. Once more, proportions of findings were considered in relation to cited categorical sonographer injury rates of the profession (Murphy & Russo, 2000).

The same observation methodology was used here as for comparisons during the early observation periods, in which the use of data collected from the observation instrument was again greatly simplified. As a reminder, a negative behavior was logged as taking place within a DSM category only when repeated more than once and when sustained each time for a period designated in the guide (e.g., 15 seconds or longer), meaning each behavior was recorded as either present or absent. Table 4.8 shows the observational findings of negative behavioral incidences among the 40 retained subjects at the two to five year scan experience timeframe. The 108 incidences that were observed among the 40 sonography subjects represented prior cardiac graduates performing adult echocardiograms when still working within that specialty area, and general sonography graduates performing adult abdominal studies when still working within that specialty area, with the observer using the same protocol guidelines as had been used based upon the laboratory protocol of earlier observations. In the very limited cases where retained subjects did not work within these specialty areas (e.g., a dedicated obstetrics setting), the observer was forced to adapt to a five-minute, five-task protocol based upon the five initially completed tasks within the observed study.

Table 4.8 Frequencies of Observed Incidences among Post-Graduate Subjects with Two to Five Years of Scan Experience compared to Proportions of Sonographer Injuries Cited in Literature

Observed Risk Behaviors at Final Observation	Observed Frequency	Observed Proportion (%)	Actual Proportions from Literature* (%)
<i>n</i> = 108 (incidences)			
Shoulders (Scan or Non-Scan)	20	18.5	76.0
Neck	28	25.9	74.0
Wrist	29	26.9	59.0
Upper or Lower Back	31	28.7	58.0
Total	108	100.0	Will Not Equal 100.0**

*Source: Murphy & Russo (2000)

**Assumes the same sonographer could report multiple areas of pain

The most commonly observed behaviors of risk concern included the shoulders, wrist, neck, and back, consistent with all prior commonly reported categories for MSI complaints and concerns among early career sonography subjects and as identified by Murphy & Russo (2000). During this more experienced timeframe at the final observation period, shoulders (18.5%) demonstrated the least proportion of negative risk behaviors; while necks (25.9%), wrists (26.9%), and backs (28.7%) all demonstrated very similar negative risk behavior proportions.

Though the proportions of observed risk behaviors were all lower than the career-long injury proportions cited for sonographers, these results point to some additional statistics of interest that the researcher would like to emphasize in this section where data have been calculated and are more readily accessible.

- 1) Whereas the sonography subjects with two to five years of scan experience were most often reporting shoulder pain (37.2%), shoulders were the least detected risk behaviors (18.5%) during the final observation stage. Nevertheless, these shoulder risk behaviors did equal approximately one-fourth of the career sonographer injury rate cited for that DSM category.
- 2) Reported neck complaints (21.0%) were very close to the proportions of negative risk behaviors (25.9%) at the time of final observation, being approximately one-third of the cited career sonographer neck injury rate.
- 3) The back complaint proportions (30.2%) were also very close when compared to the risk behaviors that were observed (28.7%) during the final observation, approximating nearly one-half of the published back injury rates.
- 4) Reported wrist complaints (11.6%) were less than one-half of the detected negative risk behaviors during scanning (26.9%) at the final observation. The observed values were nearly one-half the published values for sonographer wrist MSIs.
- 5) Based on these findings, observations and reports at the two to five year period of scan experience seemed to correspond in only one-half of the common categorical findings. Observed negative risk behavioral proportions were already reaching anywhere between one-fourth to one-half of the career-long sonographer injury rates when assessed categorically.

Reported versus Observed Concerns Comparison between Early Learners and Graduates

Research Question 1 originally asked: How closely did sonographers' pre-instructional scan complaints and risk behaviors correspond with final musculoskeletal complaints and risk behaviors of prior published professional injury rates?

Comparisons have taken place within each of the prior headings regarding proportions reported and observed at various stages and within sub-groups in relation to cited injury rates. Comparisons have also been made between early sub-group findings. However, for the researcher to more broadly consider the observations of ergonomic behavioral concerns compared to behavioral concerns at the onset of the learning experience, as well as reported concerns during both the early career period and at the time of the final observation, a systematic procedure was implemented to form a comprehensive table of such comparisons.

Methodology for Comprehensive Comparison

The observation guide (Appendix F) was the instrument used throughout this study to record ergonomic behaviors. This tool was designed from grounded theory and the literature review, with DSM categories (e.g., shoulder, neck, back, wrist, and elbow) given specific descriptions of ergonomic movement behaviors within each of those categories. This tool listed five protocol tasks, whereby categorical scan behaviors could be assessed by the expert observer during each task period. The researcher set a one-minute time limit per task on this set of five (5) given scan tasks, so that each participant would receive no greater than one mark for each observation event in each particular task category within that one-minute time period, with a

maximum of five potential marks within each risk category description. One anatomical area of concern, however, might contain a greater number of potential incidences than another, depending on the number of descriptive concerns that might exist for that area. For instance, hyperabduction of the shoulder could only occur in either the scan shoulder that was extended toward the patient (for a maximum of 5 times in a 5-minute period) or the non-scanning shoulder that was extended toward the ultrasound unit (for a maximum of 5 times in a 5-minute period). The maximum number of shoulder incidences, then, could have only equaled 10; whereas the wrist was assessed for three DSM activities - hyperflexion, dorsiflexion, or lateral flexion – within those same 5 minutes, creating the potential for 15 recorded negative wrist actions. In order to standardize interpretation, the researcher calculated proportions for citing these categorical behaviors. Table L.1 (Appendix L) provides a condensed example to assist the reader in understanding the proportional interpretation used for the comprehensive table of comparisons between early and post-graduate reports and observations.

Reported and observed concerns have been included in Table L.2 of Appendix L, developed as a dual visual comparison between early and late pain reports paired with early and late observation risk behaviors. It must be pointed out that early pain reports and observations were not conducted with Group A's subjects in this study, so only post-graduate WRMSD complaints and observed risk behaviors can be compared for Subjects A through T. Groups B and C begin with Subject U, in which early complaint reports can be compared to both post-graduate complaint reports and early and late observational behaviors; and early to late observational comparisons may also be made and compared back to reported complaints in each individual thereafter, through Subject NN. Figure L.1 provides graphic representation of data from a Group A subject within Table L.2, while Figure L.2 provides graphic representation

within the same table of a transactional subject, to assist the reader in interpretation differences. Table L.2 is rich in information about those study subjects who were retained through the final observation. Though the reader may draw additional conclusions, some pertinent results which should not be overlooked have been included in the following segments.

Contrasting Reports and Observations of Groups B and C with Group A

For Groups B and C (Subjects U through NN of Table L.2), who underwent an initial, pre-instructional observational evaluation, all 20 subjects (100.0%) demonstrated negative scan behaviors at a proportion of greater than 20.0% at the time of the final observation, with 19 (95.0%) demonstrating those risk behaviors in multiple categories. Only one (5.0%) demonstrated a categorical risk behavior at over 70.0% during the final observation, however.

Comparing the results of Groups B and C for pain and discomfort reports, 15 of these 20 transactional and transformational subjects (75.0%) registered pain or discomfort reports after the first several weeks of scanning, while 15 of the 20 (75.0%) also reported WRMSD concerns at the time of the final observation. Only one of these subjects reported having no pain or injury concerns during both the early and late observational stages.

Though Group A subjects had no early comparisons of reports or behavioral frequencies, 14 of the 20 retained transmissional subjects (70.0%) reported WRMSD concerns at the time of the final observation, while six (30.0%) reported no scan-related pain or discomfort. All 20 subjects (100.0%) in Group A demonstrated negative scan risk behaviors in multiple categories, with 14 of the 20 (70.0%) demonstrating at least one categorical risk behavior at over 70.0% and multiple categorical risk behaviors at over 70.0% in three of the transmissional subjects (15.0%).

Reports and Observations among All Groups for Comparative Purposes

Twenty-seven of the 40 retained subjects (67.5%) demonstrated some level of association between observed risk behaviors and reported WRMSD complaints, with eight subjects (20.0%) demonstrating multiple comparative associations. Six subjects reporting WRMSD complaints (15.0%) demonstrated no corresponding risk behaviors, while 10 subjects (25.0%) made no late complaints, but had risk behaviors in those categories. If taking these figures together, one might statistically express that there were at least 16 cases (40.0%) in which a direct connection could not be documented, though there would be some level of associated cross-over.

Furthermore, among the 20 transactional and transformational subjects who had early and late observations, there were 16 instances in which risk behaviors were repeated in both the early and late observation periods, yet no WRMSD complaints were reported within these same DSM categories. Thus, one might also statistically express that alignment could not be documented in 80.0% of the subjects in Groups B and C in this regard, with the need to continue to monitor these situations on a longer term basis for any determination of additional career-long findings.

Also of key importance, in only four (20.0%) of the 20 subjects from Groups B and C did early reported pain concerns align with WRMSD complaints reported at the final observation stage. In each of these four cases of later complaints (Subjects W, X, Z and FF of Table L.2), there was a strong association not only between early reported complaint categories, but also early risk behavior observations within those same categories.

There existed multiple instances within subject cases in which the expert observer logged high proportions of risk behaviors in one category, yet pain reports came from a category with much fewer proportional behaviors, or even no observed risk behaviors. The non-shaded categorical boxes of Table L.2 demonstrated this multitude of instances, in which measures of

association became so greatly diluted that one might reasonably question whether any early reported discomfort areas or risk observations provided any predictive value concerning future WRMSDs. However, findings also suggest that the majority of WRMSDs may be predicted from the same major categories of earlier established reported discomfort when the same early and persistent risk behaviors are also present.

Lastly, a study limitation reminder should be issued that, in all instances, reported WRMSD complaints during the final observation stage were made by the majority of subjects without evidence of medical reports of injury. In some rare cases (e.g., navicular cysts, shoulder injury), medically documented evidence did exist. The researcher, in fact, sought to confirm with each subject that any such registered complaint had an absolute association with scan activities and/or was perceived as being further aggravated by conditions within the sonographer's work environment, rather than other extraneous factors or activities. The researcher had no means by which to establish various pain tolerance levels among subjects as related to the boundaries or purpose of this study.

Research Question 2

Did having transmissional knowledge of other sonographers' injuries and statistical injury risk rates influence early career sonographers' beliefs of personal susceptibility to injury?

Null Hypothesis 2a

Transmissional knowledge regarding other sonographers' incidences of work-related musculoskeletal disorders (WRMSDs) demonstrated no relationship to belief patterns held by early career sonographers regarding personal risk perception of musculoskeletal injuries (MSIs).

Descriptive Statistics for Null Hypothesis 2a

Seventeen (65.4%) of the 26 students from Groups B and C, who were involved in the transactional interview process, claimed to have knowledge of at least one sonographer with a WRMSD. Nevertheless, when asked in Question 3 of the Pre-instructional Interview (Appendix E) about one's own perceived susceptibility for risk in consideration of this knowledge, only 11 (42.3%) of the 26 cited belief of presently being at any risk for developing an MSI. Seven (26.9%) of the 26 cited no belief of personal risk for developing an MSI. An additional eight (30.8%) of the 26 were uncertain regarding personal risk of developing an MSI. Table 4.9 demonstrates a cross-tabulation of Interview Question 3, personally being aware of sonographers with WRMSDs, and Interview Question 5, the participants' belief of personal susceptibility for MSI development.

Table 4.9 Contingency Table of Personal Awareness of Sonographer Injuries with Belief of Personal Susceptibility to MSI

Belief of Personal Risk Factor for MSI	Personal Awareness of Sonographer Injuries						Belief Perception Totals	
	Unaware of Sonographer MSIs		Aware of at Least 1 Sonographer's MSI		Aware of 2 or more Sonographers' MSIs			
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Believes presently at risk	5	55.6	4	40.0	2	28.6	11	42.3
Does not believe presently at risk	2	22.2	3	30.0	2	28.6	7	26.9
Uncertain if presently at risk	2	22.2	3	30.0	3	42.9	8	30.8
Awareness Category Totals	9	34.6	10	38.5	7	26.9	26	100.0

Analysis of Null Hypothesis 2a

A two-way contingency table analysis was conducted to evaluate whether early career sonographers would express beliefs in personal susceptibility for developing MSIs based upon awareness of other sonographers' injuries revealed through clinical interactions. The two variables included belief in present personal risk and personal awareness of sonographer injuries. Awareness and risk belief were not found to be significantly related, Pearson $\chi^2(4, N=26) = 1.36, p = .85$, Cramér's $V = .16$, suggesting the null hypothesis was retained.

Due to this small sample size, results should be interpreted with caution. Repeating the test with a larger sample size would be advisable. In the data available, however, the fact that the test demonstrated no significance was an important finding when considering learner beliefs at the transmissional stage. This finding will be further addressed in the qualitative discussion of Chapter V within the personal prevention plan (PPP) reflections, as well as within the research conclusions of Chapter VI.

Null Hypothesis 2b

Transmissional knowledge regarding other sonographers' published rates of work-related musculoskeletal disorders (WRMSDs) demonstrated no relationship to belief patterns held by early career sonographers regarding personal risk perception of musculoskeletal injuries (MSIs).

Descriptive Statistics for Null Hypothesis 2b

Only three (11.5%) of the 26 subjects involved in the early transactional interview were able to cite a statistical rate of sonographer injuries within a close range of published data, in response to Interview Question 7 (from Appendix E). After being made aware of the approximated 80.0 to 90.0% injury rate among sonographers, 15 subjects (57.7%) maintained the earlier perception of stated risk injury, while 11 subjects (42.3%) were undecided about any personally increased risk. Table 4.10 demonstrates a contingency table that cross-tabulates Interview Question 7, awareness of the cited MSI rate within the sonography population, and Interview Question 8, the participants' reconsideration of belief of personal susceptibility for MSI development.

Table 4.10 Contingency Table of Personal Risk Factor Reconsideration on the Basis of Transmitted Knowledge of MSI Rate in the Sonography Population

Personal Risk Factor Reconsideration	Awareness of MSI Rate in the Sonography Population				Risk Perception Totals	
	Unaware of MSI Rate		Aware of MSI Rate			
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
No Change in Perception of Risk based upon Statistic	14	60.9	1	33.3	15	57.7
Undecided Belief in One's Own Increased Risk based on Statistic	9	39.1	2	66.7	11	42.3
Awareness Category Totals	23	88.5	3	11.5	26	100.0

Analysis of Null Hypothesis 2b

A two-way contingency table analysis was conducted to evaluate whether early career sonographers would express a greater belief in personal susceptibility for MSI development based upon awareness of an approximate 80.0 to 90.0% WRMSD rate among the sonography population. The two variables included reconsideration of belief in present personal risk and transmissional awareness of the cited injury rate within the sonography population. Awareness and risk belief were not found to be significantly related, Pearson $\chi^2(1, N=26) = .82, p = .36$, Cramér's $V = .18$, suggesting the null hypothesis was retained.

Due to this small sample size, results should be interpreted with caution. Repeating the test with a larger sample size would be advisable. Nevertheless, once again, the fact that the test demonstrated no significance was an important finding when considering learner beliefs at the transmissional stage, which will be further addressed in the qualitative findings in Chapter V within the personal prevention plan (PPP) reflections and within the conclusions of Chapter VI.

Research Question 3

Could differences in MSI perceptions and risk behavioral changes be detected post-instructionally based upon the learners' participation in the photoplethysmographic (PPG) diminished blood flow quasi-experiment?

Null Hypothesis 3a

The photoplethysmography (PPG) flow study participants' mean self-susceptibility rating for MSI risks was the same as for those who did not participate in the quasi-experimental blood flow study.

Descriptive Statistics for Null Hypothesis 3a

Of the 26 subjects originating from Groups B and C, 11 (42.3%) were engaged in a quasi-experimental PPG study, in which participants viewed personal blood flow recordings in the subjects' own fingertips while using both neutral and negative scan maneuvers to assess for diminished flow. The remaining 15 subjects (57.7%) served as the control group.

Figure L.3 (Appendix L) provides an example of the customary blood flow response of this study, as registered by the PPG sensor, in which Maneuver 1 created an obvious decrease of flow in the experimental subject based upon compression with the shoulder in neutral position; while Maneuver 2 created an even greater decrease, along with increased recovery time, due to hyperabduction of the scan shoulder during compression. On a strip chart recording, like the one demonstrated in Figure L.3, registering a potential range of 0.0-9.0 frequencies along the vertical hash mark lines, the 11 experimental subjects displayed calibrated baseline flow recordings from 7.0 to 9.0 ($M = 8.13$, $SD = 0.86$). Flow was reduced to 37.4% of the group's original mean value during Scan Maneuver 1, with recorded displays ranging from 1.0 to 5.0 ($M = 3.04$, $SD = 1.24$); and further reduced to 34.9% of the group's original mean value during Scan Maneuver 2, with recorded displays ranging from 0.0 to 7.5 ($M = 2.84$, $SD = 2.10$). Table 4.11 contains these

numerical comparisons, while Figure L.4 (Appendix L) provides a boxplot comparison of the three scan positions (baseline, neutral with compression, hyperabduction with compression).

Table 4.11 Means, Standard Deviations, and Proportions of Baseline Blood Flow Volumes in PPG Participants

Recordings Based upon Maneuver Position	<i>M</i>	<i>SD</i>	Percentage (%) of Baseline Flow Volume
Baseline Flow Recordings	8.13	0.86	100.0
Scan Maneuver 1 Recordings	3.04	1.24	37.4
Scan Maneuver 2 Recordings	2.84	2.10	34.9

Analysis of Null Hypothesis 3a

An independent-samples *t* test was conducted to evaluate the null hypothesis that the mean MSI self-susceptibility rating of subjects undergoing diminished blood flow during scan maneuvers with a PPG study would be equal to the mean self-susceptibility rating of those subjects who did not undergo the PPG quasi-experimental study. The test was not significant, $t(22.34) = -.99, p = 0.33$; therefore, the null hypothesis was retained. The 95% confidence interval for the difference in means ranged from -2.35 to 0.83. The eta square index indicated that only 3.3% of the variance of MSI rating was accounted for by whether or not the subject participated in the PPG study. Table 4.12 provides the means and standard deviations for the two study sub-groups.

Table 4.12 Means and Standard Deviations of MSI Susceptibility Ratings according to PPG Study Participation

Group	<i>n</i>	<i>M</i>	<i>SD</i>
PPG Study Participant	11	6.73	1.35
Control Group	15	5.97	2.51

Beyond the small sample sizes, there may be further insight into why these test results may be flawed. Narrative disclosures will be provided in the PPG-related section of Chapter V, in which subjects' responses demonstrated some skewing of the MSI ratings, compared to what the researcher had anticipated. Likely important to note here, however, is that interview responses did reveal that the PPG subjects' beliefs were impacted by viewing one's own diminished blood flow volume.

Null Hypothesis 3b

No significant difference existed between the mean personal prevention plan (PPP) score of the PPG flow study participants and the PPP mean score of those who did not participate in the PPG study.

Analysis of Null Hypothesis 3b

An independent-samples *t* test was conducted to evaluate the null hypothesis that the personal prevention plan scores of subjects undergoing diminished blood flow during PPG scan

maneuvers would equal the scores of those subjects who did not undergo the PPG quasi-experimental study, through comparison of the score means. The test was not significant, $t(24) = -1.27, p = 0.22$; therefore, the null hypothesis was retained. The 95% confidence interval for the difference in means ranged from -24.03 to 5.18. The eta square index indicated that only 6.3% of the variance of PPP scores was accounted for by whether or not the subject participated in the PPG study. Table 4.13 provides the means and standard deviations for the two study sub-groups.

Table 4.13 Means and Standard Deviations of PPP Scores according to PPG Study Participation

Group	<i>n</i>	<i>M</i>	<i>SD</i>
PPG Study Participant	11	77.1	14.9
Control Group	15	67.9	20.2

Null Hypothesis 3c

The PPG flow study participants exhibited the same frequencies of observed ergonomic risk behaviors from the pre-instruction to the post-instruction transactional observation stage, as compared to those who did not participate in the quasi-experimental blood flow study.

Ultimately, changed behaviors were the gold standard result being sought within this study. Despite the lack of significant findings in regard to the PPG quasi-experiment compared to the subjects' cited MSI risk beliefs or personal prevention plan (PPP) scores, the researcher felt it was necessary to further test for benefit of the blood flow study to compare behavioral results between the PPG sub-group and the control subjects.

Descriptive Statistics for Null Hypothesis 3c

(Negative Scan Behaviors)

Assessing the differences among the 26 subjects within Groups B and C who participated through the transactional learning stage, 24 (92.3%) exhibited a reduction in negative scan behaviors from the first observational event at the beginning of the learning period to the second expert observation at the end of the transactional learning period ($M = 8.50$, $SD = 6.88$). The range of observational behaviors included a maximum reduction of 23 negative scan behaviors in one participant and an increase of seven additional negative scan behaviors in another.

Analysis of Null Hypothesis 3c

(Negative Scan Behaviors)

An independent-samples t test was conducted to evaluate the null hypothesis that the difference in negative scan behaviors from the initial expert observation to the second observation at the end of the transactional stage would be the same for those subjects engaged in the PPG quasi-experimental study as for those who did not participate. The test results were significant, $t(24) = -2.67$, $p = 0.01$. These findings suggested that the null hypothesis was rejected.

The 11 subjects participating in the PPG study ($M = 12.27$, $SD = 4.59$) on the average had approximately two times the number of reductions in negative scan behaviors from the first expert observation to the second, at the end of the transactional learning stage, than did those 15 subjects who did not participate ($M = 5.73$, $SD = 7.09$). The 95% confidence interval for the

difference in means ranged from -11.59 to -1.49. Table 4.14 provides the means and standard deviations for the two study sub-groups.

Table 4.14 Means and Standard Deviations of Differences in Reduction of Negative Scan Behaviors from the First to the Second Expert Observation according to PPG Study Participation

Group	<i>n</i>	<i>M</i>	<i>SD</i>
PPG Study Participant	11	12.27	4.59
Control Group	15	5.73	7.09

Research Question 4

Did observed scan behavior incidences demonstrate an impact toward positive work habitus among study subjects, particularly those within the transformational group, due to ergonomics instructional intervention?

Because scan behaviors toward a positive work habitus included a reduction in negative habitual risk behaviors and an increase in positive habitual behaviors, this null hypothesis was tested on both merits. Hypothesis 4a-i first tested for frequency differences in negative scan behaviors among the retained subjects of the three learning groups at the two to five year career period, then Hypothesis 4a-ii tested for differences in the frequencies of positive scan behaviors among these learning groups.

Null Hypothesis 4a-i

The incidences of negative scan behaviors recorded at the final observation event (post-graduation) were the same for the transformational learning group (Group C) as compared to the other study groups (Groups A and B).

Analysis of Null Hypothesis 4a-i

(Negative Scan Behaviors)

A one-way analysis of variance was conducted to evaluate the relationship between the frequency of negative scan behaviors and the classification of learning types. The ANOVA was significant, $F(2, 37) = 61.98, p = .00$. These findings suggested that the null hypothesis was rejected. The strength of relationship between the learning category and the frequency of negative scan behaviors at final observation, as assessed by η^2 , was very strong, with the learning category accounting for 77.0% of the variance of the dependent variable.

When a post-hoc test using Tukey was performed, the retained transformational learning subjects of Group C ($M = 6.44, SD = 2.24$) showed a greater decrease in negative ergonomic behaviors in comparison to both the transactional and transmissional groups; while the retained transactional learning subjects of Group B ($M = 19.73, SD = 7.73$) showed a greater decrease in negative ergonomic behaviors in comparison to the transmissional learning subjects of Group A ($M = 32.60, SD = 6.00$). Table 4.15 shows the results of the ANOVA for negative behavioral differences among learning categories.

Table 4.15 Post-hoc Analysis for Negative Ergonomic Scan Behaviors

Learning Category	<i>n</i>	<i>M</i>	<i>SD</i>	Trans- missional	Trans- actional	Transfor- mational
Transmissional	20	32.60	6.00	-		
Transactional	11	19.73	7.73	*	-	
Transformational	9	6.44	2.24	*	*	-

An * indicates significance at the .05 level. NS designates not significant, if applicable.

Null Hypothesis 4a-ii

The incidences of positive scan behaviors recorded at the final observation event (post-graduation) were the same for the transformational learning group (Group C) as compared to the other study groups (Groups A and B).

Analysis of Null Hypothesis 4a-ii

(Positive Scan Behaviors)

A one-way analysis of variance was conducted to evaluate the relationship between the frequency of positive scan behaviors and the classification of learning types. The ANOVA was significant, $F(2, 37) = 22.67, p = .00$. These findings suggested that the null hypothesis was rejected. The strength of relationship between the learning category and the frequency of positive behaviors, as assessed by η^2 , was relatively strong, with the learning category accounting for 55.1% of the variance of the dependent variable.

When a post-hoc test using Tukey was performed, the retained transformational learning subjects of Group C ($M = 9.78, SD = 3.27$) showed a greater increase in positive ergonomic

behaviors in comparison to both the transactional ($M = 4.82$, $SD = 2.44$) and transmissional ($M = 3.00$, $SD = 2.15$) learning groups. No significant difference existed between the transactional group compared to the transmissional group. Table 4.16 shows the results of the ANOVA for positive behavioral differences among learning categories.

Table 4.16 Post-hoc Analysis for Positive Ergonomic Scan Behaviors

Learning Category	<i>n</i>	<i>M</i>	<i>SD</i>	Trans- missional	Trans- actional	Transfor- mational
Transmissional	20	3.00	2.15	-		
Transactional	11	4.82	2.44	NS	-	
Transformational	9	9.78	3.27	*	*	-

An * indicates significance at the .05 level. NS designates not significant.

Null Hypothesis 4b

The Personal Prevention Plan (PPP) scores demonstrated no difference between the transformational learning group (Group C) and the other study groups (Groups A and B).

Analysis of Null Hypothesis 4b

A one-way analysis of variance was conducted to evaluate the relationship between the personal prevention plan (PPP) scores and the classification of learning types. The ANOVA was significant, $F(2, 58) = 6.82$, $p = .002$. Findings suggest that the null hypothesis was rejected. The strength of the relationship between the learning category and the PPP scores, as assessed by η^2 , was strong, with the learning category accounting for 19.0% variance of the dependent variable.

When a post-hoc test using Dunnett's *C* was performed, the transformational learning group ($M = 76.4$, $SD = 19.1$) showed greater gains in PPP scores than did the transactional group ($M = 67.9$, $SD = 17.5$) or the transmissional group ($M = 42.5$, $SD = 37.9$). However, a significant difference only existed between the transmissional and transactional learners. (Recall that no additional learning occurred for the transformational learners, as compared to the transactional learners, at the stage when personal prevention plans were due.) Table 4.17 shows the results of the ANOVA for PPP score differences.

Table 4.17 Post-hoc Analysis for Personal Prevention Plan (PPP) Scores

Learning Category	<i>n</i>	<i>M</i>	<i>SD</i>	Trans- missional	Trans- actional	Transfor- mational
Transmissional	35	42.5	37.9	-		
Transactional	14	67.9	17.5	*	-	
Transformational	12	76.4	19.1	*	NS	-

An * indicates significance at the .05 level. NS designates not significant.

Figure 4.1 provides a boxplot of increasing means from the transmissional to the transformational learning groups, with the visual distribution of scores which display some amount of cross-over among each group represented in the study. Narrative themes that were captured in the prevention plans will be addressed in the related qualitative analysis in Chapter V to further assess differences among these groups.

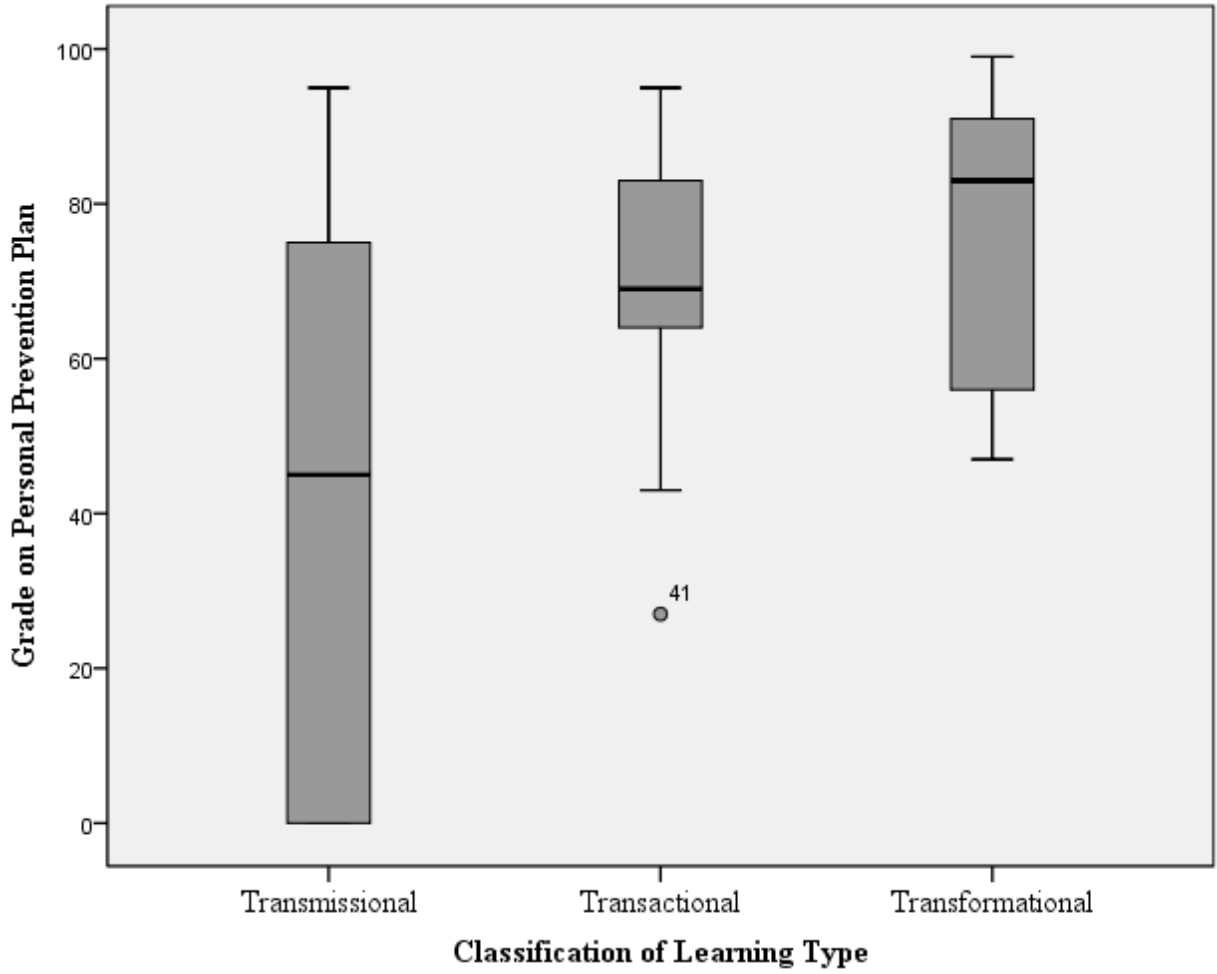


Figure 4.1 PPP Score Distributions and Means based upon Learning Classification

Research Question 5

How were student attitudes impacted by the interactions and reflections of the formative self and peer assessment process during the transformational learning stage?

Research Question 5a

Did learner self-reflections and collaborative peer reflections demonstrate a positive impact on learner attitudes concerning longer-term transformative assessment benefit?

VMA Question 1

Question 1 of the Video Mirroring Adjustment (VMA) survey specified the number of times the subject used the padcam (for still and/or video imaging) during the VMA to collaborate with peers on possible ergonomic issues that the subject was able to identify as a laboratory partner scanned.

The sample consisted of 31 VMA responses, conducted over a period of three laboratory scan sessions, from among the 12 transformational learning subjects of Group C. Table L.3 (Appendix L) shows the frequencies and percentages for the number of times the padcam was used (either through still or video imaging) to provide peer feedback regarding ergonomic scan habits. In 15 of the possible 31 responses (48.4%), subjects used the padcam 1-3 times; in eight of the 31 responses (25.8%), subjects used the padcam 4-6 times; six responses (19.4%) indicated that subjects' use was 7-10 times; and two responses (6.4%) designated the use as over 10 times during a scan session for feedback purposes. Of interest, there was never a scan session

in which subjects designated no use of the padcam. Within Appendix L, Table L.1 provides a synopsis of the VMA responses for each lab, where the practical padcam usage was ordinarily between 1 and 10 times ($M = 1.84$, $SD = .97$).

VMA Question 2

Question 2 asked the student evaluator to rate the following statement on a Likert scale of 1 to 5, with 5 designating the strongest agreement and 1 designating the strongest disagreement: I found today's experience in receiving ergonomic padcam feedback from my laboratory partner regarding my scan behavior to be informative and beneficial.

The sample consisted of 31 VMA responses, conducted over a period of three laboratory scan sessions, from among the 12 transformational learning subjects of Group C. Within Appendix L, Table L.4 shows the frequencies and percentages for the number of times survey respondents were in some level of agreement to the benefit of the padcam usage ($M = 4.71$, $SD = .46$) to better understand feedback of personal ergonomic scan habits. Twenty-two of the possible 31 responses (71.0%) strongly agreed to the statement, while nine (29.0%) somewhat agreed to the statement of personal benefit.

VMA Question 3

Question 3 of the VMA asked the student evaluator to rate the following statement on a Likert scale of 1 to 5, with 5 designating the strongest agreement and 1 designating the strongest disagreement: I perceived that my laboratory partner found the lab experience in receiving

ergonomic padcam feedback from me regarding his/her scan behavior to be informative and beneficial.

The sample consisted of 31 VMA responses, conducted over a period of three laboratory scan sessions, from among the 12 transformational learning subjects of Group C. Table L.5 of Appendix L shows the frequencies and percentages for the number of times survey respondents were in some level of agreement to the benefit of the padcam usage ($M = 4.68$, $SD = .48$) for observed peers to better comprehend ergonomic scan habits. Twenty-one of the possible 31 responses (67.8%) strongly agreed, while 10 of the 31 (32.2%) somewhat agreed to the statement of perceived peer benefit.

VMA Question 4

Question 4 of the VMA asked the student evaluator to rate the following statement on a Likert scale of 1 to 5, with 5 designating the strongest agreement and 1 designating the strongest disagreement: In regards to assisting me in identifying and discussing ergonomic behaviors, I found the addition of the padcam demonstrations in this activity to add benefit in enhancing visual and conceptual understanding.

The sample consisted of 31 VMA responses, conducted over a period of three laboratory scan sessions, from among the 12 transformational learning subjects of Group C. Table L.6 within Appendix L shows the frequencies and percentages for the number of times survey respondents were in some level of agreement to the benefit of the padcam usage ($M = 4.77$, $SD = .43$) to discuss and reflect upon ergonomic scan behaviors. Twenty-four of the possible 31

responses (77.4%) strongly agreed, while seven of the 31 (22.6%) somewhat agreed to the statement of perceived discussion and reflection benefit.

VMA Question 5

Question 5 of the VMA asked the student evaluator to rate the following statement on a Likert scale of 1 to 5, with 5 designating the strongest agreement and 1 designating the strongest disagreement: I could have as easily made adjustments to my ergonomics behavior by someone verbally explaining what should be corrected, rather than viewing myself engaged in those activities through video archiving.

The sample consisted of 31 VMA responses, conducted over a period of three laboratory scan sessions, from among the 12 transformational learning subjects of Group C. Table L.7 within Appendix L shows the frequencies and percentages for the number of times survey respondents were in some level of agreement to the benefit of the padcam usage ($M = 3.32$, $SD = 1.25$) as compared to receiving a verbal description to comprehend ergonomic scan behaviors. Six of the possible 31 responses (19.3%) strongly agreed, while 10 of the 31 (32.3%) somewhat agreed to the statement of perceived peer benefit. Five of the 31 (16.1%) were uncertain; eight (25.8%) somewhat disagreed; and two (6.5%) strongly disagreed.

Null Hypothesis 5b

The mean MSI risk rating from the end of the transactional stage of learning to the end of the transformational stage of learning exhibited no attitudinal differences among the transformational learners of Group C.

Analysis of Null Hypothesis 5b

A paired-samples *t* test was conducted to evaluate whether the MSI personal risk ratings of Group C's transformational subjects were the same at the end of the transactional learning stage (end of the first semester) as were the MSI personal risk ratings by the same learning group at the end of the transformational learning stage (end of the program year). The results, as shown in Table 4.18, indicated that the mean MSI rating at the end of the transactional stage ($M = 7.00$, $SD = 1.71$) was significantly greater than the mean MSI rating at the end of the transformational stage ($M = 5.08$, $SD = 1.44$), $t(11) = 2.92$, $p = .01$. Based upon these findings, the null hypothesis was rejected.

Table 4.18 Means and Standard Deviations of MSI Susceptibility Ratings according to the End of the Learning Stage

Group	<i>n</i>	<i>M</i>	<i>SD</i>
Transactional Stage	14	7.00	1.71
Transformational Stage	12	5.08	1.44

The standardized effect size index, d , was .85, though there was some overlap in the distributions for the 10-point Likert ratings between the learning stages, as shown in Figure 4.2. The 95% confidence interval for the mean difference between the two ratings was .47 to 3.36.

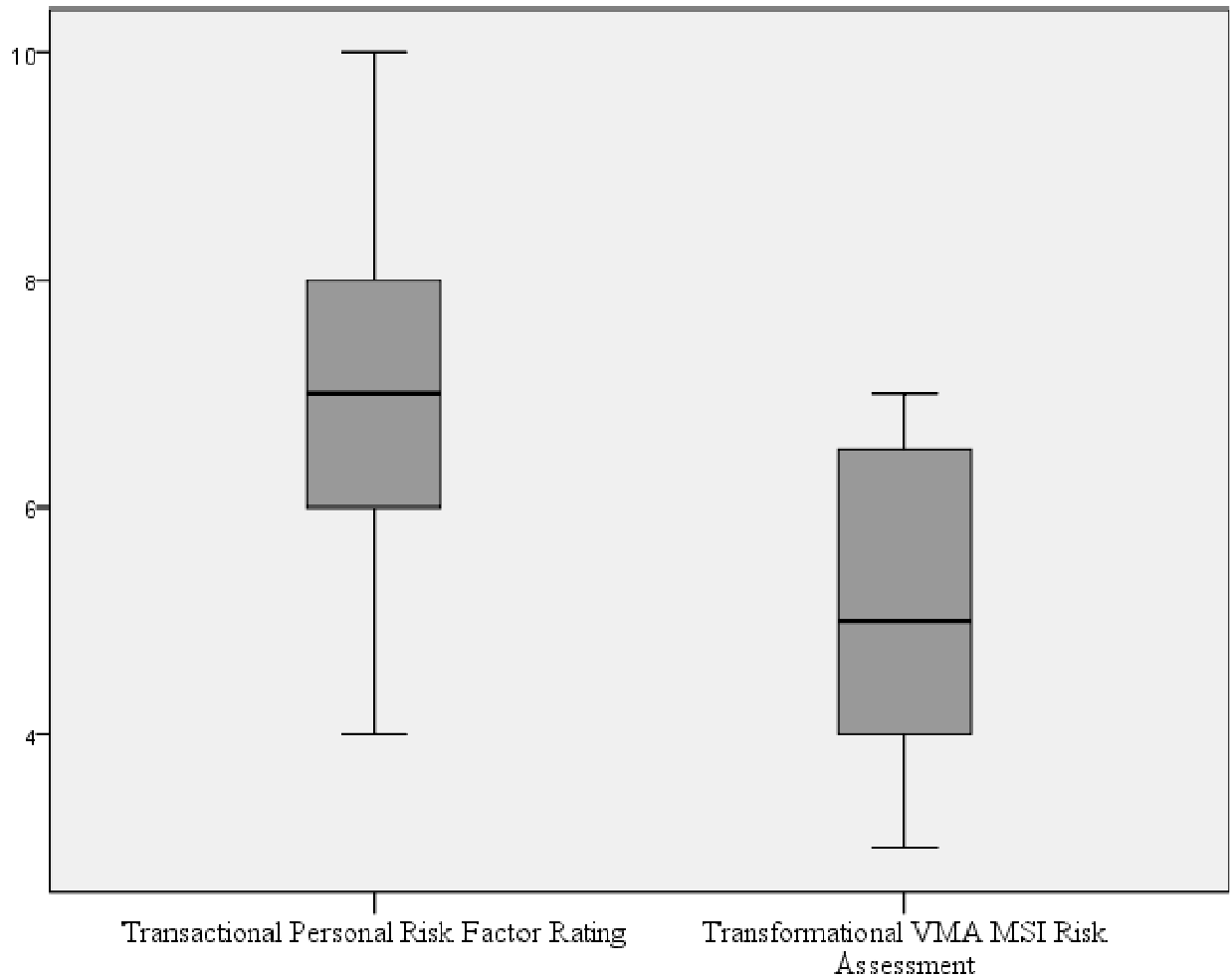


Figure 4.2 Boxplots of Group C's MSI Risk Factor Ratings from the Transactional to the Transformational Stages

Research Question 6

What patterns of responsiveness regarding injury awareness and prevention feedback were evidenced among program graduates at the time of final observation?

The researcher wished to look at this question from two different perspectives, requiring two different hypotheses to do so. First, the researcher was concerned that early career sonographers might express a greater interest in instituting corrective measures for poor ergonomic habits only after these practitioners had developed signs and symptoms of a WRMSD. Hypothesis 6a was used to evaluate this concern, in which a *t* test was conducted to test the graduates' perceived responsiveness to ergonomics feedback based upon whether or not there was a report of a musculoskeletal injury.

Based on the central research question surrounding the type of learning in which these graduates were involved, the researcher also wished to consider differences in responsiveness ratings according to learning classification. Since the transformational learners were more accustomed to engaging in collaborative feedback and making corrective measures based upon another colleague's assessment of that individual's behaviors, the researcher posited that this group might also demonstrate greater responsiveness toward corrective measures provided through evaluator feedback. To conduct this comparison among the three learning groups (A, B and C), the researcher performed an ANOVA for Hypothesis 6b.

Null Hypothesis 6a

Post-graduate sonographers who expressed concerns of work-related musculoskeletal disorders (WRMSDs) were perceived by the evaluator to demonstrate the same level of

responsiveness to ergonomic feedback at the final observation stage as sonographers who did not express WRMSD concerns.

Descriptive Statistics for Null Hypothesis 6a

The evaluator assigned a responsiveness rating at the time of the final observation to signify each graduate's perceived level of interest in receiving feedback toward identifying problematic ergonomic behaviors and corrective measures. This responsiveness rating was quantified as 0 if the graduate seemed resistant (or even argumentative) in regards to the feedback, 1 if the graduate responded in an ambivalent manner regarding feedback received, or 2 if the graduate appeared highly interested and reflectively interactive concerning feedback during or following the observation.

Of the 40 study subjects who were retained until final observation, 29 (72.5%) reported personal WRMSD concerns at this observation period of two to five years of scan experience. The 29 post-graduate subjects reporting WRMSD concerns in the final observation stage ($M = 1.55$, $SD = .57$) demonstrated nearly twice the rate of responsiveness to ergonomic feedback than did those 11 graduates (27.5%) who denied any WRMSD concerns ($M = .82$, $SD = .75$). The 95% confidence interval for the difference in means ranged from -1.18 to -.29. Table 4.19 provides the means and standard deviations for these two groups.

Table 4.19 Means and Standard Deviations of Ergonomic Feedback Responsiveness Ratings based upon Graduate Reports of WRMSD Concerns

Group	<i>n</i>	<i>M</i>	<i>SD</i>
Denial of WRMSD Concern	11	0.82	0.75
Report of WRMSD Concern	29	1.55	0.57

Analysis of Null Hypothesis 6a

An independent-samples *t* test was conducted to evaluate the null hypothesis that post-graduate sonographers expressing WRMSD concerns demonstrated the same level of responsiveness to ergonomic feedback as did those who did not express such concerns, where 0 designated resistance to feedback, 1 designated an ambivalent responsive to feedback, and 2 designated a responsive rating of high interest for receiving feedback from the expert observer. The test was significant, $t(38) = -3.32, p = .002$. These findings suggested that the null hypothesis was rejected.

Due to this small sample size, results should be interpreted with caution. Repeating this test with a larger sample size would be advisable. However, Figure 4.3 demonstrates that, within this sample, sonographers who had been scanning for two to five years did, in fact, demonstrate greater responsiveness toward prevention and corrective feedback measures when reporting personal injury concerns than did those sonographers who denied any personal WRMSD concerns.

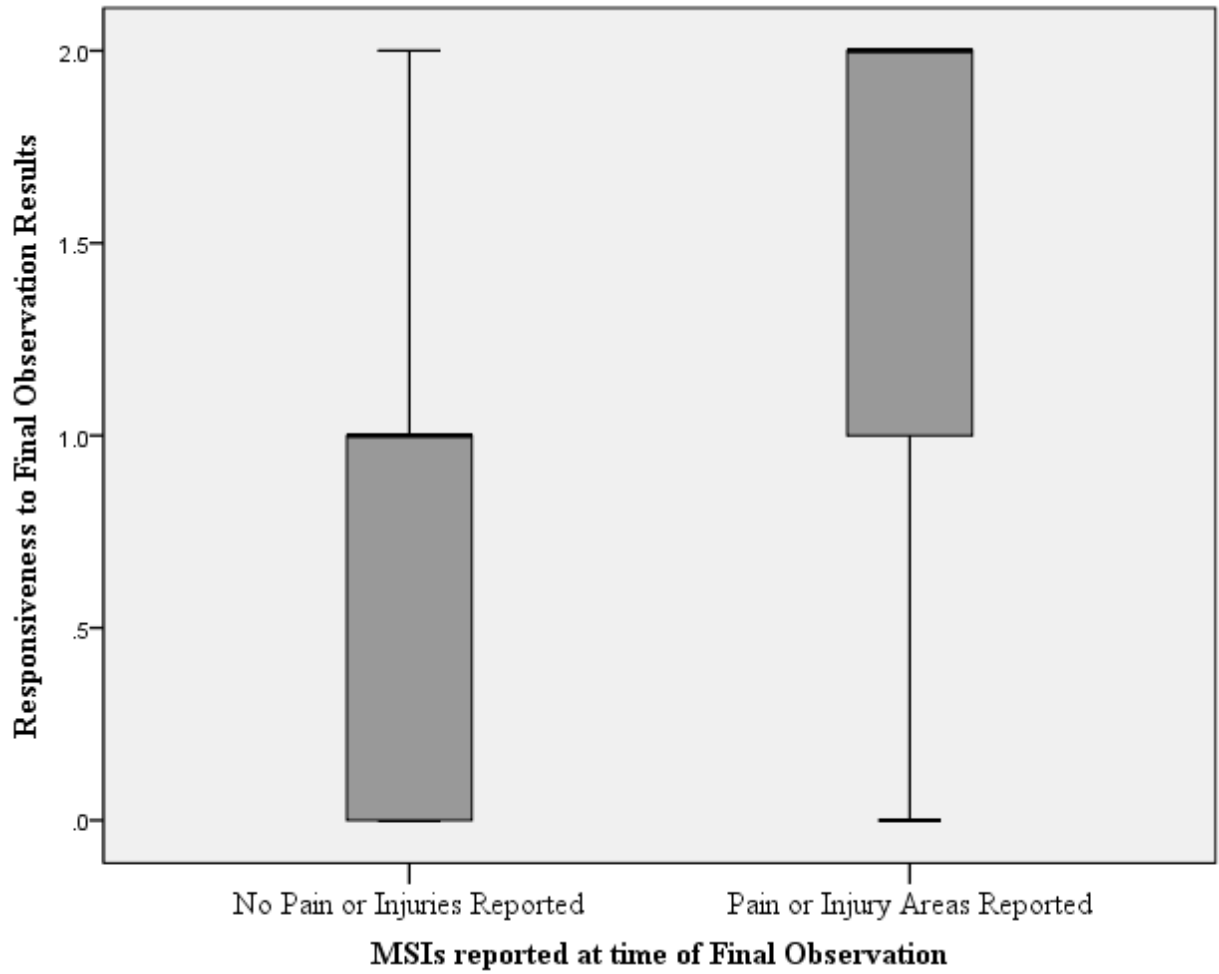


Figure 4.3 Boxplots of Responsiveness Ratings between Graduates Who Reported versus Those Who Did Not Report WRMSD Concerns during the Final Observation Stage

Null Hypothesis 6b

No difference existed between the evaluator responsiveness ratings of graduates regarding final observation feedback based upon the learning classification (Group A, B or C) in which the graduates had been formally engaged while in school.

Analysis of Null Hypothesis 6b

A one-way analysis of variance was conducted to evaluate the relationship between the study graduates' assigned responsiveness ratings following the final ergonomics observation and the classification of learning type in which each graduate was involved. The ANOVA was significant, $F(2, 37) = 4.12, p = .02$. These findings suggested that the null hypothesis was rejected. The strength of relationship between the learning category and the assigned responsiveness rating toward the observer's feedback, as assessed by η^2 , was strong, with the learning category accounting for 18.2% variance of the dependent responsiveness rating variable.

When a post-hoc test using Dunnett's *C* was performed, the retained transformational subjects of Group C ($M = 1.89, SD = 0.33$) showed a greater responsiveness rating in comparison to both the transactional subjects of Group B ($M = 1.27, SD = 0.65$) and the transmissional subjects of Group A ($M = 1.15, SD = 0.76$). Significance was only demonstrated between the transmissional and transformational groups, however, as displayed in the results for the responsiveness rating differences in Table 4.20.

Table 4.20 Post-hoc Analysis for Responsiveness Ratings among Graduate Learning Groups

Learning Category	<i>n</i>	<i>M</i>	<i>SD</i>	Trans- missional	Trans- actional	Transfor- mational
Transmissional	20	1.15	.75	-		
Transactional	11	1.27	.65	NS	-	
Transformational	9	1.89	.33	*	NS	-

An * indicates significance at the .05 level. NS designates not significant.

Summary

This chapter presented findings and statistical analyses of data garnered from Chattanooga State sonography students within a span of four program years, in which learners were classified according to type of ergonomic educational engagement. The learning group designations were transmissional (Group A), transactional (Group B), and transformational (Group C). In some instances, learners of Groups B and C were further sub-divided during the transactional learning stage according to participation status in a quasi-experimental PPG blood flow study. Multiple assessment tools were used to gather data according to learning progressions, as previously listed in Table 3.2, from the first semester of learning until two to five years of post-graduate scan experience among retained subjects. There was a 34.4% attrition rate among all of the research participants at the time of the final observation stage of two to five years' scan experience.

Several hypotheses were tested and descriptive statistics provided in an attempt to answer the six specific questions that were guided by the primary research question: What differences in learner attitudes and behaviors can be determined within the ergonomics work habitus frame of reference when comparing the transmissional, transactional, and transformational learning events

for the early career scanning sonographer? Results were analyzed and provided according to descriptions or null hypotheses developed for each question. Qualitative themes that may offer additional insight into these results have been addressed in Chapter V. Conclusions from these results, independent of and in consideration with, other findings have been further discussed in the final chapter.

CHAPTER V

QUALITATIVE ANALYSIS OF DATA

Introduction

This chapter provides the reader with enriched insight into narrative and observed themes discovered during various stages of ergonomics instruction among the designated learning groups. Prominent themes emerged from transactional pre-instructional and photoplethysmography (PPG) interviews, personal prevention plan (PPP) reflections, collaborative corrective plans of adjustment, and habitual ergonomic behaviors recorded during expert observations. Descriptions of identified work habitus factors have been classified as either commonly repeated findings that were anticipated by the researcher, or recurrent patterns that were unanticipated contributors to be further considered.

Though all qualitative findings are within the scope of the six specific research questions of this study, each qualitative analysis may intersect multiple questions and various hypotheses tested in Chapter IV. To assist the reader in synthesizing analyses from both chapters, transecting questions and hypotheses will be identified as these various themes are addressed:

- 1) the transactional stage's pre-instructional interview, with specified transmissional elements;
- 2) the transactional stage's PPG quasi-experimental interview findings;
- 3) the personal prevention plans' reflective findings, at the end of the first semester for all learning groups;

- 4) collaborative plans of adjustment from the VMA surveys, performed only among transformational learners in later semesters; and
- 5) observed clinical behaviors and descriptions of sonographer participants, along with work habitus discoveries, at the final observation.

Pre-Instructional Interview Findings

The pre-instructional interview (Appendix E) was a one-on-one event conducted after the initial scan observation and prior to any formal ergonomics learning. This event was designed for pre-instructional interaction, or the beginning of a transactional approach, with Group B (transactional) learners and Group C (transformational) learners. The interview was designed to assist both the researcher and learner in identifying personal early ergonomic professional beliefs. Group A (transmissional) learners did not undergo this process.

Within this interview, there were at least two pairs of questions designed for the transmission of information related to sonographer injuries. The pairing of Interview Questions 3 and 5, then the pairing of Interview Questions 7 and 8, allowed for testing and analyses of Hypotheses 2a and 2b in Chapter IV. For this reason, the qualitative feedback had direct association to Research Question 2: Did having transmissional knowledge of other sonographers' injuries and statistical injury risk rates influence early career sonographers' beliefs of personal susceptibility to injury?

Pre-Instructional Interview Question 1

Additionally, the interview began with Interview Question 1 (IQ1), which asked the learner to identify any scan-related pain or discomfort, and ended with Interview Question 10, reviewing the learner's scan behavior results conducted during the early expert observation. Comparisons were made to assess if any of the identified risks corresponded with reported discomfort areas. For this reason, this qualitative feedback also coincided with data gathered and analyzed in Chapter IV for Research Question 1: How closely did sonographers' pre-instructional scan complaints and risk behaviors correspond with final musculoskeletal complaints and risk behaviors of prior published professional injury rates? Since IQ1 was so thoroughly addressed within Chapter IV, additional related information presented in this section will be limited.

The remaining questions gleaned information from study participants to further comprehend ergonomic attitudes of early career sonographers upon entry into the field. Feedback was based upon initial clinical transactions and early transmitted learning.

Pre-Instructional Interview Question 2

Interview Question 2 asked for the learner's understanding of the ergonomics term as associated with scanning responsibilities of sonographers (prompting the participant to define the term).

Four (28.6%) of the 14 transactional learners from Group B did not attempt to define the ergonomics term. The remaining 10 participants (71.4%) from Group B demonstrated a fundamental understanding of applicability to body positioning in relation to equipment (though

not necessarily to the patient or to injury risk factors). One hundred percent of the transformational learners from Group C defined ergonomics in terms of computer or equipment usage, while nine (75.0%) of the 12 participants of Group C provided a minimal understanding of the applicability of ergonomics within the sonographer's work place setting in regards to optimal body positioning.

Pre-Instructional Interview Question 3

Interview Question 3 (IQ3) asked if the learner was personally aware of any sonographers who had experienced injuries related to repetitive scanning in the ultrasound environment. Interview Question 5 (IQ5) was cross-referenced with IQ3 in Null Hypothesis 2a of Chapter IV, which stated that transmissional knowledge regarding other sonographers' incidences of work-related musculoskeletal disorders (WRMSDs) demonstrated no relationship to belief patterns held by early career sonographers regarding personal risk perception of musculoskeletal injuries (MSIs). After personally contemplating known injuries from IQ3, IQ5 asked the learner to consider, Do you believe you are presently at risk for a musculoskeletal injury related to your professional duties?

As previously disclosed in the testing of Hypothesis 2a within Chapter IV, 17 (65.4%) of the 26 learners from Groups B and C claimed to have knowledge of at least one sonographer with a WRMSD. Nevertheless, when asked in IQ5 about one's own perceived susceptibility for risk in consideration of this knowledge, only 11 (42.3%) of the 26 cited belief of presently being at any risk for developing an MSI. Seven (26.9%) of the 26 cited no belief of personal risk for developing an MSI. An additional eight (30.8%) of the 26 were uncertain regarding personal risk

of developing an MSI. In fact, as Figure 5.1 reveals, the greatest frequency of early career sonographers citing the least amount of personal awareness about injuries among sonographers (black bar) were those learners who cited having a personal MSI risk belief.

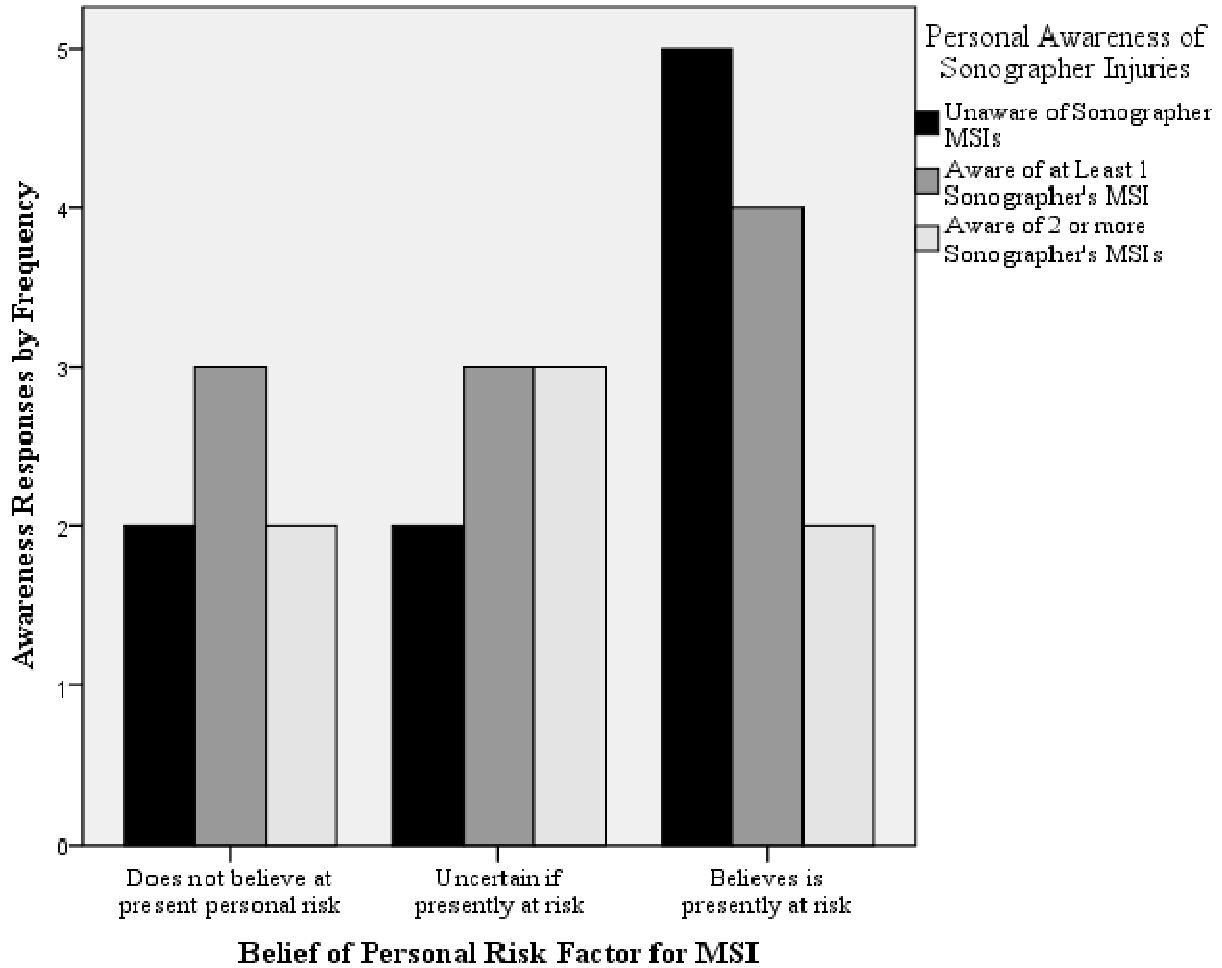


Figure 5.1 Learner's Personal MSI Risk Belief based upon Awareness of Sonographer Injuries

Shoulders and wrists were the most commonly cited injury categories among the sonographers with whom the learners of both the transactional and transformational groups interacted, with backs and necks mentioned the next most frequently. Surgical intervention was described by the learners in multiple numbers of these cases. Irrespective of such reports, all early career sonographers within this study were hesitant to cite any belief for personally developing an MSI, as demonstrated in the statistical data of Chapter IV. A crucial representative transactional remark was provided from an early career participant who reported not knowing of a sonographer with an injury, and then responded about personal injury concerns by saying, “Not yet. A [sonographer] commented that, by the time I was 30, I’d probably have carpal tunnel [syndrome]. Someone said their wrist bothered them at first, but you just build up to it and it no longer hurts.”

Pre-Instructional Interview Question 4

Interview Question 4 was a reasonable extension of IQ3, following up with: If you know of a sonographer with a WRMSD, do you believe there were individual, personal circumstances surrounding this injury, or do you believe any sonographer’s duties place her/him at the same risk for a work-related injury?

Among those taking part in the pre-instructional interview, whether from Group B or C, three (11.5%) of the 26 respondents cited uncertainty of whether contributing risk factors were due to personal circumstances. Eight (30.8%) of the respondents believed that personal circumstances attributed to the injury. One of these respondents further explained that the sonographer’s awareness of body positioning would make a difference, while another described

that the sonographer's body habitus could make a difference. A third participant responded that outside stressors could be a contributing factor, while another later cited that injuries were "just the luck of the draw." The remaining 15 respondents (57.7%) cited beliefs that any sonographer would be at similar risk for becoming injured on the job, though none seemed to be able or willing to expand upon this reasoning. An important belief to ponder came from a student who stated, "Everyone is subject to sacrificing their own body for the betterment of their patient. You'll go out of your way to make your patient more comfortable, regardless of the price to your body." Current sonography injury rates do not appear to refute this respondent's claim.

Pre-Instructional Interview Question 5

IQ3 through IQ5 were important elements to capture learner beliefs based upon clinical transactions. As Carey & McCardle (2011) expressed, "Students and faculty alike view the field experience as the critical step in the development of a social work identity" (p. 357). Learners were interrogated through IQ5 about personal risk beliefs based upon transactional clinical knowledge of known sonographers' injuries, with responses already depicted in Figure 5.1. Three (11.5%) of the 26 subjects provided responses as to why each did not possess a personal risk attitude, three additional respondents (11.5%) indicated uncertainty of personal risk, and seven (26.9%) of the study participants gave statements exhibiting hesitation of belief. Specific participant statements in each of these categories are located in Appendix M.

Pre-Instructional Interview Question 6

Interview Question 6 prodded learners to consider what would enhance personal risk belief when asking, What circumstances do you believe would place you at risk either now or at some point in the future?

Participants identified many problems encountered during the early scan observation, despite the fact that learners had not yet viewed results from the primary expert observation, and despite a large number of study participants earlier denying personal risk concerns. The researcher perceived this question to be the most difficult for respondents to answer, based upon the extended pauses and the use of “if” qualifiers prior to the responses. Even when answering, responses were worded more hypothetically (or others-oriented) than personally, with learners providing scenarios about others instead of scenarios based on the belief of personal susceptibility. Nevertheless, categorical circumstances (in which individual respondents could provide more than one idea) of which the 26 study participants believed would increase personal MSI risk were:

- 1) Poor posture or improper body mechanics (8 responses);
- 2) Poor transducer grip or extended grip compression (e.g., scanning obese patients) leading to carpal tunnel syndrome (8 responses);
- 3) Shoulder hyperabduction (reaching) due to patients who cannot reposition themselves, who are not asked to reposition themselves, or because the sonographer is of a short stature, thus forced to overextend one’s reach (5 responses);
- 4) Lack of microbreaks (failure to pause or reposition while scanning), particularly when pain or discomfort became evident (4 responses);

- 5) High work productivity demands, with pressure to do more exams in less time and/or being hurried to complete the current patient on the scan table (3 responses);
- 6) Lack of forearm/elbow support during scanning (1 response); and
- 7) Prolonged repetitive motions (1 response).

Table M.1 in Appendix M further provides the study participants' hypothetical responses as compared to the expert observer's findings.

Pre-Instructional Interview Questions 7 and 8

Interview Question 7 (IQ7) asked, Do you know the published rate of musculoskeletal injuries among all sonographers? Interview Question 8 (IQ8) followed up by providing the published rate and then asking, Does that change your opinion of your own personal risk factor? IQ7 and IQ8 were cross-referenced as part of Chapter IV's testing of Hypothesis 2b, Transmissional knowledge regarding other sonographers' published rates of work-related musculoskeletal disorders (WRMSDs) demonstrated no relationship to belief patterns held by early career sonographers regarding personal risk perception of musculoskeletal injuries (MSIs). Beyond the results revealed in Chapter IV, there were some pertinent qualitative points to add in regards to IQ8, when the interviewer transmitted the approximated 80.0 to 90.0% sonographer injury rate.

In response to IQ7 of the interview, only three (11.5%) of the 26 subjects involved in the early transactional interview were able to cite a statistical rate of sonographer injuries within a reasonably close range of published data. After being made aware of the approximated injury rate among sonographers, 15 subjects (57.7%) maintained the earlier perception of stated risk

injury from IQ5, while 11 subjects (42.3%) were undecided about the possibility of any personally increased risk.

Seven of the 15 subjects who did not cite an increase in susceptibility were firm in this stated belief, displaying no hesitation in response. One participant hesitated before deciding that the statistic could not be disputed, but argued that there would be no increased risk if that individual “[adjusted] some things.” Another who denied the possibility of being included in that statistic stated, “You just put it in the back of your mind that it’s not going to happen to you.” Some participants began citing proactive prevention measures, such as “I need to begin exercising to build up my muscles again.” Others were less specific in determined action, such as, “I have to figure out how to prevent it.” These responses provided some evidence of belief pattern reformation toward realization in the need for changed behaviors as prevention.

Of those 11 subjects in the undecided category, the majority would not confirm or negate any change in opinion. Two nearly acquiesced, with one responding to “possibly a little” more risk concern and another answering, “maybe, I think.” The majority of comments tended to lean toward denial of personal susceptibility, many again making others-focused comments instead. Specific comments among those citing lack of certainty in changed risk are located in Appendix M. Within these comments, the lack of personalization in the statements about “them” or “sonographers,” the “probably” qualifier, and the minimizing statement of “every job” tended to emphasize the denial sequela associated with the Health Belief model’s intent.

When initially provided with the published range of rates of sonographer MSIs, then asked if that information changed the opinion of one’s personal risk factor, there was a pause in 100.0% of the responses. Except in the three cases where learners were already aware of the

injury rate, the initial responses generally (in 20 of the remaining 23 instances) began with filler sounds or phrases, as also listed in Appendix M.

Pre-Instructional Interview Question 9

Such raw responses of being caught off-guard by potential injury risks gave way to the nature of Interview Question 9 (IQ9), Does that percentage of injuries cause you to believe that you will still be able to scan, pain-free and injury-free, as a sonographer 20 years from now? IQ9 was an attempt to get study participants to consider future consequences, in the event the early learners could not yet relate to injury susceptibility in the immediate timeframe. At this point, only five (19.2%) of the 26 participants stated a belief of scanning pain-free and injury-free throughout a career-long period. Each of these five respondents attributed awareness and corrective action to the reduction of risk as reasons for a future career void of WRMSDs. Twelve of the respondents (46.2%) cited belief of scanning at some level of pain in the future due to a MSD, though there were still attempts made to minimize the possibility. The “if” and “probably” qualifiers emphasized this minimization of belief. The remaining nine respondents (34.6%) would not commit to a direct answer. Based on the responses received, participants appeared to rely more on hope, luck, or leaving the field as the only preventative courses of action against personal injury. Specific statements have been included in Appendix M.

Pre-Instructional Interview Question 10

Interview Question 10 (IQ10) asked the learner to look at the personal results from the pre-instructional expert observation. This was, in fact, a transactional discussion opportunity for the researcher to review each participant's scan behavior frequencies during the initial expert observation to compare with any learner-reported pain or discomfort areas. Information gained from this interview segment directly corresponded with Research Question 1: How closely did sonographers' pre-instructional scan complaints and risk behaviors correspond with final musculoskeletal complaints and risk behaviors, with comparative consideration given to prior published professional injury rates?

Participants were generally positive toward this review segment, becoming engaged in viewing individual results and providing thoughtful responses about changes that could be made in scan behavior. Within the transactional group (Group B), three (21.4%) of the 14 respondents did not believe that expert observations matched the reported discomfort areas. The remaining 11 transactional respondents (78.6%) cited a match between the comparison with observed behaviors and reported concerns. A sampling of the feedback received from transactional participants is included in Appendix M.

The methodology was changed for the transformational group (Group C), in which the learner and a learning partner performed a self-assessment and peer-assessment using the video of the initial expert observation, while using the same observer tool, to compare collaborative results to those provided by the expert. Participants appeared to interact positively with peers when reviewing personal observations together and comparing problematic behaviors to reported discomfort areas. In 100.0% of cases, the transformative learners cited a match between the comparisons of observed behaviors and reported concerns. The majority of feedback comments

came at the conclusion of the second expert observation, when learners again reviewed findings and began to express comments of relief. Such comments denoted more hopefulness, not according to the luck of the draw, but rather according to learners' recognition of behaviors, thus personal empowerment, toward positive work habitus adjustments for transformation. A sampling of the feedback received from transformational participants is also included in Appendix M.

PPG Quasi-Experimental Interview Findings

Of the 26 subjects originating from the transactional learners (Group B) and the transformational learners (Group C), 11 were engaged in a quasi-experimental PPG study at the transactional learning stage. The participants designated as the experimental sub-group viewed personal blood flow recordings in each subjects' own fingertips while using both neutral and negative scan maneuvers to assess for diminished flow. Six of the 11 conducting the PPG flow studies were from the transactional (Group B) learning classification, while the remaining five were from the transformational (Group C) learning classification. The remaining 15 subjects from both learning classifications, who were not involved in the PPG analysis, served as the control group.

The PPG interview was closely tied to Research Question 3: Could differences in MSI perceptions and risk behavioral changes be detected at the transactional post-instructional stage based upon learners' participation in the PPG diminished blood flow quasi-experiment? The additional four questions addressed in this section were posed to the PPG participants to challenge learners to further gauge susceptibility beliefs according to supplementary knowledge

gained through a personalized health consequence experience, and to assist in further comprehending attitudes of the early career sonographer upon entry into the field.

PPG Interview Question 1

PPG Question 1 provided opportunity for the learner to interpret personal blood flow findings from the baseline volume through the two challenging scan maneuvers (as demonstrated in Figure L.3). Through such means, the researcher assessed the participant's ability to understand that diminished vascular supply could create atrophy of muscles and nerve damage when habitually repeating or sustaining similar behaviors, thus increasing personal risk for MSDs. Table M.2 (Appendix M) provides the categorization of comments by themes of explanations, with frequencies designated by learning classification.

Without exception, 100.0% of the 11 participants among the two groups had no trouble identifying the decreased changes in blood flow volume during the two scan maneuvers. Three of the nine participants who cited losses of sensation from the joint strain also mentioned a feeling of coldness or numbness in the fingertips following the two maneuvers. Two of these participants discerned a direct comparison of findings with the handout description provided prior to the experiment, both nearly stating verbatim, "Continued blood loss will result in degeneration of muscles and nerves over the years." Four subjects complained of muscle fatigue from this short experiment.

PPG Interview Question 2

PPG Question 2 was closely tied to the Likert scale results tested in Null Hypothesis 3a of Chapter IV: The photoplethysmography (PPG) flow study participants' mean self-susceptibility rating for MSI risks was the same as for those who did not participate in the quasi-experimental blood flow study. After researcher assurance of learner comprehension of the personal blood flow volume differences in PPG Question 1, the participant was asked PPG Question 2: After the assessment of your personal findings in this experiment, do you believe that you are presently at risk for a musculoskeletal injury related to your professional duties?

Ten (90.9%) of the 11 participants who were engaged in the PPG experiment affirmed being at greater risk for musculoskeletal injury, with eight (72.7%) being quite definitive in affirmation. One of the transactional students proclaimed, "Unless I do some major changing, [my MSI risk factor] is a 10. Just hope it's not career ending." The eleventh respondent admitted to probably being at greater risk, but also hoped the risk could be lessened - continuing on the theme of hope rather than stating any direct action, though action may have been implied. The theme of hope was not viewed in a completely negative light by the researcher. Hope for better probable outcomes may have also designated that these learners were considering personal consequences and calculating the benefits and costs of making changes, as addressed in Hancock's Ergonomics Injury Belief Enhancement Model (Figure 2.1).

There was a difference in descriptive responses between Group B's (transactional) PPG participants compared to Group C's (transformational) PPG respondents. In the transactional group, one subject expressed surprise that discomfort was associated with reduction in blood flow, another admitted to still being uncertain if improvement in behaviors could reduce risk, and the participant denying risk from the experiment explained that anyone would remain at the same

risk. One transactional learner did not seem to have developed a reasonable perception of susceptibility because the learner did not yet seem to have developed a reasonable perception of career duties. Though the sonography student was already spending approximately 30 hours per week in the scan environment, the learner stated, “I believe that my risk will be around 3 or 4 if I try to develop better ergonomic skills before I begin my career as a sonographer.”

The transformational learners tended to express belief in ultimately less risk when taking immediate corrective action to change poor behaviors. At least one respondent admitted to possibly waffling to a comfortable mid-range risk number, responding to the requested personal MSI risk factor as, “Probably a 5, that is if I continue to practice good ergonomic habits. But even with good ergonomics, there is always a risk.” Bolder representative comments to denote the ability to take corrective action came from four Group C participants, as included in Appendix M. Such attitudes of empowerment were later cited by these four members of the transformational group as the reason for decreasing personal MSI risk ratings in discussion with the researcher. The researcher was led to believe that these explanations may have had an impact on the findings of Null Hypothesis 5b: The mean MSI risk rating from the end of the transactional stage of learning to the end of the transformational stage of learning exhibited no attitudinal differences among the transformational learners of Group C, where some transformational ratings decreased. Three of the transformational learners went on to explain the urgency to make a change, in which specific statements may also be found in Appendix M.

The most commonly cited problems involved scan positions and scan compression. The problem that most often arose in discussions, in which learners expressed little control, was the perceived increase of obese patients, where sustained compression could not be avoided. Those who brought this topic to light, however, agreed with the researcher that additional microbreaks

throughout the study could allow for periodic restoration of blood flow. Table M.3 (Appendix M) provides categorized patterns of stated associated risk susceptibility behaviors identified from the PPG study, where frequencies of thematic responses are also designated by learning classification.

PPG Interview Question 3

PPG Question 3 extended on the theme of corrective actions, asking the participant to identify what changes could be made to reduce the likelihood of work-related injuries. A relationship was expected to exist between the reflection opportunity within this segment and the testing of Null Hypothesis 3c: The PPG flow study participants exhibited the same frequencies of observed ergonomic risk behaviors from the pre-instruction to the post-instruction transactional observation stage, as compared to those who did not participate in the quasi-experimental blood flow study.

All respondents (100.0%) agreed that intentional changes could be made. The majority of subjects in both Groups B and C mentioned the reduction of reaching for the patient or the equipment through closer positioning. Table M.4 (Appendix M) lists all the suggested corrective personal action themes verbalized by the PPG participants, with frequencies identified within each of the learning groups.

Five respondents (45.5%) expressed multiple negative behaviors that had been visualized with the researcher during self-review, providing some level of evidence in consideration of instructor corrected guidance. One participant's declaration provided compelling evidence

toward transformational belief in regards to behavioral feedback: “This is definitely at the forefront of my mind whenever I am scanning now.”

PPG Interview Question 4

PPG Question 4 asked the learner: What is your response to the findings of this experiment and the results you have received so far, in general? This question was posed as an opportunity for the subjects to reflect upon instructional learning, to date, prior to fulfillment of the Personal Prevention Plan (PPP) self-reflective writing assignment. The most common response among subjects in Groups B and C was the increased awareness of personal injury risk. Table M.5 (Appendix M) provides a comprehensive listing of thematic responses, designated by frequencies within the learning groups.

One transformational participant showed evidence of value expectancy considerations, in calculating costs of certain behaviors over time: “I’m scared. With 10 hour days, 10 patients per day, 3 to 4 minutes on each patient like this, this is a significant amount of time without blood flow.” Another demonstrated some transformation in attitude based on personal benefit gained: “This was helpful. I didn’t think this would be a big issue in the beginning. I was wrong.”

Personal Prevention Plan Findings

The Personal Prevention Plan (PPP) allowed for comprehensive learner reflections among all of the categories of learners (Groups A, B and C), though not defined as a transformational learning progression element within the scope of this study due to differences in

various groups' engagement at this instructional stage. Quantitative analyses were addressed in Chapter IV in relation to the PPG experiment within the testing of Null Hypothesis 3b: No significant difference existed between the mean personal prevention plan (PPP) score of the PPG flow study participants and the PPP mean score of those who did not participate in the PPG study. More comprehensively, in assessing and comparing all learning groups, the quantitative testing of Hypothesis 4b in Chapter IV should have been influenced according to qualitative findings which expressed dominance in this segment of the study. Null Hypothesis 4b stated, The PPP scores demonstrated no difference between the transformational learning group (Group C) and the other study groups (Groups A and B).

Whereas the personal prevention plan grades provided the data components for testing the aforementioned hypotheses, PPPs from learners of each of the three designated learning groups – transmissional (Group A), transactional (Group B), and transformational (Group C) – were assessed to identify prominent, recurring qualitative patterns in regards to attitudes and behavioral plans, particularly in searching for any differences among groups.

Of mention, the PPP assignment and rubric were posted on the ergonomics module platform for all groups to view at the transmissional stage of ergonomics learning. Such transparent availability could have skewed the outcomes, as individual participants could have completed this exercise at any time during instruction, rather than completing the assessment at the end of each group's designed instructional stage, as assigned and as intended by the researcher. To calculate results, the researcher conducted a blind review of papers to identify PPP patterns (in which the reviewer was unaware of each author's identity), as designated by availability disclosed in Table 5.1.

Table 5.1 Availability of Personal Prevention Plans for Review by Learning Designation

Group	Learning Designation	<i>n</i>
A	Transmissional	25
B	Transactional	15
C	Transformational	10
Total Among Groups		50

Themes were sorted, with PPP authors later identified by group based upon an assistant's assigned numerical coding. Nine prominent themes were identified by the researcher. Themes will be addressed numerically, with group descriptive statistics provided for each.

PPP Theme 1

- 1) The learner's personal prevention plan was primarily written in third person, rather than in first person to be deemed as a personalized plan for the author.

Though the third person is an appropriate method for research writing, this assignment was meant to represent a journal of personal beliefs and actions. The written instructions for the assignment's rubric (Appendix D) reminded the learner: Remember that this should be written as a reflection for your personal benefit, so that you can use the new knowledge that you've gained for your future benefit. As well, each criterion in the rubric emphasized personalization for the highest amount of categorical points. Table 5.2 shows the related descriptive statistics by sample group responses and percentiles.

Table 5.2 Personal Prevention Plan Descriptive Statistics for Theme 1

Group	Learning Designation	<i>n</i>	Percentile Within Group (%)
A	Transmissional	17	68.0
B	Transactional	7	46.7
C	Transformational	7	70.0
Total Among Groups		31	62.0

Subjects from the transformational group (70.0%) and transmissional group (68.0%) demonstrated greater percentages of making third person statements in comparison to those in the transactional group (46.7%). Appendix M contains subjects' specific statements, categorized by group designation, with the individual number representing nothing more than the order in which the assignment was recorded from any particular group (A, B, or C). Table M.6 provides pertinent examples for transmissional learners, while Table M.7 contains the examples of the transactional learners, and Table M.8 of the transformational learners.

PPP Theme 2

- 2) The learner used rote repetition of transmitted information from the ergonomics module, without additional critical reflection of personal meaning for present resolution of an issue or for future career considerations.

The researcher expected transmissional learning elements to be present within the ergonomics module, as the recall of base knowledge is essential for the development of awareness. However, statements were categorized as rote repetition with no evidence of learner meaning when modular information was supplied without inclusion of reflective personalization,

or without attempts toward resolution of any stated problem. Table 5.3 shows the related descriptive statistics by sample group responses and percentiles.

Table 5.3 Personal Prevention Plan Descriptive Statistics for Theme 2

Group	Learning Designation	<i>n</i>	Percentile Within Group (%)
A	Transmissional	20	80.0
B	Transactional	8	53.3
C	Transformational	5	50.0
Total Among Groups		33	66.0

Table 5.3 reveals that the greatest percentage, by group, of rote repetition from transmissional modular information was provided in the PPPs submitted by transmissional learners (Group A). Approximately one-half of the other two learning classification participants' PPPs also contained evidence of rote repetition without personalization or resolution. Within Appendix M, Table M.9 provides pertinent examples for transmissional learners; while Table M.10 contains examples from transactional learners, and Table M.11 from transformational learners. Admittedly, a large number of these statements could have also been included in Theme 1, but the researcher has attempted to best classify examples only once within the most applicable category.

PPP Theme 3

- 3) The learner used statements that were construed as lack of empowerment on the part of the author to make corrective changes.

The transactional (Group B) learners demonstrated the greatest percentage of non-empowerment statements (73.3%), with transmissional (Group A) learners rating the second by percentage (56.0%) to express a lack of empowerment in changing behaviors. Table 5.4 shows the related descriptive statistics.

Table 5.4 Personal Prevention Plan Descriptive Statistics for Theme 3

Group	Learning Designation	<i>n</i>	Percentile Within Group (%)
A	Transmissional	14	56.0
B	Transactional	11	73.3
C	Transformational	4	40.0
Total Among Groups		29	58.0

To assist the reader in further comprehending the researcher's classifications of non-empowerment statements, Table M.12 of Appendix M provides pertinent examples for transmissional learners; Table M.13 contains the examples of the transactional learners, and Table M.14 of the transformational learners.

PPP Theme 4

- 4) The learner either misinterpreted the meaning of the ergonomics-related finding, as presented within the PPP, or expressed fear or doubt in the ability to correct the issue.

The transformational (Group C) learners demonstrated the least percentage of statements related to misinterpretation or doubt regarding ergonomics issues (10.0%), while the transmissional (Group A) and transactional (Group B) learners both had 20.0% each in such types of statements. Table 5.5 shows the related descriptive statistics.

Table 5.5 Personal Prevention Plan Descriptive Statistics for Theme 4

Group	Learning Designation	<i>n</i>	Percentile Within Group (%)
A	Transmissional	5	20.0
B	Transactional	3	20.0
C	Transformational	1	10.0
Total Among Groups		9	18.0

To assist the reader in further comprehending the researcher's classifications of learners' misinterpretation of fear and doubt when dealing with ergonomic issues, Table M.15 (Appendix M) provides pertinent examples for transmissional learners; Table M.16 contains the examples of the transactional learners, and Table M.17 of the transformational learners.

PPP Theme 5

- 5) The learner expressed strong, positive, definitive statements that affirmed the benefit of ergonomics awareness.

The prominent themes discovered within the PPPs were not all negative in nature, as was the case for Theme 5. The percentile of transformational learners (Group C) was greatest (60.0%) in affirming the benefit of personal ergonomics learning, compared to the transactional learners (33.3%) and the transmissional learners (28.0%). Table 5.6 shows these related descriptive statistics.

Table 5.6 Personal Prevention Plan Descriptive Statistics for Theme 5

Group	Learning Designation	<i>n</i>	Percentile Within Group (%)
A	Transmissional	7	28.0
B	Transactional	5	33.3
C	Transformational	6	60.0
Total Among Groups		18	36.0

To further assist the reader in understanding the basis by which the researcher classified strong, definitive ergonomic statements, Table M.18 (Appendix M) provides pertinent examples for transmissional learners; Table M.19 contains the examples of the transactional learners, and Table M.20 of the transformational learners.

PPP Theme 6

- 6) The learner identified specific corrective actions of personally identified ergonomic issues, demonstrating critical reflection toward resolution.

The correction of risk behaviors was the ultimate outcome measure of this study, as related to belief patterns. Therefore, this was an important theme to recognize as present. Both the percentile and the frequency of responses in identifying corrective measures for negative scan behaviors increased from transmissional (16.0%) to transactional (46.7%) to transformational (90.0%) learners. Table 5.7 shows the related descriptive statistics.

Table 5.7 Personal Prevention Plan Descriptive Statistics for Theme 6

Group	Learning Designation	<i>n</i>	Percentile Within Group (%)
A	Transmissional	4	16.0
B	Transactional	7	46.7
C	Transformational	9	90.0
Total Among Groups		20	40.0

To further assist the reader in understanding the basis by which the researcher classified learner identification of corrective measures toward resolution of ergonomic issues, Table M.21 (Appendix M) provides pertinent examples for transmissional learners; Table M.22 contains the examples of the transactional learners, and Table M.23 of the transformational learners.

PPP Theme 7

- 7) The learner provided vague descriptions without synthesis of importance within the scheme of the personal prevention plan.

In the case of this theme, learners may have demonstrated more than rote repetition of instructional components, yet the researcher was not convinced the learner provided evidence of synthesis, or deriving more complex meaning through reflections. Eighty percent of Group C's learners engaged in this writing habit of vague expression, along with 52.0% of Group A's learners and 46.7% of Group B's learners. Table 5.8 shows the related descriptive statistics.

Table 5.8 Personal Prevention Plan Descriptive Statistics for Theme 7

Group	Learning Designation	<i>n</i>	Percentile Within Group
A	Transmissional	13	52.0%
B	Transactional	7	46.7%
C	Transformational	8	80.0%
Total Among Groups		28	56.0%

All included examples serve to assist the reader in understanding the basis by which the researcher classified vague descriptions by lack of learner synthesis, or by redundancy of thought patterns with little meaning. Located in Appendix M, Table M.24 provides pertinent examples for transmissional learners; Table M.25 contains the examples for the transactional learners, and Table M.26 for the transformational learners.

PPP Theme 8

- 8) The learner made alarming statements, on the basis of poor ergonomic beliefs or practices that could contribute to musculoskeletal injuries.

Beyond a simple misunderstanding of information, there were certain reflective statements that raised flags to the researcher. Some of these reflective statements seemed to demonstrate a lackadaisical tone toward corrective action considerations or possibly even promotion of poor ergonomic behaviors. Other issues involved reflections failing to coincide with the known history of the work environment’s actions or reflections, demonstrating a lack of support for or input from sonographers toward corrective action. Table 5.9 shows the related descriptive statistics.

Table 5.9 Personal Prevention Plan Descriptive Statistics for Theme 8

Group	Learning Designation	<i>n</i>	Percentile Within Group (%)
A	Transmissional	6	24.0
B	Transactional	5	33.3
C	Transformational	1	10.0
Total Among Groups		13	26.0

Alarming descriptions were written by 33.3% of the transactional learners of Group B, 24.0% of learners classified as Group A’s transmissional learners, and only one, or 10.0%, of Group C’s transformational learners. To further assist the reader in understanding reflective remarks that were most alarming to the researcher, Table M.27 (Appendix M) provides pertinent examples for transmissional learners; Table M.28 contains the examples of the transactional learners, and Table M.29 of the transformational learners.

PPP Theme 9

- 9) The learner made statements within the personal prevention plan that provided strong evidence of positive clinical transactions that could benefit both the learner and scanning colleagues.

The personal prevention plan assignment was due at the end of the first semester for all learners. At this time, the transmissional learners (Group A) would have concluded the transmissional ergonomics learning module; whereas the transactional (Group B) and transformational (Group C) learners would have completed the transactional learning stage. Clinical transactional benefit was an important theme for the researcher to confirm, especially if this theme was more prevalent among the transactional and transformational learners by greater frequencies and percentages than were demonstrated by the transmissional learners. Table 5.10 shows the related descriptive statistics.

Table 5.10 Personal Prevention Plan Descriptive Statistics for Theme 9

Group	Learning Designation	<i>n</i>	Percentile Within Group (%)
A	Transmissional	4	16.0
B	Transactional	9	60.0
C	Transformational	8	80.0
Total Among Groups		21	42.0

The transformational learners documented strong evidence of beneficial clinical interactions related to instructional engagement in 80.0% of the submitted PPPs; and the transactional learners also documented strong evidence in 60.0% of the submitted reports. Only 16.0% of the transmissional learners documented evidence of strong clinical interactions. This

discrepancy may be a result of the other two groups (B and C) engaging in conscious transactional learning events, of which Group A was not instructionally included. To further assist the reader in understanding reflective remarks that denoted strong clinical transactions, Table M.30 (Appendix M) provides pertinent examples for transmissional learners; Table M.31 contains the examples of the transactional learners, and Table M.32 of the transformational learners.

Video Mirroring Adjustment Reflections

After all first semester ergonomics instructional components had been achieved, the transformational learners (Group C) continued with the upper level of learning progression tiers. The goal of this transformational learning stage was to allow for enhanced opportunities of self-reflection and transactional collaboration with peers over an extended learning timeframe. The researcher postulated that such conditions might allow for improved belief patterns concerning awareness and health to evolve toward solidified behavioral patterns with a longer-term positive work habitus response. Transformational learning progressions also removed the responsibility of behavioral evaluations from the instructor, and transferred these duties to learners to reinforce collaborative practice in identifying concerns and developing solutions. Transformational learning progressions included:

- 1) an enhancement of the personal viewing session of the post-instructional observation video at the end of the first semester (the end of the transactional learning stage), in which the learner used the observation guide to perform a self-assessment of

- behavioral frequencies in conjunction with one or two peers, reflecting upon one another's results;
- 2) three laboratory scan sessions, with learners using *iPads* to input ergonomics behavioral frequencies of a scan partner, while using the padcam application for video or still imaging to mirror both positive and negative behaviors for peers to visualize and from which to make immediate adjustments;
 - 3) three collaborative sessions to reflect upon laboratory scan attitudes and behaviors of both self and scan partner, and to develop corrective action plans for each group member, using the video mirroring adjustment (VMA) survey.

VMA Description of Findings

The VMA survey (Appendix I) was developed for critical reflective guidance regarding attitudinal perceptions and future behavioral considerations. Learners reflected within the VMA survey by collaborating with peers to develop individualized corrective plans of action toward adjustment in scan behaviors. Both self review comments and peer review comments from the VMA corrective action plans have been categorized in Table M.33 (Appendix M).

The qualitative feedback evaluated in this section is most closely related to Research Question 5: How were student attitudes impacted by the interactions and reflections of the formative self and peer assessment process during the transformational learning stage? To consider the reflection of attitudes on observed behavioral changes, the researcher's assessment included a comparison of repeated learner behaviors, as logged in the corrective action plan comments of Table M.33, compared to WRMSD complaints of the retained graduates who

participated in the final observation stage, as recorded in Table L.2. Because of this transformative behavioral component, consideration should be given to Research Question 5a: Did learner self-reflections and collaborative peer reflections demonstrate a positive impact on learner attitudes concerning longer-term transformative assessment benefit? Some relationship may also exist between these qualitative findings and Research Question 6: What patterns of responsiveness regarding injury awareness and prevention feedback were evidenced among program graduates at the time of final observation?

VMA Analysis of Findings

Twelve transformational learners participated in the VMA surveys with development of corrective action plans. Eleven participants (91.7%) completed corrective action plans during the first scan lab, and 10 subjects (83.3%) participated with corrective action plans during the remaining two scan labs. Important findings that were revealed in Table M.33 have been summarized below:

- 1) There were 19 instances (61.3%), of possibly 31 from all scan labs, in which the participant noted the same behavioral findings as did the laboratory partner performing the peer review. Such similarity may signify concordance in findings due to personal awareness, as well as the learner's ability to more readily acknowledge behavioral concerns due to collaborative reflection.
- 2) There were 12 instances (60.0%), of possibly 20 from the final two scan labs, in which risk behaviors were logged as repeated from a prior laboratory reflection.

- 3) Of the eight retained graduates reporting WRMSD concerns during the final expert scan observation, four (50.0%) of these subjects reported problems that were directly related to the repetitive scan behaviors reported during the VMA Corrective Plan of Action reports.
- 4) During Lab 1, only one respondent made a reflective remark within the corrective action plan: "Seeing myself helped me realize what I was doing wrong." By the second scan lab, four respondents (33.3%) of the 12 transformational learners had included reflective remarks concerning ergonomic awareness.
- 5) During Lab 1, the corrective plan of action demonstrated two remarks of positive scan behaviors in only one student (one in self review and the other in peer review). By Lab 3, there were nine positive scan behavior remarks included in corrective plans of action, providing evidence of learners demonstrating increased awareness of positive scan actions in addition to continued awareness of negatively observed behaviors.
- 6) During Lab 2, one learner began to use ergonomic terminology to describe personal scan behavior: "Don't over-abduct arm." By Lab 3, this learner demonstrated increased usage of ergonomic vocabulary (shoulder over-abduction and external flexion of the wrist). Two other learners who had worked with this same student during Lab 3 also began using ergonomics terminology in the corrective plan: "Keep arm close to body (stop over-abducting shoulder)," and "Shoulder/arm is over-abducted."

The transformational learners exhibited immediate curiosity when becoming engaged with *iPads* as an emergent technology within the scan laboratory experiences, practicing assessment links and padcam usage with one another well beyond the instructor-led session. At

the beginning of the initial in-service and before each laboratory session, study participants continued to display eagerness to gather a personal *iPad* device for use in conducting collaborative student mirroring exercises. Impromptu remarks became commonplace, such as “This is cool,” or “Do we get to use the *iPads* for this lab?” Some of the transformational learners would independently request an *iPad* to practice mirroring techniques in laboratories when formal research was not taking place. The researcher would later find evidence of non-assigned, learner motivated use through archived images on the devices. One student began a reflective electronic journal of transformation throughout the program year with a personal device, sharing pertinent video clips with faculty and providing permission for sharing with future classes. Following the concluding laboratory scan session, the transformational learners self-reliantly set the self timer on the padcam to offer the researcher some final visual feedback of professed attitudes surrounding the VMA learning experience, as demonstrated in Figure 5.2.



Figure 5.2 Attitudinal Expression of Transformational Learners' Collaborative Laboratory Experience

Behavioral Findings from the Final Expert Observation

Behavioral findings from early and final observations, using the Observational Guide of Appendix F, were compared to reported pain concerns using data analyzed in Chapter IV as related to Research Question 1: How closely did sonographers' pre-instructional scan complaints and risk behaviors correspond with final musculoskeletal complaints and risk behaviors of prior published professional injury rates? Furthermore, Research Question 4 sought to answer, Did observed scan behavior incidences demonstrate an impact toward positive work habitus among study subjects, particularly those within the transformational group, due to ergonomics instructional intervention?

This section explains and demonstrates discovered behavioral patterns of participants within this study, also making comparison based upon assigned learning classifications. Because risk behaviors are of such great concern to sonographer injuries, the information relates most directly to the analysis of Null Hypothesis 4a-i: The incidences of negative scan behaviors recorded at the final observation event (post-graduation) were the same for the transformational learning group (Group C) as compared to the other study groups (Groups A and B). Positive scan behaviors that were applicable to prevention or correction of the identified negative behaviors were also addressed, directly relating to the analysis of Null Hypothesis 4a-ii: The incidences of positive scan behaviors recorded at the final observation event (post-graduation) were the same for the transformational learning group (Group C) as compared to the other study groups (Groups A and B).

In all instances of risk maneuvers identified by expert observation, the most commonly reported WRMSD complaints and the most commonly observed negative scan behaviors among study participants involved the shoulders, wrist, neck, and back, just as the literature suggested;

thus, most behaviors in these categories constituted anticipated findings. However, even within or associated with these categories, the researcher documented behaviors that were not necessarily expected and, thus, were categorized as unanticipated findings.

Shoulder Behaviors

The expert observer assessed for one shoulder activity on both the scan arm and the instrumentation (non-scan) arm, evaluating for sustained or repetitive hyperabduction of either shoulder. Hyperabduction was defined, for the purposes of this study, as any reach that placed the lateral body to inner arm angle at greater than 30 degrees for at least 15 seconds concurrently (sustained) or at least 30 seconds cumulatively (repetitive).

Anticipated Findings – Shoulder

The researcher anticipated high percentages of problematic shoulder behaviors based upon the cited injury rate of 76.0% among career sonographers (Murphy & Russo, 2000). All observed frequencies that were recorded according to the five-task, five-minute limit consisted of an overextension of the arm, either by the sonographer reaching across the patient or toward the ultrasound system, rather than:

- attempting to have the patient move closer in relation to the sonographer's neutral position;
- adjusting the height of the scan table in relation to the sonographer's neutral shoulder position;

- moving the equipment closer in proximity to the sonographer and scan table to constrict the workstation area.

Figure N.1 (Appendix N) demonstrates an instance in which either lowering the scan table or vertically repositioning by standing would have reduced the subject's scan shoulder angle to less than 30 degrees, preventing the hyperabduction from being sustained throughout the exam.

In this research study, general abdominal sonographer subjects more commonly overextended arm reach across the patient's right side when imaging left-sided structures (e.g., spleen and left kidney). Cardiac sonographer subjects more commonly overextended arm reach during the sub-costal view, usually due to failure of lowering the scan table, whether in the seated or standing position. Figure N.2 (Appendix N) demonstrates how standing and lowering the scan table returned subjects' shoulders to acceptable angular alignment to the lateral body.

Based on the central hypothesis, the researcher anticipated a difference in shoulder risk behaviors among the three classifications of learners. Using Table L.2 to look specifically at expert observations among the number of retained sonography participants (rather than proportions of incidences), 20 (50.0%) of the study's 40 retained sonographer subjects demonstrated negative shoulder risk behaviors during the final observation. Thirteen (65.0%) of the 20 retained participants exhibiting negative hyperabduction behaviors were transmissional learners (Group A), also equating to 65.0% of the retained transmissional participants. Six (30.0%) of the 20 subjects with risk behaviors of the shoulder area were transactional learners (Group B), equaling 54.5% of retained subjects within the transactional group. The remaining one sonographer with a shoulder risk behavior was a transformational learner (Group C), which comprised 5.0% of the entire shoulder risks observed, or 11.1% of the retained transformational

subjects. Table 5.11 delineates the negative shoulder observations within the various groups and among all of the groups by number and percentiles.

Table 5.11 Observed Shoulder Risk Behaviors among Retained Subjects

Learning Classification	<i>n</i>	Percentile (%) Within the Group	Percentile (%) Among All Groups
Transmissional <i>N</i> = 20	13	65.0	65.0
Transactional <i>N</i> = 11	6	54.5	30.0
Transformational <i>N</i> = 9	1	11.1	5.0
Totals <i>N</i> = 40	20	50.0*	100.0**

*Percentile of all retained subjects; will not produce a column sum.

**Percentile among observations only, rather than among all retained subjects.

One anticipated shoulder finding, confirmed during final observation feedback, involved discomfort created in the scan shoulder following additional compression maneuvers on obese patients. Since only a limited number of retained study participants were observed scanning obese patients during final observations, no statistical proportions of this factor have been included.

A final anticipated finding was related to subject scanning, though not performed by the subjects. Because of the importance to the study's methodology of instructing early career sonographers, the researcher felt the need to mention this particular finding. Sonography instructors assisting learners in scanning, as was the case during early scan observations, must also be cognizant of increased injury risk from the demands of scan assistance. Figure N.3 (Appendix N) demonstrates an example of the additional challenges that sonography instructors face when assisting sonography learners in the early scan stages, not only with shoulder

hyperabduction, but a general lack of optimal body positioning. Such maneuvering should be greatly limited and ideally excluded from practice through creative repositioning whenever feasible.

Unanticipated Findings – Shoulder

The researcher did not anticipate such a great amount of discrepancy between shoulder risk behaviors of general versus cardiac sonographers from the early observation stage, where only one (3.2%) of 31 early incidences was logged for cardiac subjects, while 12 (29.3%) of 41 incidences were logged for general subjects. This discrepancy was particularly puzzling because of the comparable proportions of early reported shoulder pain frequencies, being 52.4% of the general sonographers' complaints and 55.6% of the cardiac sonographers' complaints. Among the retained general and cardiac sonographers, shoulders accounted for 37.2% of the reported WRMSD complaints, while shoulder risk behaviors, by categorical description, only accounted for 18.5% of observed incidences.

There were two additional shoulder risk behaviors that the observer logged during the final observation stage in the participants' work environments that had not been described within the observation guide. One of these behaviors generally occurred in addition to shoulder hyperabduction; while the other was not associated with hyperabduction and was more prominent among cardiac sonographers performing apical views. The fact that hyperabduction was the only categorical risk behavior description for the shoulders may have accounted for the discrepancies between shoulder risk behaviors and shoulder pain reports in the cardiac subgroup. Descriptions of these two unanticipated findings follow.

Hyperabduction with Anterior Shoulder Roll

In the risk maneuver associated with hyperabduction, some sonographer subjects would lift the shoulder and roll the joint anteriorly, not only increasing strain within and surrounding this joint, but also adding strain to the cervical spine and scapular areas. Figure N.4 (Appendix N) demonstrates two examples of subjects anteriorly rolling the scan shoulder during hyperabduction.

Posteroinferior Shoulder Displacement

In the second unanticipated shoulder risk maneuver, independent of hyperabduction, strain was placed on the joint when the sonographer slightly dropped the shoulder inferiorly and additionally displaced the joint in a dorsal direction. This maneuver was associated with complaints at the anterior joint level, as well as muscular aches around the concomitant scapular area. This maneuver was most often captured during apical imaging views when the sonographer did not lift the scan table to an appropriate level or did not seek assistance from the patient in proximal movement. Figure N.5 (Appendix N) demonstrates a subject's shoulder joint displaced posteriorly, though not associated with the apical view in this particular instance.

Eleven (55.0%) of the 20 retained transmissional students demonstrated negative posteroinferior displacement of the shoulder joint. In all cases, observed participants were performing cardiac studies. Four subjects expressed WRMSD complaints of the same shoulder in which the behavior was observed, one cited tingling of the fingers after performing this action, and two complained of pain between the shoulder blades. Two (18.2%) of the eleven retained transactional participants were observed engaging in this behavior; while none of the

transformational participants (most being cardiac sonographers) were recorded to demonstrate this risk behavior.

Among the reported WRMSD complaints at the final observation stage, one retained transmissional participant, who had been scanning for a career term of four years, sustained a shoulder injury in which this graduate was limited to scanning two patients per day until otherwise medically released. The graduate cited high examination volumes and more difficult patients (in aspects of obesity, non-ambulatory functionality, and greater severity of health conditions) as contributing factors to the shoulder grievance.

Neck Behaviors

Four neck behaviors were identified during pilot observation studies, with three of these most commonly associated with monitor adjustments. Two of these behaviors, cervical hyperflexion and cervical hyperextension, could be readily adjusted by raising or lowering the monitor to the sonographer's neutral line of sight. The third behavior, lateral cervical rotation, or twisting of the neck, generally occurred when the sonographer was not in optimal body alignment from a lateral perspective to the ultrasound system or, more specifically, to the display monitor. The fourth behavior, lateral cervical extension, will be discussed as an unanticipated finding.

Anticipated Findings – Neck

The researcher anticipated high percentages of problematic neck behaviors based upon the cited 74.0% injury rate among career sonographers (Murphy & Russo, 2000). As disclosed in Chapter IV, observations of negative neck behaviors were similar between general (31.7%) and cardiac (32.3%) sonographers during the first observation stage; just as there was similarity between early general (28.6%) and cardiac (22.2%) sonographers' early neck pain reports. The WRMSD complaint proportion at the final observation stage was closely aligned with earlier reports, being at 21.0%; just as the final scan observations were closely aligned with earlier observations, demonstrated at 25.9% of observed incidences.

Based upon the central hypothesis, the researcher anticipated a difference in neck risk behaviors between the three classifications of learners. Using Table L.2 to look specifically at expert observations among the number of retained sonography participants (rather than proportions of incidences), 28 (70.0%) of the study's 40 retained sonographers demonstrated negative neck risk behaviors during the final observation. Eighteen (64.3%) of those 28 sonographers in which negative neck behaviors were observed were transmissional learners (Group A), also equating to 90.0% of retained transmissional participants. Eight (28.6%) of the 28 with negative neck behaviors were transactional learners (Group B), also equaling 72.7% of retained transactional subjects. The remaining two sonographers with neck risk behaviors were transformational learners (Group C), comprising 7.1% of observed neck risk behaviors, or 22.2% of retained transformational subjects. Table 5.12 delineates the negative neck observations within the various groups and among all of the groups by number and percentiles.

Table 5.12 Observed Neck Risk Behaviors among Retained Subjects

Learning Classification	<i>n</i>	Percentile (%) Within the Group	Percentile (%) Among All Groups
Transmissional <i>N</i> = 20	18	90.0	64.3
Transactional <i>N</i> = 11	8	72.7	28.6
Transformational <i>N</i> = 9	2	22.2	7.1
Totals <i>N</i> = 40	28	70.0*	100.0**

*Percentile of all retained subjects; will not produce a column sum.

**Percentile among observations only, rather than among all retained subjects.

Lateral cervical rotation due to non-alignment with the monitor was the most commonly logged individual risk behavior (rather than categorical risk behavior) at the final observation, with 100.0% of the 20 transmissional learners (Group A), who also accounted for 50.0% of the retained participants, engaging in this action. Six of the transactional (Group B) learners, also comprising 15.0% of the retained participants, demonstrated cervical rotation; as did four of the transformational learners, who made up 10.0% of retained participants. Figure N.6 (Appendix N) demonstrates a cervical hyperflexion incidence in combination with lateral cervical rotation, both due to misalignment of the sonographer's line of sight to the monitor.

Cervical Extension Resolution Behaviors

Cervical hyperflexion and hyperextension could be readily corrected by subjects with slight adjustments in monitor height, monitor tilting, or through vertical movement on the part of the sonographer (e.g., raising or lowering the scan chair). Figure N.7 (Appendix N) demonstrates

a study subject assuring proper cervical alignment through the appropriate display monitor height adjustment, as well as lateral alignment to the sonographer's neutral line of sight.

Cervical Rotation Resolution Behaviors

Beyond appropriate vertical adjustment of the monitor, lateral cervical rotation can most readily be resolved on state-of-the-art ultrasound systems through the use of the monitor swing arm. On systems without swing arm capacity, the sonographer should angle the equipment and scan table where the sonographer's line of sight is placed in optimal alignment with the display monitor without the need for cervical rotation. Readjustments are likely throughout the study, for which additional exam time should be appropriated. In Appendix N, Figure N.8a demonstrates a monitor in the neutral arm position, while Figure N.8b shows range of monitor mobility, with the capability of right or left lateral motion and vertical tilting as the monitor extends upon the swing arm.

Each of the negative neck behaviors that have been discussed thus far were corrected by subjects through discernment of actions followed by simple monitor adjustments of either physically raising or lowering the monitor or the sonographer's chair, by making vertical tilts of the display monitor, or through lateral motion of the swing arm or repositioning of the system. The other observed risk behaviors of the neck did not require equipment manipulation but strictly acumen on the part of the sonographer, as will be discussed within unanticipated findings of the neck.

Unanticipated Findings – Neck

Lateral Cervical Extension

A particular neck maneuver was quite unanticipated in the early stages, as the behavior appeared to have nothing to do with equipment placement or patient scan interactions. The researcher termed this behavior as lateral cervical extension, otherwise referred to as a lateral neck tilt. The maneuver was logged as a task behavior whenever a sonographer sustained the head in a laterally tilted maneuver for at least 15 seconds concurrently or at least 30 seconds cumulatively within each minute of observation. Figure N.9 (Appendix N) demonstrates this maneuver taking place during a scan laboratory.

During pilot studies, the researcher questioned learners about the need for performing this maneuver. As suspected, there were no reasonably cited causes for the behavior and even lack of awareness on the part of the early career sonographers in whom the behavior was taking place. Once made aware of the behavior and further interrogated about cognitive processes, learners cited confusion or critical reflection in relation to interpretation of the anatomy being displayed on the monitor. The researcher concluded that the lateral cervical extension risk behavior was prevalently associated with uncertainty during higher cognitive reasoning periods.

Forward Slump with Chin Jut

The second unanticipated finding was the observance of subjects slumping forward while jutting the chin outward when assessing information on the display monitor. Again, the expert observer could not associate this behavior with a need for the subject to move closer to the display due to poor monitor adjustments, as in every circumstance, the sonographer subjects

would readjust to neutral upright postures to resume scan duties. This led the researcher to believe the behavior was not caused by eye strain, which was confirmed upon further interrogation of the subjects. Figure N.10 (Appendix N) provides an example of this neck risk behavior.

When further questioned about the behavior, the early career sonographers gave explanations involving higher order thinking processes to interpret information being displayed on the monitor. The researcher concluded, just as with the lateral cervical extension behavior, that the habitual body language motion of slumping forward and jutting the chin to assess the display screen was prevalently associated with greater processing needs during cognitive reasoning for some subjects.

In essence, sonographers who habitually practice these unanticipated neck risk behaviors need to become more aware of body language responses during demanding cognitive scan periods to consciously adjust unnecessary repetitive and sustained actions.

Wrist Behaviors

Three wrist behaviors were identified during pilot observation studies and added to the observation guide. The most obvious identified wrist actions were hyperflexion and dorsiflexion, occurring through vertical bending of the wrist joint, as shown in Figure N.11 (Appendix N).

The third behavior was lateral flexion, originally defined as only an outward flexion movement creating ulnar deviation. Radiographers refer to this imaging position as the navicular view. The expert observer also documented instances of inward flexion that created navicular deviation. Both behaviors are represented by scan subjects in Figure N.12 (Appendix N).

Slight, periodic wrist flexions are normal to hand function, as joints are designed to allow additional flexibility in anatomical mobility. Each of the flexion incidences recorded as risk behaviors met the observation guide's definitional standards of sustained and/or repeated angular concerns. Moreover, specific hand and finger movements were not categorized in the observation guide, as were wrist actions. Rather, the expert observer assessed for any common behavioral hand themes as will be addressed in the unanticipated findings for the wrist and hand category.

Anticipated Findings – Wrist

The researcher had anticipated high percentages of observed problematic wrist behaviors based upon the cited injury rate of 59.0% among career sonographers (Murphy & Russo, 2000). At the time of final observation, reported wrist complaints (11.6%) were not impressively high compared to the observed incidences (26.9%) that more than doubled reported proportions. No discrepancy was evidenced when comparing early observations with complaints between general and cardiac sonography participants. Observed negative wrist risk behaviors in the earliest scan stages were 29.0% for early cardiac sonographers and 31.7% for early general sonographers. As in the final stage, the reported wrist complaints in the early scanning months were also much lower for both groups, registering 11.1% for early cardiac sonography learners and 9.5% for early general sonography learners.

Each of the described wrist behaviors was noted at final observation. Nineteen (95.0%) of the 20 retained transmissional learners exhibited negative risk behaviors, also making up 47.5% of all retained study participants and 65.5% of participants engaging in these negative wrist behaviors. Seven (63.6%) of the 11 retained transactional learners demonstrated such behaviors,

accounting for 17.5% of all retained participants and 24.1% of subjects observed performing negative wrist behaviors. Lastly, three (33.3%) of the nine retained transformational learners engaged in negative risk behaviors, which also equated to 7.5% of all retained subjects and 10.4% of those observed conducting negative wrist behaviors. Table 5.13 delineates the negative wrist observations within the various groups and among all the groups by number and percentiles.

Table 5.13 Observed Wrist Risk Behaviors among Retained Subjects

Learning Classification	<i>n</i>	Percentile (%) Within the Group	Percentile (%) Among All Groups
Transmissional <i>N</i> = 20	19	95.0	65.5
Transactional <i>N</i> = 11	7	63.6	24.1
Transformational <i>N</i> = 9	3	33.3	10.4
Totals <i>N</i> = 40	29	72.5*	100.0**

*Percentile of all retained subjects; will not produce a column sum.

**Percentile among observations only, rather than among all retained subjects.

Beyond increasing awareness and taking corrective actions for specific behaviors, microbreaks were considered to be the most practical protective measure in which sonographer subjects could engage throughout every examination to reduce the risk of wrist injury. During the earliest pilot stage, the researcher made a notation of one of the learners verbally complaining about pain of the wrist, yet continuing to scan without taking a break or without repositioning the transducer grip. During final observations, this pattern was repeated, as multiple sonographers complained of scanning well beyond the point of aching during the work day due to high volumes of patients and expressed concerns of impending carpal tunnel syndrome.

At the time of final observation, not nearly enough sonographers were engaging in microbreaks. During the five task, five minute observation period, only seven (35.5%) of the 20 transmissional subjects engaged in one microbreak. Six (54.6%) of the 11 transactional subjects engaged in at least one microbreak, with two of them observed taking two microbreaks (most often during structural measurements). Eight (88.9%) of the nine transformational subjects were observed engaging in this positive behavior, with two subjects taking one microbreak, three subjects taking two microbreaks, one participant taking a third microbreak, and two participants taking four microbreaks of five possible recordings. Thus, a greater proportion of transformational learners not only engaged in the positive microbreak behavior, but a larger proportion of transformational subjects did so more often.

Unanticipated Findings – Wrist and Hand

As earlier indicated, specific hand or finger behaviors were not anticipated as categorized findings within the observation guide. Even though the literature review sources made mention of hand and finger injuries, scan risk behaviors were not described in detail. The researcher used observation scan sessions as a means to determine the most prevalent behaviors noted among subjects in this study.

Maladjusted Grips

There were two classifications of behaviors that were recognized by the expert observer in this study. The first of these involved maladjustment of the hand over the transducer, in which the palm was not fully utilized or the grip was not evenly distributed. The researcher termed the first of these grip maneuvers on the scan probe as a talon grip, noting that this behavior was often accompanied by wrist hyperflexion. In Appendix N, Figure N.13a demonstrates this negative hand scan behavior. The second common maladjusted grip, in which the index and middle fingers were more greatly strained, was termed by the researcher as a knuckle ball grip, as demonstrated in Figure N.13b.

Fifth Digit Maneuvers

Another common negative hand maneuver involved the release and extension of a single digit, thereby excluded from assisting in the transducer grip function. Though the researcher observed this behavior occasionally performed with the index finger, the maneuver most often involved the fifth digit. Figure N.14 (Appendix N) demonstrates two negative behaviors involving the digit of primary concern after which both maneuvers have been named. The first is the outward splaying of the fifth digit, known as the tea cup grip. The second is the application of additional pressure on the fifth digit against the transducer, referred to as the pinky press grip.

Back/Postural Behaviors

Categorically, back behaviors made up the greatest proportion of risk incidences recorded at final observation, observed in 31 (77.5%) of the 40 retained subjects, with 12 subjects (30.0%) exhibiting risk behaviors from the mid to lower spine in excess of 70.0%. Categorical descriptions on the observation guide included two identified risk maneuvers that placed sonographers out of optimal body position (OBP), as hips and/or spinal misalignment created directional susceptibility of movement (DSM) at the core. Whenever a sonographer is misaligned and out of balance at the core, injury risk factors greatly increase. The two identified behaviors that were repeated and sustained involved lateral flexion (leaning laterally at the waist) and rotation (twisting) of the trunk, creating spinal torsion.

Anticipated Findings - Back

The researcher anticipated high percentages of problematic back behaviors based upon the cited injury rate of 58.0% among career sonographers (Murphy & Russo, 2000). Among the 40 retained subjects, 31 (77.5%) were observed engaging in negative scan behaviors of the back. Twenty (100.0%) of the transmissional learners, also equating to 64.5% of subjects with observed behaviors or 50.0% of all retained subjects, demonstrated negative risk behaviors of the back at the final observation stage. Eleven (55.0%) of the 20 transmissional subjects demonstrated such behaviors at a categorical proportion of 70.0% or greater. Nine (81.2%) of the 11 transactional learners, comprising 29.0% of subjects with observed behaviors or 22.5% of all retained subjects, demonstrated negative back behaviors at final observation; but only one of those transactional participants (9.1%) did so at a categorical proportion of 70.0% or greater.

Two (22.2%) of the nine transformational learners, equaling 6.5% of subjects with observed behaviors or 5.0% of all retained subjects, demonstrated negative risk behaviors of the back; though the back was not the most common category of negative behaviors for anyone in Group C, with none demonstrating proportions of 70.0% or greater, as had the other learning groups. Table 5.14 delineates negative back observations within the various groups and among all the groups by number and percentiles.

Table 5.14 Observed Back Risk Behaviors among Retained Subjects

Learning Classification	<i>n</i>	Percentile (%) Within the Group	Percentile (%) of Subjects with <i>P</i> ≥ .70	Percentile (%) Among All Groups
Transmissional <i>N</i> = 20	20	100.0	55.0	64.5
Transactional <i>N</i> = 11	9	81.2	9.1	29.0
Transformational <i>N</i> = 9	2	22.2	0.0	6.5
Totals <i>N</i> = 40	31	77.5*	30.0*	100.0**

*Percentile of all retained subjects; will not produce a column sum.

**Percentile among observations only, rather than among all retained subjects.

Sonographers engaged in both of the categorical descriptive behaviors of lateral flexion and spinal torsion, regardless of whether standing or sitting to scan. However, the reasons for negative behaviors in each of these scan positions required different awareness and adjustment factors.

Standing Position

The majority of early sonographers who performed scans while standing did not remain in balance or alignment, tending to jut one hip outward and/or stand with one foot in front of the other, even many times crossing the other foot. Further discussion will take place in the Unanticipated Findings category.

Sitting Position

The majority of early sonographers who performed scans while sitting tended not to use the chair's backrest when doing so. Furthermore, many tended to lean over one side of the scan chair or stool. Further discussion will take place in the Unanticipated Findings category.

The interrelated issue to these two postural findings noted among early career sonographers involved the lack of variation in position selection. Once a scan position was chosen, learners did not usually tend to vary to another position. For instance, whereas sitting may remove stress on lower limb joints, standing to prevent hyperabduction may remove stress on the shoulder joint. Variation in scan positions was discussed with the learners of Groups B and C in early observational feedback and, again, among all retained subjects following the final observation stage. The researcher noted more variation in movement among scan positions in the retained participants, yet not enough to prevent continuing the risk behaviors of back flexion and rotation that could have otherwise been avoided.

Unanticipated Findings – Back

Back behaviors were most closely tied to lack of OBP, with leaning and torsion of the trunk accounting for the greatest proportion of postural directional susceptibility of movements. Beyond the postural concerns, this section has been divided into categorical DSM findings that the researcher either did not expect to discover regarding OBP concerns, or did not anticipate would occur in such great frequency, with an analysis of cause where identified.

Early Sonographer Attitudes

In early observations, the researcher discovered that sonography students did not intuitively search for positive adjustment solutions toward comfort during scanning. When assessing initial observations with study subjects, many explained that the act of producing and interpreting the image on the display required such focus that learners did not notice any discomfort until later and did not think to make OBP corrections as a result.

There was another explanation to DSMs placing sonographer subjects out of optimal body position, though. Many of the participants indicated that the perceived appropriate protocol in the provision of patient care was to make sacrifices on behalf of the patient. One respondent verbalized this perception as, “I would rather allow myself to be uncomfortable to the point of potential injury than trouble my patient to move closer to me during an examination.” This patient care myth was more solidly ingrained in two early study subjects who even mentioned the concept of patient care ethics as the basis for this belief. The extent of this patient care aspect belief among participants was amplified when the patients who were not being troubled to move at the time of preliminary observations were, in fact, laboratory partners participating in the scan

lab who all possessed high levels of mobility. Because the researcher recognized the implication of enhanced injury potential when subjects were operating in inferior care circumstances, where unhealthy patients may possess greater limitations in mobility, further discussion ensued. Study subjects were questioned on the likelihood of asking for patient assistance or using creative, alternative means to prevent DSMs. Early subjects could not respond with any certainty, except for one learner who offered verbal comprehension:

I need to pay attention to my body – what hurts, why it hurts, give it a break when it hurts. Even if my patients are a little uncomfortable for a while, they won't be doing this for the rest of their lives. It will be hard to make changes, but if I'm going to be doing this every day, I need to consciously work on making changes.

At the time of final observation, the expert observer continued to observe multiple study participants failing to seek patient assistance through mobility requests in order to prevent sonographer DSMs.

Back Behaviors Unrelated to the Act of Scanning

Lateral rotation (bending sideways) during scanning was not an unexpected finding. The expert observer noted how early career sonographers did not naturally make height adjustments of the scan table or make requests of the patient to move closer for the avoidance of overextended reaching. Spinal torsion of the midsection during scanning was less surprising after noting how sonography learners did not attempt to horizontally align the display monitor to the line of sight. This previously described action that created torsion of the cervical spine coincidentally did so to the thoracic and lumbar spine during overextended reaching. However, continual forward bending, or even squatting, throughout the day was not an anticipated complaint, especially when related to the work environment that did not involve direct patient

contact. When conducting a work station inventory, one of the transformational learners mentioned a concern that has since been voiced by several sonographers and observed by the researcher:

Linen could be placed in a better location. The sheets are located in a cabinet about six inches from the ground and require the sonographer to bend low to change linen. In a home setting, this would not be an issue, but in the work setting, continuous bending at the waist may cause future back problems.

Sonographers were also observed hyperabducting the shoulder and engaging in spinal torsion to reach linen placed in cabinets hanging high on walls at clinical facilities.

OBP Misalignment during Standing

The Anticipated findings section of the back identified that a large proportion of early career sonographers scanned with spinal misalignment when standing. The researcher noted two common behaviors not specifically anticipated by sonographers during standing. The first behavior was to jut one hip outward while locking the adjacent knee joint and positioning the contralateral foot forward. The second behavior was to cross the legs while standing, placing one foot over the contralateral one. Without exception, 100.0% of all observed learners in Groups B and C who stood while scanning engaged in some variation of at least one of these behaviors. (Transmissional learners from Group A were not observed in the early scan stages.) In Appendix N, Figure N.15a demonstrates an example of a jutted hip, and Figure N.15b shows an example of crossed legs during scanning.

Where learners were not so quick to place any burden upon patients in mobility assistance, the researcher sensed greater responsiveness from early learners about personal postural adjustments. One transactional learner responded,

It is important for the sonographer to become aware of posture and scan habits. Bad posture is something that can easily be fixed if you continue to make a point to correct it. It will eventually turn into a good habit.

For those sonographers who were engaged in the early observation discussions, recognition did bring about some positive postural transformation. Conversely, during the final observation stage, four retained transmissional subjects, who had not been engaged in early observations, stood while scanning. All four (100.0%) were out of optimal body alignment throughout the observations. Four retained transactional subjects also stood during scanning. Three (75.0%) of the four were also out of OBP alignment on all five tasks (100.0% of the time). The fourth remained in an ideal OBP throughout the observation. Of the four retained transformational subjects who stood, two (50.0%) were out of OBP, but each one for only one of the five tasks (or 20.0% of the time). Spinal alignment was of obvious concern when sonographer subjects stood during scanning.

Standing in a straight posture with weight balanced evenly and knees slightly bent (not locked) to relieve joint pressure was discussed as a corrective measure for postural behaviors that created negative risks toward back injuries. The absence of ergonomic mats to relieve joint stress and fatigue when standing in a sustained position amplified the risk concern. The researcher discovered, during the final observation stage, that none (0.0%) of the clinical facilities where 40 expert observations were conducted provided any evidence of operating with ergonomic mats at scan workstations. One facility stated that mats once existed at all workstations, but had mysteriously disappeared. The sonography supervisor explained that housekeeping often complained about cleaning around the mats and were likely responsible for these removals. The matter of these disappearances, however, had not been investigated nor had an inquiry been made about replacements.

OBP Misalignment during Sitting

Standing is not necessarily the best positional choice in terms of postural or joint stress considerations, especially in the absence of protective ancillary equipment (i.e., ergonomic mats). However, the researcher came across some unanticipated findings, also of great concern to sonographers' injury risk, related to sitting while scanning that required further attention. *Sitting is the New Smoking*, an article published in the Harvard Business Review by N. Merchant (2013, as cited in Louv, 2013), has largely contributed to the coining of the same contemporary buzz phrase. Though the original reference was in regards to increased health risks of inactivity (e.g., obesity, heart disease, and diabetes), there is another significant meaning for the scanning sonographer. Lack of awareness to seated ergonomic risks could just as readily contribute to MSIs from scanning. As one transformational subject reflected following the PPG experiment, "I was surprised because I thought x-ray was a big strain and, in ultrasound, I'd get to sit. But ultrasound has more risk, even sitting, than a lot of other fields."

The final observation results revealed that 16 (80.0%) of the 20 transmissional participants, seven (63.6%) of the 11 transactional participants, and five (55.6%) of the nine transformational participants sat to scan. These frequencies equated to 28 (70.0%) of the 40 retained subjects revealing a preference for sitting, thus increasing the odds of seated risks among this study's group of participants. The majority of these sonographers were using office chairs or round stools for performing seated scan duties, as only four (10.0%) of the 40 retained subjects had access to chairs designed for ergonomic scan use. An additional ergonomic chair was on site during the expert observer's visit, but had remained unassembled in the box for several weeks with no scheduled date for assembly. The expert observer noted behavioral concerns with the use of stools and office chairs, otherwise termed by the researcher as faux

ergonomic seats. The most common arrangement of all ultrasound departments at observed clinical facilities included the faux ergonomic seat as part of the workstation configuration, as exhibited in Figure N.16 (Appendix N).

At a minimum, ergonomic chair design for sonographers should include the considerations of a saddle seat with short depth and width, back support, short arm rests for elbow support, lateral mobility, vertical mobility, and a footrest with limited depth to permit close proximity to the ultrasound system and scan table. Faux ergonomic seats have some of these qualities, but may increase injury risk factors by the allowance of too much sonographer mobility. As noted during expert observations, when the seat is too wide, or there is no saddle to maintain the sonographer's balance, the sonographer tends to slide to the side of the seat, often leaning toward the patient. In Appendix N, Figure N.17a, this occurrence is demonstrated by a subject scanning in a wide chair, while the same occurrence is demonstrated in Figure N.17b while a subject is scanning on a round stool.

As witnessed in expert observations, when the seat is too deep, the sonographer tends to slide or lean forward in the seat, creating a greater likelihood of the sonographer engaging in both slumping and spinal torsion without the support of a back rest. Deep seats without foot rests tend to accentuate the problem, as the sonographer also seeks to find a footing for balance, yet engages in spinal torsion when turning in the seat. One learner reflected upon this in the PPP: "I tend to sit on the edge and twist my upper body, rather than using the chair to rotate." Appendix N, Figure N.18a demonstrates a sonographer subject using approximately one-half of the depth of the faux ergonomic seat without the use of the back support, while Figure N.18b demonstrates a retained sonographer subject in an ergonomic chair designed to meet scan criteria. The

sonographer subject is using the backrest, is evenly balanced in the saddle seat, and is supporting the elbow of the scan arm using the shortened, posteriorly placed arm rest.

In cases where the circular footrest may prevent the sonographer from coming into close proximity to the ultrasound unit or scan table, particularly when the sonographer has a shorter reach, the chair may be modified through removal of the footrest, especially in cases where the ultrasound system has been designed with a purposeful footrest included. Nevertheless, sonographers should take care to remain within the saddle seat and against the chair back, firmly planting feet on acceptable surfaces (which may even include the scan table frame) to avoid spinal torsion when altering between facing the patient and the system. Figure N.19 (Appendix N) provides a demonstration of this modified footrest concept on an ultrasound system, as used by one of the four retained subjects who had access to an ergonomic chair with a saddle seat.

A well-designed ergonomic chair within a department does not automatically solve poor sonographer postures or scan habits. Even when removed from a box and assembled, the presence of a properly designed ergonomic chair merely signifies that sonographers have additional opportunities to reduce risk behaviors. Conscious decisions to do so must still take place. Figure N.20 (Appendix N) demonstrates a few negative risk behaviors of which early career sonographers must still become aware, as conducted by the majority of subjects during early scan laboratory sessions. Positive adjustments can be made, but must be purposeful, regardless of the availability of equipment.

Elbow/Forearm Behaviors

Statistically, risk behaviors to the forearm and elbow joint at the time of final observation were near the cited 31.0% injury rate (Murphy & Russo, 2000). Yet, only one retained participant reported a WRMSD concern of the elbow/forearm area, stating the aggravated pain was intermittent. The expert observer saw no evidence of negative elbow/forearm risk behaviors in this study participant, as defined within the observation guide. In addition, no recorded instances of elbow/forearm hyper-supination, one of the two categorical descriptions for this anatomical region, was performed by any of the study participants. Ten (25.0%) of the 40 retained participants did demonstrate hyper-pronation behaviors, the second of the two categorical descriptions for this region. Figure N.21 (Appendix N) provides examples of each of these.

The researcher noted measureable room for improvement in the primary positive behavior associated with prevention measures of elbow and forearm injuries, in terms of the categorical descriptive criterion. Categorical description 16 on the observation guide allowed for logging a five task frequency on whether the participant often engaged in either resting the scanning forearm on the patient's body or the scan table or an alternative arm rest. The criterion for often was engagement of this behavior during at least three of the five tasks. Six (30.0%) of the 20 transmissional subjects, equaling 15.0% of the retained subjects, met this criterion at the final observation stage; as did six (54.6%) of the 11 transactional subjects (15.0% of all retained subjects), and eight (88.9%) of the nine retained transformational subjects (20.0% of all retained subjects). The remaining 50.0% of retained subjects showed evidence toward need of improvement in this positive behavioral action. Table 5.15 delineates positive forearm resting

behaviors observed within the various groups and among all the groups by number and percentiles.

Table 5.15 Observed Positive Forearm Resting Behavior among Retained Subjects

Learning Classification	<i>n</i>	Percentile (%) Within the Group	Percentile (%) Among All Groups
Transmissional <i>N</i> = 20	6	30.0	30.0
Transactional <i>N</i> = 11	6	54.6	30.0
Transformational <i>N</i> = 9	8	88.9	40.0
Totals <i>N</i> = 40	20	50.0*	100.0**

*Percentile of all retained subjects; will not produce a column sum.

**Percentile among observations only, rather than among all retained subjects.

When the patient's body was used as an armrest by subjects, permission was obtained, no greater than light pressure was applied at the rest location, and an advisable practice was to place linen between the sonographer's arm and the portion of the body that the arm rested upon. Maintaining support cushions in the ultrasound department was highly advisable, as the majority of clinical sites did not have these at the time of final observations. Figure N.22 (Appendix N) demonstrates one of the transformational subjects alternatively using available linen to provide a makeshift armrest while performing a parasternal cardiac view.

Risk Behaviors by Learning Classification

Table 5.16 compares the expert observer's findings at the final observation among learning classifications, by the broader listed categorical behaviors earlier identified by learners in Pre-Instructional IQ6 (Table M.1).

Table 5.16 Percentages of Categorical Risk Behaviors among Transmissional (Group A), Transactional (Group B), and Transformational (Group C) Learners

Expert Observations	Group A %	Group B %	Group C %
Poor Posture and Improper Body Mechanics (Lack of OBP) - Back Risk Behaviors	100.0	81.2	22.2
Wrist Risk Behaviors	95.0	63.6	33.3
Shoulder Risk Behaviors	65.0	54.4	11.1
Neck Risk Behaviors	90.0	72.7	22.2
Lack of Microbreaks	65.0	45.5	11.1
Lack of Arm Support While Scanning	70.0	45.5	11.1

In every categorical instance, transmissional learners demonstrated the greatest percentage of risk behaviors among the learning groups, with transactional learners consistently demonstrating the second greatest percentage of negative categorical behaviors. The transformational learners demonstrated the lowest group percentage of negative scan behaviors considered to be precursors to WRMSDs within each of the most commonly cited and observed injury categories.

Work Habitus Findings at Final Observation

All categorized interactions of this section took place within the authentic work environment at the time of the final expert observations, but were not direct behavioral or attitudinal scan responses on the part of the study's retained subjects. In the work habitus realm, other environmental elements are often pertinent to the development of beliefs and the expressions of behaviors, also coinciding with Research Question 6: What patterns of responsiveness regarding injury awareness and prevention feedback were evidenced among program graduates at the time of final observation? The upcoming work environment interactions addressed were not all-inclusive but were recognized repetitive patterns that should warrant discussion. As none were planned within the study's methodology, all fall into the category of unanticipated findings.

Perceived Work Habitus Supervisory Responsiveness

In the personal prevention plan reflection, one transformational student wrote, "Administration would rather incur the price of fixing equipment or adding an accessory [device] to help alleviate strain, then [sic] incur the price of worker's compensation." Based upon some of the unanticipated findings during the final observation stage in retained sonographer subjects' clinical work environments, such a statement might be reasonably challenged.

This study's methodology did not include interviewing supervisors for ergonomics-related attitudes. Rather, the information discussed in this section came from incidental findings based upon feedback received at the time of final observations. The reader should take note that the administrative representatives were not given an opportunity to respond to the following

observations, whether made by subjects or the researcher, which could introduce some level of bias and reduced objectivity to the findings. Nevertheless, supervisors of these facilities cannot dispute the objective observations of the lack of ergonomic equipment, such as 100.0% of the retained sonographer subjects having no access to ergonomic mats, 90.0% of these sonographers scanning without properly designed ergonomic chairs, at least 50.0% scanning on surfaces that were not ergonomically designed as scan tables, and a minimal number of work sites possessing other ancillary equipment, such as support sponges.

Refusals to Approach Administration

All of the blame for lack of appropriate equipment cannot be transferred to administration, as one transmissional sonographer participant was insistent that ergonomic equipment was not necessary in the subject's department. Rather, the individual denied the need for acquisition of any ancillary equipment, assuring the expert observer that personal flexibility was an adequate preventative measure against all injury. This retained subject demonstrated the level of perceived flexibility to the expert observer to stress the extent of this belief. Such belief emphasized a likely key factor beyond denial or egotism. Regardless of any reason for or level of belief, sonographers and supervisors do not appear to be effectively communicating about the issue of injury risk and prevention measures, as noted by the expert observer during informal exchanges at the time of final observation.

Besides sonographers denying personal risk potential, refusals to approach administration were more far reaching, as discovered during informal exit interviews. Many subjects expressed a lack of support in ergonomic equipment acquisition, citing budgetary concerns as the reason.

One sonographer wrote a telling statement in the reflective PPP, three years prior: “I discussed the benefits of a scanning table with arm rests and a head extension with our department leaders. They have taken it into great consideration and are looking for new tables as we speak.” During the final observation, three years later, the expert observer noted that this site had not, in fact, purchased any ergonomic equipment. When addressed about the possibility of approaching administration again to reconsider such a purchase, the sonographer stated fear due to the potential of having work hours reduced, as had recently happened to a colleague at the facility.

Refusals of Administration to Act

One case example of a supervisor’s refusal to act on behalf of the sonographers’ ergonomic benefit was not foreseen by a subject who, three years prior, had written in the reflective PPP:

In my work situation, the department is getting ready to move, and the administration has done an excellent job of discussing with the staff ideas and improvements that need to be included in the budget to reduce MSIs. Some of the improvements will include more space in the room which will allow some things to be easier to reach, more maneuverability of the patient bed and equipment, and also new ergonomic, fully adjustable chairs which will hopefully encourage some of the ones who stand all day to sit and make the proper adjustments to prevent injury.

The expert observation was performed in this same department three years after this PPP was written. The large doors and spacious rooms gave way to accessibility of full-sized hospital beds. Therefore, rather than transfer patients from wheelchairs onto ergonomic scan tables, patients were transported from the floors and the emergency room to be scanned in these large (non-ergonomic) hospital beds. Sonographers complained of having to stand and lean for all exams and that ergonomic concerns had worsened from this practice. The practice had become so

common that the expert observer watched a seasoned sonographer standing on her toes and leaning across a 15-year-old mobile patient, without asking the patient to move from the middle of this spacious bed, as the patient texted on her cell phone throughout the procedure. Ergonomic scan chairs had not been purchased for the newly designed department, being cited as too costly. The department had budgeted heavily for aesthetics and access, and apparently went to extremes to provide customer service, yet took no sonography MSI issues into consideration. The supervisor representing the department in design decisions was a (non-practicing) sonographer who stated an inability to refute administration in the decision to purchase all facility chairs in bulk order, rather than request properly designed ergonomic seats for the sonographers. As the supervisor stood in a multi-million dollar, newly designed department, the proclamation was made to the researcher that no funds existed to budget for ergonomic equipment.

In another case, a sonography supervisor, who had transitioned less to scanning and more to administrative duties over the past few years, denied other sonographers' risk potential in the department when ergonomic equipment purchases were mentioned. The supervisor stated to the researcher, "I've been scanning for over 20 years, and I don't have any problems." In this same department, another sonographer, who had scanned for less time than the supervisor, cited having a prior surgery due to a WRMSD, as well as experiencing current pain when scanning. The supervisor jokingly referred to that sonographer as an ergonomic nightmare and the other sonographers who also affirmed areas of discomfort as lightweights. The other sonographers in the workroom laughed in accordance.

In yet another case of an ergonomic chair purchase, a cardiologist had become involved and insisted multiple times on the equipment purchase for the sonographer's benefit. The facility's imaging administrator had earlier refused the sonographer's request on multiple

occasions. The immediate supervisor had not supported the earlier requests on the basis that “the ultrasound units [had] plenty of ergonomic benefits for the sonographer to use.”

Communication Breakdown

In very few instances were supervisors approached directly by sonographers, either before or following the discussion of final observation findings. In one case, the sonographers decided to approach the imaging director following evaluation by the expert observer, as the lack of ergonomic chairs appeared to be a major contributing factor to many of the recorded negative scan behaviors. The director responded first by requesting the cost of a properly designed ergonomic chair and then followed with the statement, “Can’t you just stand?” The purchase of ergonomic mats was then discussed for the purpose of standing on concrete flooring while scanning, in lieu of sitting. Upon later investigating to assess any course of action, the researcher learned that the director had purchased a pillow cushion for sonographers to place between the back rest and the body while sitting to scan. No plans were discussed for future budgetary considerations of ergonomic chair or mat acquisitions.

In another instance, a non-sonographer imaging manager had taken the initiative to purchase and assemble an ergonomic chair without the sonographer instituting the request. Without being provided any specifications for operation, the sonographer was uncertain on how to best manipulate the recently acquired ergonomic equipment. Lacking directions, the sonographer subject did not take the initiative to acquire instructions online or directly from the company. The expert observer assisted in the adjustment of the chair to the sonographer’s body habitus and provided some on-site training of alternate chair positioning techniques following the

final observation. Both the imaging manager and the sonographer stated the assistance was helpful. The manager had taken action in purchasing the chair, without being requested to do so, to support the sonographer; but the failure to communicate the intent through assurance of appropriate assembly and operation on the part of either party, though unintentional, was evident. This final case demonstrates the impact of communication and understanding between administration and sonographers in a different light from the other cases. Yet in all cases, there was evidence of disconnections between sonographers and administrators to assure adequate operational provisions and/or responsible budgetary planning.

Perceived Work Habitus Non-Supervisory Responsiveness

This study's methodology did not include the assessment of department or room design. Rather, the information discussed in this section came from incidental attitudinal findings based upon early learner reflections or informal interviews with retained subjects at the time of the final observation.

The importance of supervisory support has already been established by subjects as an environmental attitudinal factor toward positive work habitus. Also of great importance to the study's participants was the stated need for support by other sonographer peers within the work environment. One transactional learner representatively emphasized this need for mentorship and collaboration toward the development and maintenance of a positive work habitus in the early reflective PPP: "From observing the sonographers that I work with, I like to practice good body mechanics as they do to prevent injury or pain to myself." Another transactional learner expressed the benefit of sharing what had been learned with sonographers in the workplace:

After watching other sonographers scan, I shared some of the knowledge I have learned with the sonographers in my department, and they were surprised at some of their techniques. Some sonographers are going to strive to achieve better ergonomic skills as a result of our discussion.

Repeatedly, sonographers expressed both disbelief and dismay when other sonographers within the work environment did not support positive ergonomic practices or injury prevention measures. Multiple complaints were offered at the final observation stage regarding the continuation of sonographers expressing lack of time to correct poor scan habits or lack of sustainable budgets to justify ergonomic equipment purchases. Multiple retained subjects cited fear as prevalent among sonographers who believed additional departmental expenditures would result in employee downsizing as either punishment or budgetary backlash.

Summary

Chapter V captured prominent narrative attitudinal themes of key interview and reflective feedback mechanisms within this study regarding risk and prevention beliefs. Collaborative corrective action plans were also evaluated for comparison between self-assessments and peer assessments, as were repetitive risk behaviors compared to final stage WRMSD complaints.

This chapter also comprehensively assessed categorical behaviors observed in the study, providing specific, and even visual, descriptions for both anticipated and unanticipated findings. The researcher identified how qualitative findings corresponded to various research questions of the study, each segment either to an individual question or, in some cases, in coordination with multiple questions. In certain cases, qualitative findings also corresponded to analyses of tested hypotheses within Chapter IV and, where applicable, sought to provide additional pertinent

insight into some of those findings, based upon subjects' expanded explanations or the expert observer's notations.

Work environment conditions were additionally addressed in regards to attitudinal and behavioral influences on the study's subjects, particularly concerning risk factors and preventative measures. Responsiveness of sonographer supervisors and workplace peers to the subjects' ergonomic needs were the most commonly cited influencing factors of the subjects' sense of value to the employer or personal belief of extended ergonomic well-being. The need for continued measures to be taken toward increased injury risk beliefs, scan behavior improvements, and administrative support for healthy departmental operations were evident factors emphasized within the various segments of this chapter.

CHAPTER VI

SUMMARY OF FINDINGS, IMPLICATIONS, AND RECOMMENDATIONS

Introduction

The overriding research question directing this study was: What differences in learner attitudes and behaviors can be determined within the ergonomics work habitus frame of reference when comparing transmissional, transactional, and transformational learning events for the early career scanning sonographer? This chapter summarizes the research study's findings with that intent, being mindful of the original purpose of the study as related to value expectancy toward implications of these findings. Recommendations are offered for the sonography industry, sonographers in practice, the ergonomics instructional setting, and in regards to future research.

Purpose of the Study

Coinciding with published injury rates of 80.0 to 90.0% within the sonography profession over the past two decades (Baker, 2009; Friesen et al., 2006; Kaiser, 2007; Philips Medical Systems, 2007; Ransom, 2002), the healthcare industry has been negatively impacted through:

- the loss of highly trained and credentialed sonographers prior to planned career exit,
- increased administrative costs associated with work-related sick days or worker's compensation claims when sonographers are recovering from injury, and

- decreased patient access to healthcare services when fewer professionals are available to perform studies.

OSHA has long been aware of injury rates in the sonography field, even specifying an expectation of some level of risk assessment performance; but most sonographers do not reveal having risk assessments targeted on scan behaviors or the ergonomic capacity of departmental equipment. Rather, most risk assessments are generally measures that apply to a larger body of healthcare service providers. The literature review revealed that, although accredited sonography programs are responsible for providing some level of ergonomics instruction as of 2011, sonography educators have not historically been named as the primary means by which sonographers have learned to make ergonomic scan adjustments.

The inclusion of WRMSD awareness measures within an educational curriculum serves as a purposeful action toward injury reduction, as the development of beliefs and behaviors toward a positive work habitus should begin as early as possible within the sonographer's career. The Evans et. al (2009) study revealed, however, that the majority of sonographers within the highly designated WRMSD population cited receiving ergonomics information through what the researcher would term a transmissional instructional type. Furthermore, the Evans et al. study revealed that the percentage of sonographers receiving this type of ergonomics learning (90.4%) was exactly the same as the percentage who indicated scanning in pain (90.4%). Philips Medical Systems' (2007) training module listed training issues related to ergonomic scanning techniques as one of the primary influencing factors of MSDs reported among sonographers, though no specific techniques or guidelines were provided for training measures.

The SDMS benchmark survey stated "...on average, within 5 years of entering the profession, sonographers experience pain while scanning" (Parhar, 2004, para. 1), emphasizing

the need for early instructional intervention. NIOSH was most concerned with future research that would suggest how to reduce ergonomic injuries, rather than more research to document that such injuries existed. The literature review accentuated the need to determine specific causes of excessive WRMSDs among sonographers to, more importantly, identify intervention measures. The purpose of this study was to compare three instructional methods to assess whether transformative ergonomics learning in a collaboratively participatory and reflective environment could demonstrate a significant difference in the reduction of negative ergonomic scan habits associated with reported MSDs. The methodology sought to assess early career sonographer adoption of learned principles as reinforced practice within the work habitus frame of reference.

Research Design

Planned learning events occurred within a transmissional module for transmissional learners (Group A), extended to transactional events until the end of the first semester for transactional learners (Group B), and continued through the program year with reflective and collaborative exercises toward longer term transformation for transformational learners (Group C). Just as Taylor (2003) conducted a longitudinal study of belief changes based upon behavioral patterns, and Taylor (2007) later concluded that most of the longitudinal studies looking at transformative learning took place over a time period of two to five years, the data from this study were gathered from the same approximate period among the three comparative sample groups (Groups A, B and C).

Population and Sample

The inferred study population consisted of sonographers at the career entry point, who had not yet been broadly exposed to the profession's associated WRMSD risk factors and who were likely unaware of the published injury rates from repetitive and sustained activities in which sonographers engage while scanning. More specifically, the population encompassed Chattanooga State sonography students, from which four years of classes served as the sample in comparing transmissional, transactional, and transformational learning techniques.

Methodology

This was an ex post facto study utilizing a mixed methods approach, involving a causal-comparative component with a longitudinal perspective, a quasi-experimental element, and limited observations and interviews within the qualitative portion. The study followed four years of sonography graduates through the early career scan period, comparing results of three learning methods, classified as transmissional, transactional, and transformational in nature.

The methodology of the study assured that the retained subjects of this research were followed from the first semester of learning to beyond graduation, but prior to five years of scan experience. Such boundaries were designed to meet the literature review conditions of past longitudinal transformative learning studies and the five-year benchmark of pain onset reports within the sonography profession. There were six defined research questions within the scope of this methodology, each coinciding with quantitative descriptive data or testing, as well as interview narratives or observation themes associated with selected instrumentation tools. For the

purposes of methodological explanation, a synopsis of each research question will be provided in this segment.

Research Question 1

Research Question 1 assessed the study participants' complaints of discomfort, as associated with scan activities, comparing these to scan behaviors recorded by an expert observer at the early scan stage (for transactional and transformational learners) and at the final, post-graduate observation stage (for all learning groups). Findings were considered in conjunction with rates cited from the literature specific to common injury categories for career sonographers. Subjects' early and final WRMSD complaints (divided into categories of neck, back, shoulder, and wrist), and early and final observed negative risk behaviors (classified by the same categories) comprised the variables that were analyzed for association in this segment of the study. Descriptive statistics were used to analyze the data gathered, while observed behavioral findings were further described in qualitative terms.

Research Question 2

Research Question 2 assessed whether transmissional knowledge of injuries and risk rates influenced early career sonographers' beliefs of personal injury susceptibility. Two hypotheses were tested at this transmissional learning stage: one to determine the presence of any relationship between belief patterns and personal risk perceptions based on the knowledge of other sonographers with WRMSDs; the other to determine any relationship between increased

risk susceptibility perceptions based upon published professional injury rates being transmitted to the learner. The independent variables consisted of an awareness level of both pieces of information, with the dependent variable as the learner's perception of personal MSI susceptibility. Hypotheses were tested using chi-square with cross-tabulations of the associated interview question responses. Learners' quotes and belief patterns from the pre-instructional interviews, where this information was transmitted, were provided in relation to the study's intent.

Research Question 3

Research Question 3 assessed the value of the photoplethysmographic (PPG) quasi-experiment conducted within the transactional and transformational learning groups during the transactional learning stage. Three hypotheses were tested, assessing between the experimental and control groups as follows:

- differences in the mean self-susceptibility ratings for MSI risks,
- differences in the mean personal prevention plan (PPP) scores, and
- differences in frequencies of observed ergonomic risk behaviors from the pre-instructional to the post-instructional transactional observation stages.

Through this testing, both beliefs and behaviors were measured. In all cases, the independent variable consisted of whether or not one was engaged in the PPG experiment to view one's own personal blood flow volumes in neutral and negative scan maneuvers. The dependent MSI ratings, on an interval Likert scale of 1 to 10 to designate one's perception of susceptibility, were analyzed through a *t* test for difference in means among the groups, as were the interval PPP

scores. The final dependent variable in this quasi-experimental set calculated differences among ergonomic risk behaviors, using frequency-based ratios from the pre-instructional to the post-transactional observation events, giving way to the use of an independent-samples t test to analyze these data. Four interview questions (Appendix H) were asked of the PPG participants in an attempt to discern any strong narrative responses to signify reasoning of beliefs, as well as to offer the learner additional opportunity to reflect upon the results of the study, with responses categorized by learning group.

Research Question 4

Research Question 4 most directly addressed the central research question, looking for differences in learner attitudes and behaviors that could be determined within the ergonomics work habitus frame of reference when comparing the three learning classifications of this study. Three hypotheses were tested to assess differences in both negative and positive behavioral incidences, as well as differences in PPP scores, between learning groups at the final observation stage. The research question asked if there was a demonstrated impact toward positive work habitus that could be attributed to ergonomics instructional intervention. The independent variable, then, consisted of the groups to which learners had been designated. The dependent variables of positive and negative scan behaviors were analyzed through recorded frequency differences. ANOVAs were conducted to evaluate the relationship between the learning classifications and behavioral frequency differences, with post hoc tests added to evaluate pairwise differences among the means. An ANOVA was also conducted between the

instructional group classifications compared to PPP scores among the groups to denote evidence of any attitudinal differences.

The qualitative analysis associated with Research Question 4 included observational assessment of scan behaviors noted by the researcher as unanticipated findings beyond those or in association with those that were already categorically identified and described in the observation instrument. Nine dominant narrative themes were identified from the reflective personal prevention plans, which offered additional insight into belief patterns of early career sonographers and differences in reflection strengths and weaknesses among groups.

Research Question 5

Research Question 5 specifically assessed the later instructional stage of transformational learners, seeking any attitudinal impact of longer-term self-assessment and peer-assessment activities through survey responses and corrective action plans. Descriptive statistics were provided for consideration of learner perceived value through five responses on the Video Mirroring Adjustment (VMA) survey, including:

- frequency usage of the *iPad* padcam for collaborative mirroring descriptions,
- perception of both personal and peer benefit toward padcam use,
- personal and peer benefit perception in receiving collaborative feedback during scan lab,
- perception of enhanced understanding through padcam use, and
- belief that verbal explanations were as sufficient as padcam demonstrations.

Chapter V expanded on the peer interactions of transformational collaboration by providing comparisons between self-assessments and peer-assessments of corrective action plans to look for similarities and repetition in findings. Testing was also conducted on differences between mean MSI risk ratings in the transformational learners (as the dependent variable), from the end of the transactional stage (or the end of the first semester) to the end of the transformational stage (or the end of the program year). A *t* test for difference in means was conducted to test for any changes within the transformational groups' MSI ratings based upon the independent learning stage variable.

Research Question 6

Research Question 6 assessed patterns of responsiveness to prevention feedback among program graduates during the final observation stage. Two hypotheses were tested and analyzed based upon the graduate's perceived level of interest in receiving feedback toward identifying problematic ergonomic behaviors and making corrective measures. The dependent variable was determined according to the evaluator's perception of the graduate's responsiveness, rated on an interval scale of resistant, ambivalent, or responsive to feedback. In the first test, the independent variable was based upon whether or not the graduate subject reported a WRMSD concern. An independent-samples *t* test was conducted to evaluate the graduates' responsiveness levels related to WRMSD reports. In the second test, the independent variable was the type of learning in which the learner had been engaged (transmissional, transactional, or transformational). A one-way ANOVA was conducted to evaluate the relationship between the study graduates' assigned responsiveness ratings following the final ergonomics observation, according to the

classification of learning type in which each graduate had been involved. Work habitus findings that were not necessarily direct behavioral or attitudinal responses from the study's retained subjects at the time of final observation were noted, as pertinent environmental elements have the capacity to influence beliefs and expressions of behaviors. Repetitive patterns recognized by the researcher included perceived supervisory responsiveness and non-supervisory issues toward meeting sonographers' ergonomic needs.

Review of Findings

Research Question 1 Findings

How closely did sonographers' pre-instructional scan complaints and risk behaviors correspond with final musculoskeletal complaints and risk behaviors of prior published professional injury rates?

Initial observations suggested that shoulder, wrist, back, and neck maneuvers were the most problematic areas of negative behavioral scan incidences in both early general and cardiac sonographers. At the two to five year scan period, 72.5% of the retained study subjects reported WRMSD complaints and demonstrated problematic behaviors in these same categories, compared to the approximated 90.0% of MSI career-long injuries cited in published data (Baker, 2009; Coffin & Baker, 2007; Evans et al., 2009; Sound Ergonomics, 2008).

Also of importance to the data set was the 34.4% attrition rate in study participants who had less than five years of scan experience, though absence in the field among 18.0% of these subjects was not necessarily related to WRMSDs. The importance, however, lies within an assumption that might be made. Had the 18.0% of professionally inactive subjects continued to

scan, the probability of injury might also have increased, as indicated by both the literature review and the results of this study. As a result, injury reports might have been recorded in greater excess had all study participants been retained. Such an assumption might also extend to the entire population of sonographers, should data demonstrate a similar attrition rate in the field.

Injury and Complaint Prognostications

Shoulder and back complaints had reached approximately one-half of the proportion of sonographer injuries cited in the literature. Neck complaints were approximately one-third of the reported career injury rate, and wrist complaints were approximately one-fifth of the cited proportion. The researcher cannot accurately prognosticate whether the 72.5% of subjects' complaints will eventually equate to the 90.4% published MSD rate reported among the sonography population. However, data did demonstrate that, during the early career period with only 10 weeks of scan experience, nearly one-half of the sample group reported discomfort, which increased to over two-thirds of those responding by the five-year threshold. This finding would suggest that injury probabilities increase over time; thus, interventional corrections toward prevention of future MSI complaints should be enacted as early in the scan career as feasible.

Discrepancies Between and Among Specialty Modalities

Of additional importance to this study's methodology was the discrepancy between observed risk behaviors recorded between general and cardiac sonographers, with cardiac sonographers observed as conducting fewer shoulder risk behaviors. This finding was

particularly disturbing, since 37.2% of retained subjects reported shoulder pain, when only 18.5% demonstrated risk behaviors according to the observation guide's categorical descriptions. Unanticipated findings of shoulder observation revealed that risk behavior descriptions should not only include hyperabduction, but consideration should also be made for the addition of anterior shoulder rolling during hyperabduction, and posteroinferior shoulder positioning in the absence of hyperabduction (which appears to be more common among cardiac sonographers, especially when positioning for the apical view). Study participants' narrative comments, particularly in conjunction with the negative PPG experimental maneuvers, also greatly emphasized the discomfort associated with load bearing on the shoulder in the cases of obese patients, even when hyperabduction was not present.

The other discrepancy involved wrist complaints, at a low rate of 11.6% among retained subjects, compared to 26.9% of detected negative risk behaviors. Maladjusted grips were also commonly demonstrated as negative behaviors among participants, along with repeated and sustained extension behaviors, as described in the observation guide. The researcher noted that very few subjects engaged in microbreaks during the examination, while many complained of wrist discomfort when scanning, though never pausing to rest. One possibility for the discrepancy between complaints and observations may be that participants are more likely to deny wrist pain if it is intermittent and disappears when scan activities have been completed. Another possibility is that carpal tunnel syndrome or associated injuries may take longer than two to five years to become evident.

Demonstrated Risk Behaviors

Beyond the previously described shoulder and wrist observations, other risk behaviors included the neck, back, body posture, and elbow to forearm areas. For the neck, the WRMSD complaint and observation proportions at the final observation stage were closely aligned. Lateral cervical rotation due to horizontal non-alignment with the display monitor was the most commonly logged individual risk behavior. Cervical hyperflexion and hyperextension were also commonly anticipated behaviors, due to vertical misalignment with the display monitor. Lateral cervical extension (tilting of the head) and forward slumping behaviors appeared to be associated with greater processing needs during cognitive reasoning.

Back behaviors comprised the greatest proportion of categorical risk incidences noted at final observation. Back risk behaviors were most closely tied to lack of optimal body positioning (OBP), with leaning and torsion of the trunk accounting for the greatest proportion of postural directional susceptibility of movements (DSMs). Subjects were reluctant to trouble patients to move during exams to prevent negative sonographer risk behaviors, such as spinal torsion or shoulder hyperabduction.

The majority of early sonographers who performed scans while standing did not remain in balance or alignment, tending to jut one hip outward and/or stand with one foot in front of the other, even many times crossing the feet. None of the departments in which the expert observer visited possessed ergonomic mats for sonographers to stand upon. The majority of early sonographers who performed scans while sitting tended not to use the chair's backrest when doing so. Only 10.0% of the observed clinical sites had seating designed in accordance with the recommended criteria of an ergonomic scan chair. Rather, most sites possessed what the

researcher has designated as faux ergonomic scan chairs, allowing sonographers to lean to one side of the seat while reaching for the patient.

Elbow or forearm complaints were few, as were the observed risk behaviors of extended forearm supination and pronation during scanning. The associated risk of greater import was failure by half of the subjects to engage in the use of an armrest to remove strain from the forearm, elbow, and shoulder areas. Most would have to create a makeshift support, as a minimal number of clinical facilities had ancillary support sponges available.

Association between Behaviors and Complaints

Retained study subjects demonstrated some level of association between observed risk behaviors and reported WRMSD complaints. However, in several cases, a direct connection could not be established, despite some level of associated cross-over. Findings did suggest that some predictable measure of later WRMSD complaints may exist when categories of early reported discomforts coincide with the same early and persistent risk behavior categories.

Research Question 2 Findings

Did having transmissional knowledge of other sonographers' injuries and statistical injury risk rates influence early career sonographers' beliefs of personal susceptibility to injury?

Study findings did not support that having transmissional knowledge of other sonographers' injuries equated to either an original belief of personal risk susceptibility, or a reformed belief of increased risk when learners were provided with sonographer injury rates, as

established in the literature. Findings do not suggest, however, that transmissional information concerning the rate of injuries should be discounted from an instructional event, as injury rates should be considered essential as base knowledge in regards to ergonomics learning.

Nevertheless, as reasonable as it may have been to believe that having statistical injury rates among sonographers, as well as having personal transactions with sonographers who have had injuries, might stimulate changes in learner perception of personal risk, the data from this study suggest otherwise. Such early findings were the basis of considering enhanced learning techniques that might influence sonographers from the early career stage toward belief reformation and transformative action based upon value expectancy.

Research Question 3 Findings

Could differences in MSI perceptions and risk behavioral changes be detected at the transactional post-instructional stage based upon the learners' participation in the photoplethysmographic (PPG) diminished blood flow quasi-experiment?

The third series of quantitative tests evaluated MSI self-susceptibility ratings, personal prevention plan (PPP) scores, and differences in negative scan behaviors based upon the criteria of engagement in the quasi-experimental PPG blood flow study. All participants readily perceived decreased blood flow associated with the two negative scan maneuvers that were designed to sustain compression and create shoulder hyperabduction.

MSI Self-Susceptibility Ratings

The quantitative testing to assess any differences in beliefs of MSI susceptibility was not significant between the control and experimental groups, even though the majority of PPG participants affirmed being at greater risk for musculoskeletal injury during the qualitative interview. The most commonly cited concerns involved scan position and scan compression, corresponding with the two challenging scan maneuvers with which the participants were faced. Furthermore, all PPG participants agreed that intentional changes could be made to reduce one's risk susceptibility.

One possible explanation that may have biased the quantitative results was discovered during the post-PPG interview process, in which at least four of the subjects revealed that, despite seeing personally diminished blood flow, participants had elected to reduce personal MSI risk factor ratings. This numerical reduction, which was the exact opposite impact anticipated by the researcher, was due to cited beliefs of subjects being at lower risk as a result of early instructional intervention, at which time the results had inspired a desire to become more responsive to developing awareness of the issue. Such empowerment beliefs appeared to have influenced the findings of Null Hypothesis 3a, at least in the instances of four subjects. The researcher cannot make this assumption for all respondents, however. Another possible problem may have existed in the test tool, in which a broad range of response rating options may have diluted responses toward mid-scale ratings. Reducing the Likert scale from a response range of 1-10 to a range of 1-5 may or may not have had an impact on the results.

Regardless of the reasons for the reported numerical ratings, the data associated with this portion of the transactional learning event did not provide compelling evidence of short-term transformative change in MSI susceptibility belief based upon the PPG instructional element.

The researcher is not suggesting that the exercise had no value; rather, that no significant difference in the means between the quasi-experimental and control groups could be established. Therefore, further value potential was assessed through Hypothesis 3b.

Personal Prevention Plan Scores

Though the participants of the PPG study exhibited a higher mean PPP score, the difference was not considered to be statistically significant, once more suggesting that the evidence associated with the PPG portion of the transactional learning event was not compelling toward short-term transformational change. From a practical instructional standpoint, however, the researcher must point out that the mean score of 77.1 for the PPG study group was within the program's standards for passing (70.0 or above); whereas the mean score of 67.9 for the control group was just below the program's standards for passing.

Differences in Negative Scan Behaviors

The greatest identified PPG benefit was found in the reduction of negative scan behaviors at the end of the transactional learning stage (for both Groups B and C), at which time the PPG-engaged learners exhibited a significant mean reduction compared to the control group. Such data provide evidence that learner behavioral modifications began to take place following the PPG event within the transactional learning stage.

The purpose of this research study was to investigate whether there was a significant difference in the reduction of negative ergonomic scan habits associated with reported MSDs

through early career sonographer adoption of learned principles as reinforced practice within the work habitus frame of reference. The results of this particular hypothesis provided compelling evidence toward finding an instructional methodology component capable of supporting such a goal. Though the results from the other associated hypotheses relating to the PPG quasi-experiment did not demonstrate that transactional learners were yet becoming expressively aware of any significant attitudinal changes associated with the learning event, the behavioral differences demonstrated that the subjects were exhibiting enough awareness of risk factors that personal behavioral adjustments could be recognized through expert observation.

Research Question 4 Findings

Did observed scan behavior incidences demonstrate an impact toward positive work habitus among study subjects, particularly those within the transformational group, due to ergonomics instructional intervention?

The fourth research question compared overall scan behaviors among all learning classifications, first between Groups B and C learners at the end of each group's learning stage (independent of PPG study participation), and then among all learning groups (Groups A, B and C) at the final post-graduate observation stage of two to five years of scan experience.

Differences in Observed Scan Behavior Means

Though transformational learners exhibited a greater reduction in negative behaviors at the conclusion of Group C's learning stage compared to transactional learners at the first

semester's learning stage conclusion, this difference was not statistically significant between the two groups for this mid-range period. Results did reveal a promising finding, however - that transformational learners had sustained the reduction of negative behaviors from the end of the transactional stage to the end of the program year. Furthermore, a comparison among all learning groups demonstrated a significant difference in both positive and negative behaviors at the longer transformative period of two to five years, as results from the final observation divulged that the greatest amount of sustained positive work habitus behaviors were exhibited by the transformational learning group (Group C). Together, these findings strongly suggest that transformational learning provides longer-term benefit toward sustainability of positive work ergonomic habitus.

Such behavioral sustainability may have its origins from a shorter timeframe, though, as evidenced in the attitudinal differences of the PPP reflective writing scores. Use of a Dunnett's *C* post hoc test revealed a significant difference between the lower transmission learning level scores and the scores within the other learning categories. Also of practical learning value, the transformational group was the only group in which the PPP mean score of 76.4 was above the program passing grade threshold of 70.0.

The strength of relationships between the learning category and the frequency of negative behaviors was very strong, accounting for 77.0% of behavioral variance. The strength of the relationship between the learning category and the frequency of positive behaviors was also quite strong, accounting for 55.0% of behavioral variance. The strength of relationship between the learning category and mid-stage PPP scores was still relatively strong, accounting for 19.0% of score variance.

Negative scan behaviors were significantly greater in the lower transmissional instructional level, becoming progressively lessened in the sustained work setting of two to five years with learners who had engaged in the transactional learning level, and even further reduced with learners engaged in the transformational learning level. Thus, longer-term transformational learning demonstrated the greatest benefit in the reduction of observable negative scan behaviors within the post-graduate work setting. Transformational learners also demonstrated greater observable positive scan benefits within a sustained, post-graduate work environment.

Differences in Identified Risk Behaviors

In the pre-instructional transactional interview, transactional and transformational learners were asked to identify circumstances which the learners believed would increase personal susceptibility for WRMSDs. Even though these early learners had trouble personalizing the concept of scan-related injuries, the learners of Groups B and C had no trouble hypothetically listing circumstances for injury. It should be noted that transmissional learners (Group A) did not participate in this interview learning segment. The behaviors listed at the onset of ergonomics learning by Groups B and C study participants were quite similar to the behaviors noted by the expert observer throughout the study, including:

- poor posture and improper body mechanics,
- poor transducer grip or extended compression,
- shoulder hyperabduction (described as over-reaching),
- lack of arm support while scanning,
- lack of microbreaks (described as a failure to stop and/or reposition while scanning),

- prolonged repetitive movements, and
- high work productivity demands.

Study participants failed to mention neck behavioral concerns, though negative neck behaviors were identified by the expert observer and neck complaints were made by participants.

The additional behavioral nuances (e.g., anterior and posterior shoulder displacements, maladjusted transducer grips) may account for greater percentages of behavioral incidences or complaints within certain scanning populations. For instance, hyperabduction was the only risk behavior logged for negative behavioral frequencies of the shoulders; however, posteroinferior displacement was noted more often among cardiac sonographers who had fewer logged incidences of negative shoulder behaviors than did general sonographers, yet had similar discomfort complaints. As well, negative grip behaviors may not create pain for the early sonographer, as demonstrated in this study's low volume of complaints, but may be responsible for higher percentages of wrist-related WRMSDs reported by career-long sonographers. Though the sub-group comparisons between the general and cardiac subjects were of interest, the main objective was to compare recorded behavioral differences among the three learning groups.

As demonstrated in Table 5.16, in every categorical instance, transmissional learners demonstrated the greatest percentage of risk behaviors among the learning groups, with transactional learners consistently demonstrating the second greatest percentage of negative categorical behaviors. The transformational learners demonstrated the lowest group percentage of negative scan behaviors considered to be precursors to WRMSDs within each of the most commonly cited and observed injury categories. Such findings support success of transformational instructional outcomes within this study, though care must be taken in making generalizations for other populations, due to the small sample size within this study. Beyond the

differences in behaviors, attitudinal differences were also noted among the groups when comparing personal prevention plan (PPP) findings.

Differences in Personal Prevention Plan Scores

PPP scores were significantly less in the lower instructional level, where learners were expected to reflect on transmitted information, in comparison to the transactional and transformational levels of learning, where learners had some level of interaction within the learning environment from which to personally reflect. The mean transmissional score fell well below the lowest PPP scores for either the transactional or transformational groups. The highest transmissional score did not reach the mean score of the transformational group, and the highest transactional score was approximately at the mean score for the transformational group (Figure 4.1).

Results suggest that transmissional learning did not offer the necessary opportunity for subjects to sufficiently reflect upon personal preventative measures against MSIs. Transactional learners had significantly higher PPP scores than did transmissional learners. However, at the end of the first semester, there had not yet been a great amount of differentiation between the transactional and transformational learning events. The lack of significance in grades may have also been created if transformational learners began the personal prevention plans prior to comparing the self and peer video reviews with the expert observer's results, since the assignment was provided within the ergonomics module. Regardless, there was a practical score difference, whereby learners were expected to achieve a minimum grade of 70.0 throughout

program progression. The transactional PPP mean score of 67.9 was below that threshold, while the transformational PPP mean score of 76.4 was above the minimum threshold.

Differences in Personal Prevention Plan Themes

The personal prevention plans' reflections revealed more about learner application, analysis, and synthesis of ergonomic information than did the rubric-based scores alone. Nine prominent themes were identified by the researcher within the PPPs of all learning groups. Instructional sequence should be mentioned when considering any of these findings, in that the PPPs were completed by all learners during the first semester, when less difference existed among learning techniques than would have for the prolonged transformational instructional period. Nevertheless, some compelling differences were noted among these central themes.

Based upon the identified patterns, transmissional instructional themes (e.g., rote repetition) were more prominent among transmissional learners. The transactional clinical theme was strongly evident among learners of Groups B and C, who were engaged in the transactional stage at the time of the PPP assignment. Furthermore, transformational learners, who began engaging in collaborative peer assessment at the time of the assignment, demonstrated much greater percentiles, in comparison, among the identified critical reflection themes.

Research Question 5 Findings

How were student attitudes impacted by the interactions and reflections of the formative self and peer assessment process during the transformational learning stage?

This fifth question considered transformational learner attitudes concerning self-assessment and peer-assessment benefit during the prolonged instructional period that extended until the end of the program year. Frequency and Likert scale responses from Questions 1 through 5 of the VMA survey (Appendix H) provided evidence that Group C's learners found the collaborative and reflective exercises to be of value throughout the additional three laboratory sessions extending through the program year.

When assessing whether transformational (Group C) learners evidenced any change in MSI susceptibility risk belief from the end of the transactional stage to the end of the transformational stage, the researcher found considerable overlap in the distributions from the 10-point Likert scale rating for personal MSI risk (Figure 4.2). However, MSI ratings had decreased by the end of the program year. The cross-over may be partially explained by the fact that there were both control and experimental participants of Group C in the PPG quasi-experiment. Most importantly, the decreased ratings by transformational learners may have been accounted for by learner-cited empowerment toward behavioral changes, thus belief in the ability to lessen one's own susceptibility to risk.

Insight into the learners' reasoning was necessary for the researcher to more fully understand the decrease in MSI ratings among the transformational group. Subjects of this group verbally explained that, as awareness of personal risks increased, along with transformative practice, learners began to feel capable of performing corrective measures throughout the extended learning process. Prior to the study, the researcher had not considered that transformational learners might adjust MSI risk factor ratings between the transactional and transformational stages, not based solely upon awareness of ergonomic issues, but more importantly based upon perception of personal empowerment toward a future reduction in risk

according to longer-term awareness. Because of these adjustments, data were more pertinent in assessing the differences between the transactional and transformational learning stages of Group C than in making a comparison between the MSI risk perceptions between Groups B and C at the end of each group's learning stage. Group C increased personal risk ratings after engaging in transactional learning in which subjects became aware of increased risk susceptibility. Conversely, Group C then decreased personal risk ratings following transformational learning exercises, citing empowerment to recognize and make personal adjustments based upon that awareness with additional practice of positive ergonomic behaviors. In essence, the results demonstrated evidence of transformation in Group C's attitudes during longer term instruction.

Research Question 6 Findings

What patterns of responsiveness regarding injury awareness and prevention feedback were evidenced among program graduates at the time of final observation?

Responsiveness to Corrective Measures based upon

Personal WRMSD Report Status

Admittedly, the personal MSI risk rating was cause for concern to the researcher from the onset of data collection. Quantitative mean MSI ratings provided by learners throughout the learning stages often did not appear to demonstrate suitable belief in personal scan risk susceptibility in consideration of literature-cited sonographer injury rates. The researcher experienced a similar concern during the final observation stage, in which risk attitudes appeared

to differ among certain graduates based upon whether the early career sonographer had or had not personally expressed a musculoskeletal concern. Thus, a hypothesis was tested to evaluate the responsiveness of retained study subjects at the time of the final observation, which demonstrated that sonographers who had reported personal injury concerns did have more positive responses toward prevention and corrective feedback measures than did those sonographers who denied any personal WRMSD concerns. The eta square index was strong, indicating that 22.5% of the variance in the responsiveness rating was accounted for by whether or not the graduate reported a WRMSD concern. The lack of any cross-over among the distributions (Figure 4.3) between those who reported concerns and those who did not further emphasized that, until sonographers become personally injured, self-susceptibility belief for MSIs is not evidenced as apparent among early career scanning sonographers.

Responsiveness to Corrective Measures based upon Learning Classification

Retained transformational subjects demonstrated much greater responsiveness toward corrective feedback to prevent ergonomic injuries than did retained transmissional subjects. A strong eta square index indicated that 18.2% of the variance in the responsiveness ratings was accounted for based upon the subject's learning classification. Of interest, when the researcher was attempting to schedule the final observation, the three refusals for access to observe subjects in the workplace came from transmissional learners. Extended collaborative exercises among the transformational group may have accounted for the ease in which transformational subjects tended to receive feedback and more readily interacted with the expert observer in formulating

resolutions; whereas transmissional learners may have viewed observation and correction by a past instructor as more intimidating and reprimanding in nature.

Risk Assessment Attainment

Lastly, the theme of responsiveness was observed during the final observation stage through the ability (or lack thereof) of early career sonographers to express the need for administrative support with injury prevention measures. Sonographers, on the whole, were reluctant to request necessary equipment, many citing insufficient budgets without any supporting data to substantiate these claims (beyond the fear of lay-off). Administrators whose feedback was received by the researcher were generally unresponsive in appropriately meeting sonographers' ergonomic needs, by:

- replying with unsupportive remarks,
- citing budgetary insufficiency or lack of control over resources,
- failing to assure adequate equipment for all, as in the case where one ergonomic chair had been ordered for a large facility with multiple scan rooms,
- failing to convey the importance of support, such as in the case where a chair sat in a box, unassembled, for several weeks, with no known assembly date, or
- conveying a lack of concern for sonographers' well-being, such as in two instances where the supervisory retorts of "Can't you stand while you scan instead [of the department purchasing ergonomic equipment]?" and "You're just a bunch of wimps!" were presented in tones meant to be conveyed as humorous sarcasm.

Unfortunately, a humorous attitude in response to a health concern can seem as dismissive as the other scenarios, or even more callous to an individual who is injured and in pain. Such remarks may be perceived by the requestor as a lack of concern, as well as a lack of support. This was the case in one observed incident, in which the supervisor was teasing one of the sonographers who had previously undergone corrective surgery for a WRMSD, while presently in need of a second surgery.

Chapter V contained another case illustration, in which the supervisor had purchased an ergonomic chair without the sonographer initiating the request. However, the sonographer did not understand the operational design, so the ergonomic chair was not being used to full benefit. This case demonstrated a different sort of communication deficiency. However, a positive step was taken toward risk assessment and response. When sonographers fail to act upon risk assessments and fail to be adamant in pursuing the acquisition of necessary requests, or when administrators fail to act in the best interest of highly skilled and knowledgeable employees through a lack of budgetary planning or by making light of such requests, sonographers will be negatively impacted in both beliefs and behaviors. Facilities may ultimately be financially jeopardized, as was the case of the site whose sonographer was temporarily released from duty on workers' compensation and then returned to work with an unknown time limitation of scanning two patients per day.

Communication exchange should be conducted professionally from both directions, with sonographers making necessary and reasonable requests, backing those requests with feasible budgetary expectations (i.e., allowing time for items to be appropriately budgeted), and supporting such requests with updated injury statistics and costs. Administration should be willing to realistically view such requests from not only the perspective of revenues to

expenditures toward operating cost effectiveness, but also from a human resources perspective to demonstrate the value placed on a highly specialized employee. Periodic risk assessment measures also serve to ensure attention is given to such initiatives from a perspective of responsible action taken on the part of both sonographers and administrators.

Sonographers should feel confident that workplace safety measures include ergonomic risk assessments that serve to protect employees as valued members of the healthcare facility. Administrators should feel confident that sonographers are requesting such measures for the benefit of facility operations above personal agendas. One of the transactional learners beautifully described this ideal exchange within the reflective PPP:

After spending time in an ultrasound department, the director [makes] sonographer safety and health just as important as patient care. The department director tries to avoid any sonographer injuries by making sure the sonographers know the proper movements of machine and exam table to benefit them while scanning.

One learner emphasized the importance of this type of exchange in the reflective PPP, as well as the sonographer subject's expectation of administration's responsibility:

Reporting injuries to management will not only ensure workman's compensation, insurance coverage of the injury and proper FMLA leave time, but it can also help to prevent further injuries to other sonographers. If the injury is due to improper equipment, notifying management and administration may prompt purchase of updated, more ergonomic equipment. If the injury is due to improper use of current equipment and/or improper use of ergonomics by the sonographer, management may be prompted to educate sonographers on the importance of the practice of ergonomics.

Such exchanges must take place to assure responsiveness toward corrective measures and, ultimately, success in the risk assessment process.

Summary of Findings

Problematic Findings

The combination of all tests and additional narrative patterns indicated that transmissional learning did not provide compelling evidence toward attitudinal changes regarding personal risk susceptibility. Participants at the transmissional learning stage more often communicated patterns of learning in the same rote fashion in which the material had been transmitted, displaying more difficulty in projecting personal synthesis or applicability. Retained transmissional subjects were also less responsive to corrective feedback toward the prevention of MSIs. Such findings have serious implications, since 90.4% of sonographers in the Evans et al. (2009) survey described learning as what the researcher would define as transmissional in nature. The reader should take note that this same percentage of sonographers, 90.4%, also reported scanning in pain in the Evans et al. study.

Another finding of this research study was that all early complaints and risk behaviors did not necessarily correspond with later reported WRMSDs. What the study did determine, within this relational scope, was that early discomfort reports associated with early risk behaviors within the same category that were sustained at the time of the final observation precisely aligned with later WRMSD complaints. In other words, sonographers who practice and sustain poor technique and who begin to feel the effects during the early scan career period are more likely to report a future injury in that same area. This finding should emphasize the importance of sonographers learning and practicing correct ergonomic scan techniques from career onset and consistently throughout the career to lessen the risk of any potential injuries.

Sonographers do not respond as well to suggested corrective measures until being injured, suggesting that prevention is not a priority. Evidence further suggests that the

sonographers of this study are not being appropriately supported by administration through the acquisition of ergonomic equipment or risk assessment procedures to assist in the reduction of injury susceptibility. Rather, retained study subjects cited fear and doubt in making such requests on the basis of perceiving a lack of resources, and administrators who were approached failed to offer supportive responses. By such responses, both sonographers and administrators failed to value the human as the most important resource in supplying adequate sonography care.

Promising Findings

Transactional and transformational learners evidenced various levels of value expectancy through documentation of transactional application, stronger reflective attitudes, a reduction in negative scan behaviors, an increase in positive work habitus behaviors, and greater responsiveness toward injury prevention feedback. In the transformational learner, the reduction in negative scan behaviors was sustained over a longer-term career period than occurred for the transmissional or transactional learners. The PPG blood flow study also offered some additional value expectancy as evidenced by a reduction in negative scan behaviors toward long-term ergonomic transformative benefit. Instructional intervention for the early career sonographer, to include transactional assessment, prolonged collaboration, and reflection of beliefs and corrective measures, has demonstrated compelling evidence toward making a positive impact on the future health and longevity of practicing sonographers.

Compelling Key Points

- 1) A 72.5% injury pain rate was already reported among the retained study subjects prior to the five-year threshold period. This rate comprised 80.2% of the proportion of career-long sonographers who claimed to be scanning in pain in the Evans et al. (2009) study. Considering this study's 34.4% attrition rate, especially the 18.0% of early career departures, the reported injury pain rate might have been even higher, had all original study subjects been retained at the final observation stage.
- 2) Early career sonographers did not instinctively maintain OBP while scanning, regardless of whether sitting or standing to perform duties.
- 3) Early sonographers stated that being out of optimal body alignment was preferable to troubling patients to move, in order to assist in reducing negative sonographer risk behaviors.
- 4) Determining early scan risk behaviors that coincide with early pain reports and working toward preventative corrective actions may, in fact, reduce the likelihood of such future WRMSD complaints.
- 5) Only 10.0% of clinical facilities visited during the study had made ergonomic seating accommodations. Many sites were resistant to ergonomic equipment purchases, citing lack of necessity or budgetary funds for expenditures toward sonographer injury prevention.
- 6) Knowing of other sonographers with WRMSDs and knowing of the high injury statistic among career sonographers did not influence an early career sonographer's perception of personal risk susceptibility.

- 7) Learners viewing personal blood volume changes by using photoplethysmography during negative scan maneuvers demonstrated greater long-term impact toward positive transformative scan behaviors.
- 8) Transformational learning techniques provided significant results concerning a reduction in negative scan behaviors, an increase in positive scan maneuvers, and positive attitudinal differences in reflective personal plans of prevention.
- 9) Transformational learners expressed more empowerment toward reducing personal risk susceptibility through collaborative recognition and corrective action planning measures.
- 10) Unfortunately, sonographers were more responsive to injury prevention and corrective measures once WRMSD symptoms had become evident. (This finding might also account for a bias in sonographer surveys requesting WRMSD feedback, in which those who are injured would be the most likely to respond.)
- 11) Fortunately, this study did show that transformational learners demonstrate much greater responsiveness to corrective feedback that is provided with the intent of WRMSD prevention than do the other learning classifications. For this reason, the researcher believes this higher level of learning technique has the ability to reduce WRMSDs in the sonography profession through responsiveness of corrective action planning before an injury is present.

Implications for the Profession

Financial Implications within the Sonography Industry

In the Evans et al. (2009) study, 32.6% of sonographers reported lost time from work due to scanning overexertion. Within that same survey, 24.1% stated the need to change jobs due to discomfort associated with scanning. “Overexertion incidents are the leading source of workers’ compensation claims and costs in healthcare settings” (National Institute for Occupational Safety and Health, 2011). Walker-Bone and Cooper (2005) emphasized that modifications are extremely important in reducing musculoskeletal injury risks, defining such risk factors within the categories of repetitive movements and constrained postures.

To assist in WRMSD prevention, a sonography workstation could be equipped with an ergonomic scan table, chair, and additional ancillary equipment for no greater than \$6,500 in upgrade expenses. The Bureau of Labor Statistics (2014) listed 110,400 active sonographers in the U.S. in 2012. Assuming all 110,400 sonographers had individual workstations, which would be a highly unlikely scenario, total expenditures for ergonomic workstation improvements would equal approximately \$700 million. The researcher admits that this figure will sound like an excessive divestment of funds to employers. Based on value expectancy theory, the value of reducing sonographers’ risk factors for developing MSIs should override the cost of preventing such injuries, such as time away from work, therapeutic treatment, and possibly the eventual loss of a career (Society of Diagnostic Medical Sonography, 2003; Wihlidal & Kumar, 1997).

In comparison to the amount spent to prevent work-related injuries, Murphey and Coffin (2002) estimated the cost of an ergonomics-related incident to an individual sonographer to approximate \$28,000 in 2002. According to the sonography profession’s injury statistics published from the past two decades, an 80.0% to 90.0% injury rate would equate to between

88,320 and 99,360 injured sonographers within the United States, using the 2012 data from the Bureau of Labor Statistics (2014). To simplify the calculations, without consideration of future employees, if only one-half of these identified sonographers who were injured sought medical attention, workers' compensation costs could equal \$1.8 billion, when adjusting for inflation since 2002. If 20.0% of those who were injured were severely debilitated from this injury, nearly 20,000 sonographers could undergo early career departure, thereby costing the health community even greater losses in experienced staff, with need for replacement and the potential of additional loss in patient revenue. Even with the scenario of 110,400 sonographers having individual workstations, with \$700 million in expenses for ergonomic upgrades, the potential cost savings could minimally equate to \$1.1 billion compared solely to the potential for workers' compensation claims.

This above scenario also, of course, assumes that retained sonographers become aware of and continue to practice risk assessment measures to actively prevent future ergonomic injuries. According to the value expectancy theory, "...motivation can be achieved when perceived values in an activity override perceived cost of the activity derived from the effort of achieving" (Chen & Liu, 2009). The Bureau of Labor Statistics (2014) also discloses that the annual median pay in 2012 for a U.S. sonographer was \$60,350. A sonographer whose career was hindered just 10 years prior to planned cessation could potentially lose a minimum of \$603,500 in wages, not including pay increases, retirement savings, and the loss of benefits, all increasing this figure by at least 25 percent. Multiplied by the scenario of 20,000 debilitated sonographers in the U.S., the loss strictly of wages, again discounting other considerations, would exceed \$12 billion.

Implications Extending throughout the Healthcare Industry

WRMSDs are not isolated concerns for sonographers. Health care professionals across all specializations likely have susceptibility to MSIs. The National Institute for Occupational Safety and Health (2011) reported that, in 2009 alone, “more than 23,000 lost-time cases of work-related back pain, carpal tunnel syndrome, and tendonitis were reported in the Healthcare and Social Assistance sector (HCSA) by BLS...” (p. 1). Though specific duties may differ among various health care providers, repetitive motions are common in nearly any work environment where tasks rely on professional standards of care that require assurance of carefully enacted protocols. A variety of health care providers, then, are also susceptible to higher risks of injury based on the repetitive protocol criteria (National Institute for Occupational Safety and Health, 2011).

Morse et al. (2007) conducted research on dental hygienists and students regarding work related musculoskeletal disorders, noting that “risk factors...and...symptoms increase in frequency from students to experienced hygienists” (p. 1). The National Institute for Occupational Safety and Health (2011) also agreed that “...aging [within the health care workforce] likely contributes to the problem...” (p. 1), supporting the need to train health care workers toward safer ergonomic transformative practices from career onset to enhance career longevity. Nelson et al. (2006) developed and evaluated an ergonomics program for nursing personnel within a health care corporation, in which the researchers emphasized that training was necessary for all participants within such a program for it to demonstrate effectiveness. In the Nelson et al. nursing staff ergonomics program, researchers reported a reduction in cost due to lost productivity and an overall annualized cost savings per year (due to reduced workers’ compensation, reduced injury costs, and decreased loss of productivity) to be estimated at

\$204,599 per year; while the cost of the ergonomics equipment, maintenance, and training over a ten year period (the life of the equipment) was comparatively estimated to be only \$123,037 per year. Over a 10 year period, researchers estimated over \$2 million in cost savings due to enactment of the training program. These costs do not include the loss of years of specialized experience that cannot immediately be replaced. With the potential for such costly impact in the midst of health care reform enactments and wavering economic concerns, both health care employers and employees must consider the potential discomfort, both physically and financially, of ignoring ergonomic risks versus ensuring educational measures toward positive work habitus transformation. Persistence of highly specialized health care professionals should be a health care administrative priority.

Many within the healthcare industry are suffering from all costs addressed, as well as additional costs to patients that have not been addressed. From the standpoint of value expectancy, sonographers and other health care professionals need to benefit from earlier intervention that contains more than transmissional learning techniques of awareness and guides the learner toward the goal of taking responsibility for a positively transformed work habitus. Though this research demonstrates evidence that such benefit may be achieved, value expectancy in transactional and transformational learning techniques cannot be fully appreciated until broader and longer-term studies are conducted across multiple health care fields.

Recommendations based upon Value Expectancy Beliefs and Behaviors

This researcher had a personal trainer who would say to the fitness group, “A person who will cheat [oneself] will cheat anybody” (C. Russell, personal communication, February 1,

2013). The researcher shares this thought in relation to the concept of the health belief model (HBM) according to value expectancy theory as the basis of whether or not sonographers, as a conglomerate, will transform injury beliefs and scan behaviors. If sonographers continue to express denial of risk susceptibility, when faced with documented studies of approximated 90.0% injury rates in the field, these highly trained professionals will be the ones who are cheated – of both career longevity and enhanced personal health. By shortening time in the work force, fewer diagnostic contributions will ultimately cheat patients in lost expertise. By shortening personal musculoskeletal health endurance, lessened physical capabilities will cheat friends and family from shared activities beyond the work environment. Society may also be cheated, suffering an increased financial burden of common insurance disability payments for an individual who might not otherwise have become non-productive had preventative measures been taken. Employees and future professionals in the field will bear the burden of increased workers' compensation insurance coverage. Insurance companies, and thus patients, will absorb health care costs from claims that increase service expenses.

In essence, WRMSDs are not a sole individual's consequence, nor should risk of these injuries be a sole individual's burden. Working together responsibly to determine methods to reduce injury incidences should become the responsibility of the entire sonography profession. However, individual sonographers must come to the conclusion that beliefs do influence behaviors, so denial of susceptibility to injuries by health care employees or administration contributes to dangerous levels of laissez-faire behavior. Injury awareness must be given consideration, with widespread dissemination of WRMSD rates, risk assessments, and prevention measures throughout all career stages. Most related to this study, educators must assume responsibility at the earliest career point, not only to transmit compelling information

regarding the personal risk of MSIs, but to allow opportunities toward value expectancy development within a transformational learning environment toward long-term sustainability of positive work habitus behaviors. To that end, some final recommendations have been made.

Recommendations for the Sonography Industry

The National Institute for Occupational Safety and Health (NIOSH), who conducts research on safety issues and recommends standards for adoption by the Occupational Safety and Health Administration (OSHA), should continue to be informed of results on ergonomic studies within the field of sonography, this one being no exception. Sonography-specific workplace guidelines should also be considered by OSHA, in addition to the otherwise established, broader-based health care workplace standards and recommendations.

Sonography laboratory accrediting bodies should include requirements for reporting ergonomics policies and practices in the workplace setting within related safety standards. The researcher suggests documentation of periodic formal self-assessments and peer-assessments with plans of corrective action toward behavioral risks. In addition, a work station inventory should be conducted annually to assess ergonomic functions of each scan station, including the provision of ergonomic tables, chairs, mats, and other ancillary equipment. An administrative corrective action plan should also be a required component of the risk assessment, including a projected timeline and budget for recommended acquisitions. Periodic continuing ergonomics education may also be considered a part of corrective action plans.

Recommendations for the Sonography Workplace

Immediate supervisors and administrators of a sonography department should gain awareness of ergonomic injury rates and preventative measures to decrease the likelihood of workers' compensation and other liability issues within the workplace. Ergonomics should be a factor in the design and renovation of ultrasound operational spaces, as well as operational procedures of the healthcare facility. Departmental budgets should include resources for periodic ergonomic upgrades or acquisitions. Sonographers' requests for ergonomic relief should be taken seriously, with appropriate workloads investigated and maintained.

Ideally, sonographers should communicate with supervisors, from career onset, to institute preventative measures based first on available resources, such as:

- allowance for stretching during the first few minutes of the work day,
- making accommodations for adequate workday breaks and variation in duties,
- posting reminders of positive ergonomic behaviors in the work station space (e.g., taking microbreaks throughout an exam),
- assuring immediate access to economical ancillary equipment (e.g., ergonomic mats, support sponges),
- assessing the procedural design of the work space for improvements (e.g., relocating linen where sonographers are not bending low or reaching high throughout the entire day), and
- obtaining a documented evaluation of the work environment and sonographer habits (i.e., literature review, risk assessment report) to garner professional support toward future departmental expenditures.

Budgetary plans should be implemented for future purchases of more costly ergonomic equipment, such as ergonomic chairs meeting specified sonographer scanning criteria, as have been described in Chapter V of this study, or scan tables designed with adjustment and mobility functions in mind.

Sonographers should be expected to routinely perform risk assessments specific to patient care behaviors within the ultrasound department, while supervisors should be expected to routinely act upon such reported feedback in an objective manner without employee concern of ominous consequences. Risk assessment reports should include, but not necessarily be limited to:

- 1) periodic collaborative assessments (self and peer) of behaviors related to scanning, patient care, and any other department-specific duties;
- 2) reflective corrective action plans, based upon these findings, with the purpose of a more positive work environment (rather than the fear of penalty);
- 3) periodic recording (e.g., a sample week each quarter) of work-breaks, purposeful stretching, and variations in work duties throughout each day;
- 4) reports of any discomfort toward impending injuries to prevent later debilitating consequences from repetitive and sustained use of the area of concern; and
- 5) requests for equipment acquisition, making considerations for both ergonomic usefulness and budgetary considerations.

Recommendations for the Sonographer Instructional Setting

The researcher acknowledges that sonography instructors have many other specialized topics on which to focus beyond ergonomics, and that the time factors involved in the collective

research components of this study's methodology would be too time-intensive for most programs. Yet, higher levels of learning beyond the transmissional scope need to be implemented into sonography educational curricula. There are practical instructional elements that can be incorporated to achieve transformational ergonomics learning opportunities.

- 1) Instructionally provide learners with a solid foundation of ergonomics knowledge toward awareness, using these minimally suggested components:
 - a. definitional and practical understandings of ergonomics;
 - b. terms related to musculoskeletal disorders;
 - c. reported rates of WRMSDs and debilitating injuries among sonographers;
 - d. common symptoms of MSDs;
 - e. common sonographer risk behaviors and factors; and
 - f. measures to reduce or prevent risks.
- 2) Engage learners in assessing personal risk beliefs from the early instructional stages, using elements of the pre-instructional interview in a facilitated group discussion (whether on-site or online).
- 3) Post ergonomic visual aids on-site where students learn, which may include a home page in the case of a distance learning platform. (Visual aids should not only provide common scan risk concerns, but should offer suggested solutions.)
- 4) Engage clinical preceptors in continual ergonomics learning, through transactional exercises for students to complete during practicums and/or through provision of a continuing education opportunity on the subject, if feasible.
- 5) Whenever working with students in a scan setting, include directives for positive ergonomic behaviors (e.g., adjusting the scan table and monitor to appropriate

- heights), as well as provide alternative solutions when observing negative risk behaviors (e.g., have the patient move closer to avoid reaching).
- 6) Purposely design laboratory opportunities to include observational learners who are encouraged to actively collaborate toward positive adjustment solutions from the onset of the learning experience. The observation guide in Appendix F can assist in visually and descriptively directing attention to probable areas of concern.
 - 7) Promote the acquisition and use of ergonomic ancillary equipment in laboratory and clinical environments, using the information cited in the literature review with concerns and findings addressed in this study for reinforcement of need.
 - 8) If appropriate equipment is available, conduct the PPG experiment for all learners to view by using one scan volunteer to expedite the event. This may be achieved through advance video production or through live remote broadcast when all cohort members are not present on-site. At the very least, share the PPG findings within this study using Figure L.3, which denotes the reduction of blood flow during the two challenging maneuvers. Allow learners to critically process these findings, particularly in regards to personal risk susceptibility.
 - 9) Engage learners in a reflective ergonomics exercise. This could include collaborative assessment of behaviors captured in a laboratory scan session, such as was described in the observation methodology; and/or may include the development of a prevention plan personalized by the learner. The PPP rubric of Appendix D may serve as a guide for use or revision; however, the researcher cautions that reflective assignments should be made only after learners are equipped, not only with information but with

- opportunities to engage in a transactional scanning process, in order to possess the capacity to critically analyze and synthesize the experience.
- 10) Construct learner modeling activities through emerging technologies, whenever feasible, to stimulate learner interest through innovative cognitive impact.
 - 11) Encourage learners to continually self-assess and peer-assess ergonomic behaviors to collaboratively develop solutions, whether formally or informally. The described *iPad* student mirroring exercise (located in Appendices C and I) works well within the laboratory setting, provided that a procedure is in place to assure images do not leave that setting. Such controls can be achieved through settings on electronic devices, signed privacy agreements, and supervision and monitoring by the instructor to prevent such occurrences.
 - 12) Assure that all faculty members actively practice ergonomics, based upon awareness and adjustment measures, as assisting early career sonographers may further increase instructors' risk factors.

Recommendations for Future Research

As has already been mentioned, value expectancy in transactional and transformational learning techniques cannot fully be appreciated until broader and longer term studies are conducted, both within sonography and across multiple health care fields. Additional research developed by identified criteria within other specialized fields to compare the three learning techniques, with a meta-analysis conducted across professions, may eventually offer a broader analysis of WRMSD cost factors within the entire health care industry. This researcher is most

interested in expanding this research to assess the effectiveness of the Chattanooga State Sonography Program's transactional and transformational ergonomics learning designs toward greater generalization among other sonography programs.

At the time of this research, the retained post-graduate participants of this study were progressing toward five years of scan experience, a time designated in the literature when sonographers most often begin to report MSI concerns (Horkey & King, 2003; Parhar, 2004). This means the subjects in this study were also reaching approximately one-third of the sixteen-year experience timeframe which, according to Baker (2009), begins the period among sonographers for the highest reported incidences of WRMSDs. Since musculoskeletal injuries are cumulative, by nature of repetition and exertion, one might reasonably speculate a continued increase in reported complaints among these graduates as additional scan years accumulate. To that end, this researcher would like to longitudinally extend this study, continuing to follow the retained subjects through career checkpoints, particularly at 10 years and 15 to 16 years. The 10 year career period would be an approximate two-third time period to check for retained ergonomic behaviors and reported WRMSDs, prior to doing the same at the approximate 16 year career period, when there exists a perceived elevation in reported incidences. To determine career persistence, attrition rates and reasons among the study participants could be documented accordingly, searching for other reasons for career exit versus debilitating injuries.

This study has also identified some specific behaviors that were not originally listed within the anticipated broader categorical findings and has presented some discrepancies in findings between cardiac and general sonographers, which may or may not be associated with these unanticipated behaviors. Continued research on these subjects and information, as well as

additional research studies with larger sample groups, may offer insight into these findings that were not within the scope of this study.

Additionally, the researcher continues to be interested in how the degree of attitudinal support in regards to ergonomics awareness and preventative measures within the work environment may ultimately influence sonographers' career-related health and longevity. Future research could assess attitudinal supportive responses of sonographers and supervisors using a mixed methods approach, also taking inventory of ergonomic equipment upgrades and risk assessment procedures, to include work schedules as compared to exam volumes and documented injury reports and processes.

Lastly, those lesser percentages of long-term career sonographers, who are denying reports of musculoskeletal pain or injuries, should be qualitatively assessed. Such an analysis might reveal pertinent variables within the workplace and/or lifestyle habits that may be considered as contributing factors to the longer-term well-being of the scanning sonographer. If so, these should additionally be reported for consideration of adoption within the field.

Conclusions

The researcher's findings and recommendations have been made. In closure, the participants of this study have earned the right to have the final words. Many of these subjects have truly sought to become critical learners. One of the transformational students who was engaged in student mirroring adjustments wrote,

I observed sonographers leaning, twisting, stretching, bending, and every other ergonomic disaster available to them. I cannot say much about this, because when I am in the middle of a scan, I notice I am doing the same thing. I believe if everyone in a department is educated in this matter, they could then correct each other on a daily basis.

Such powerful beliefs may have the ability to influence future behaviors. Equally, after being involved in the transactional video assessment, another learner emphasized the idea of the James-Lange theory (Cannon, 1927), supporting the assumption that practiced changed behavioral patterns might also influence learners' beliefs, as this participant stated,

After viewing scan lab videos, I have pinpointed errors that need to be changed to prevent poor scanning habits from being established as a learned scan technique. I am now aware of monitor and unit placement so that neck and back strains do not become an issue. Actually viewing myself and another peer allowed me to realize the mistakes that we both have made as beginners and the corrections we need to make. As I have made those changes, I have noticed I am much more comfortable when scanning, and I don't get tired as quickly. I have much more patience during the exam and don't get frustrated as easily.

The above statements demonstrate these learners' transitioning ideas, in which each has begun to comprehend the need for the acceptance of personal responsibility in the reduction of ergonomic injury risk susceptibility, as well as the importance of collaboration in the transformation process. Another student was emphatic about the need to accept personal responsibility in the matter, saying,

Gaining information and doing training in prevention can really change the future conditions of many sonographers. I believe it is important to reach out and involve myself, taking an active part in finding solutions. I believe that raising awareness about prevention is an important step to prevent and also manage injuries.

Finally, a transformational participant summed up the value of sonographers taking such a great amount of responsibility toward transformation:

Ergonomics may be the most important subject for a sonographer to understand. Without it, we cannot prevent injuries to ourselves, we cannot be available to coworkers, and we cannot be present to serve our patients. Sonographers, as a professional group, must take responsibility for treating our bodies with respect by working out, supplying our bodies with appropriate nutrients, getting adequate rest, and performing ergonomics correctly to prolong our health and careers.

Such statements as these serve as testimonies to the importance of transformative ergonomics learning in a collaborative and reflective environment toward the reduction of sonographers' musculoskeletal disorders and the assurance of positive work habitus practices.

REFERENCES

- Anteby, M., & Khurana, R. (2012). Baker Library historical collections: A new vision. Retrieved November 27, 2012, from <http://www.library.hbs.edu/hc/hawthorne/aneurovision.html#e>
- Atkinson, J. W. (1957). Motivational determinants of risk-taking behavior. *Psychological Review*, 64(6), 359-372. doi: 10.1037/h0043445
- Baker College. (2005). *Active teaching strategies*. Flint, MI: Effective Learning and Teaching Department, Baker College.
- Baker, J. P. (2009, August 1). Time for sonographers to take individual responsibility. *Echochief.com*. Retrieved from <http://www.echochief.com/joan-baker-ergonomics.php>
- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.
- Bandura, A., & McDonald, F. J. (1963). Influence of social reinforcement and the behavior models in shaping children's moral judgments. *Journal of Abnormal and Social Psychology*, 67(3), 274-281. doi: 10.1037/h0044714
- Becker, M. H. (1974). *The health belief model and personal health behavior*. Thorofare, NJ: Charles B. Slack Inc.
- Biswalo, P. (2001). The systems approach as a catalyst for creating an effective learning environment: For adults in part-time and distance learning. *Convergence*, 34(1), 53-64.
- Boyd, R. D., & Myers, J. G. (1988). Transformative education. *International Journal of Lifelong Education*, 7(4), 261-284. doi: 10.1080/02601377880070403
- Brickner, D., Russell, J. D., & Sorge, D. (1994). Improving technology implementation in grades 5-12 with the ASSURE model. *Technological Horizons in Education Journal*, 21(9), 66+.
- Brookfield, S. (1995). Adult learning: An overview. In A. Tuinjmans (Ed.), *International Encyclopedia of Education* (Vol. X, pp. 375-380). Oxford: Pergamon Press.
- Bureau of Labor Statistics, U.S. Department of Labor. (2014). *Occupational outlook handbook: Diagnostic medical sonographers and cardiovascular technologists and technicians, including vascular technologists*. Washington, DC: Retrieved from <http://www.bls.gov/ooh/healthcare/diagnostic-medical-sonographers.htm>.

- Burke, W. W. (2011). *Organization change theory and practice* (3rd ed.). Los Angeles, CA: Sage Publications, Inc.
- Burns, M. S. (2008). Application of neuroscience to technology in stroke rehabilitation. *Topics in Stroke Rehabilitation, 15*(6), 570-579. doi: 10.1310/tsr1605-570
- Cannon, W. B. (1927). The James-Lange theory of emotions: A critical examination and an alternative theory. *The American Journal of Psychology, 39*, 106-124. doi: 10.2307/1415404
- Carey, M., & McCardle, M. (2011). Can an observational field model enhance critical thinking and generalist practice skills? *Journal of Social Work Education, 47*(2), 357-366. doi: 10.5175/JSWE.2011.200900117
- Chen, A., & Liu, X. (2009). Task values, cost and choice decisions in college physical education. *Journal of Teaching in Physical Education, 28*, 192-213. <http://www.humankinetics.com>
- Clark, P. A. (2002). *Organisations in action: Competition between contexts*. New York, NY: Routledge, Taylor & Francis Group.
- Coffin, C. T., & Baker, J. P. (2007). Ultrasound clinics: Preventing work-related injuries among sonographers and sonologists. *Contemporary OB/Gyn, 52*(7), 78-84.
- Cogan, M. L. (1953). Towards a definition of profession. *Harvard Educational Review, 23*(1), 33-50.
- Collins English Dictionary. (2012). ergon. Retrieved January 30, 2013, from <http://www.collinsdictionary.com/dictionary/english/ergon>
- Commission on Accreditation of Allied Health Programs. (2011). Standards and guidelines for the accreditation of educational programs in diagnostic medical sonography. Retrieved from Joint Review Committee on Education in Diagnostic Medical Sonography website: <http://www.jrcdms.org/pdf/Standards2011.pdf>
- Craighead, W. E., & Nemeroff, C. B. (Eds.). (2004). *The Corsini encyclopedia of psychology and behavioral science* (3rd ed.). New York, NY: John Wiley & Sons.
- Davis, E. B., Kee, J., & Newcomer, K. (2010). Strategic transformation process: Toward purpose, people, process and power. *Organization Management Journal, 7*, 66-80. doi: 10.1057.omj.2010.6
- Davis, W. (2006, April). Pain in your neck? Sonographers take note: Design, administrative, and self-help fixes can help to reduce the risk of musculoskeletal disorders. *Medical Imaging, 1-2*.

- Dirkx, J. M., Mezirow, J., & Cranton, P. (2006). Musings and reflections on the meaning, context, and process of transformative learning: A dialogue between John M. Dirkx and Jack Mezirow. *Journal of Transformative Education*, 4(2), 123-139. doi: 10.1177/1541344606287503
- Edburg, M. (2010). *Essential readings in health behavior theory and practice*. London: Jones and Bartlett Publishers International.
- Eisen, M. J. (2001). Peer-based professional development viewed through the lens of transformative learning. *Holistic Nursing Practice*, 16(1), 30-42.
- Encyclopaedia Britannica. (2012). nomos. Retrieved January 30, 2013, from <http://www.britannica.com/EBchecked/topic/417438/nomos>
- Evans, K., Roll, S., & Baker, J. (2009). Work-related musculoskeletal disorders (WRMSD) among registered diagnostic medical sonographers and vascular technologists: A representative sample. *Journal of Diagnostic Medical Sonography*, 25(6), 287-299. doi: 10.1177/8756479309351748
- Franz, N. (2007). Adult education theories: Informing cooperative extension's transformation. *Journal of Extension*, 45(1). <http://www.joe.org/joe/2007february/a1.php>
- Freiherr, G. (2003, April). Better ergonomics drives new ultrasound configurations - Once an afterthought, operator comfort is focus of latest generation equipment. *Diagnostic Imaging*, 69.
- Freire Institute. (2013). Banking concept of knowledge. Retrieved March 28, 2013, from <http://freire.org/banking-concept-of-knowledge/>
- Friesen, M. N., Friesen, R., Quanbury, A., & Arpin, S. (2006). Musculoskeletal injuries among ultrasound sonographers in rural Manitoba: A study of workplace ergonomics. *Association of Occupational Health Nurses Journal*, 54(1), 32-37.
- Garrison, D. (1992). Critical thinking and self-directed learning in adult education: An analysis of responsibility and control issues. *Adult Education Quarterly*, 42(3), 136-148. doi: 10.1177/074171369204200302
- Glanz, K., Rimer, B. K., & Viswanath, K. (2008). *Health behavior and health education theory, research and practice*. San Francisco, CA: Jossey-Bass.
- Grabinger, R. S., & Dunlap, J. C. (1996). Rich environments for active learning: A definition. *Association for Learning Technology Journal*, 3(2), 5-34.
- Hancock, J. A. (2002, August 30). Work-related injuries and scanning ergonomics in diagnostic medical sonography. *Chattanooga State Diagnostic Medical Sonography Program Web site*. Retrieved from http://www.chattanoogastate.edu/allied_health/sonography/index2.html

- Hancock, J. A. (2003). An interactive mock laboratory assessment of scanning ergonomics. *Journal of Diagnostic Medical Sonography*, 19(2), 130-136. doi: 10.1177/8756479303251338
- Hancock, J. L., & Ellis, J. T. (2012). Integrating the ASSURE model into a pilot assessment plan for ergonomics conceptualization among college sonography students *Unpublished manuscript*. Chattanooga, TN: University of Tennessee at Chattanooga.
- Harlen, W. (1999). Purposes and procedures for assessing science process skills. *Assessment in Education*, 6(1), 129-144. doi: 10.1080/09695949993044
- Health Insurance Portability and Accountability Act LLC. (2009). HIPAA 'protected health information': What does PHI include? *HIPAA.com*. Retrieved October 19, 2012, from <http://www.hipaa.com/2009/09/hipaa-protected-health-information-what-does-phi-include/>
- Heinich, R., Molenda, M., Russell, J. D., & Smaldino, S. E. (1996). *Instructional media and technologies for learning* (5th ed.). Englewood Cliffs, NJ: Merrill.
- Hochbaum, G. M. (1956). Why people seek diagnostic x-rays. *Public Health Reports*, 71, 377-380. doi: 10.2307/4589418
- Holistic Education Network. (2011). Transformative learning. Retrieved January 30, 2013, from <http://www.hent.org/transformative.htm>
- Horkey, J., & King, P. (2003). Ergonomic recommendations and their role in cardiac sonography. *Work*, 22, 207-218.
- Hospital Employee Health. (2007, March). NIOSH offers solutions for sonographers: Adjustable workspace reduces injury. *Hospital Employee Health*, pp. 28-29.
- Imel, S. (1998). Transformative learning in adulthood. (ERIC Digest No. 200). Retrieved January 30, 2013 <http://eric.edu.gov/PDFS/ED423426.pdf>
- Ivanov, L. L., & Blue, C. L. (2008). *Public health nursing: Leadership, policy & practice*. Clifton Park, NY: Delmar Cengage Learning.
- Javanbakht, A. (2011). A neural network model for schemas based on pattern completion. *Journal of the American Academy of Psychoanalysis and Dynamic Psychiatry*, 39(2), 243-261. doi: 10.1521/jaap.2011.39.2.243
- Joint Commission on Accreditation of Healthcare Organizations. (2006). OSHA & worker safety: Preventing occupational injury among diagnostic medical sonographers. *Environment of Care News*, 9(3), 6-7. <http://www.biodex.com/sites/default/files/report-ergonomics-preventing-injury.pdf>

- Kaiser, C. P. (2007). Sonographers worldwide face debilitating injuries - Clinical site evaluations prove effective way to change behavior and reduce injury risk. *Diagnostic Imaging*, 23(6), 16.
<http://www.diagnosticimaging.com/ultrasound/content/article/113619/1187867#>
- Kaufman, D. M. (2006). ABC of learning and teaching in medicine: Applying educational theory in practice. *British Medical Journal*, 326, 213-216. doi: 10.1136/bmj.326.7328.213
- Keller, J. M. (2010). *Motivational design for learning and performance: The ARCS model approach*. New York, NY: Springer.
- Kirkpatrick, D. L., & Kirkpatrick, J. D. (2006). *Evaluating training programs: The four levels* (3rd ed.). San Francisco, CA: Berrett-Koehler Publishers.
- Kitchenham, A. (2008). The evolution of John Mezirow's transformative learning theory. *Journal of Transformative Education*, 6, 104-123. doi: 10.1177/1541344608322678
- Knowles, M. S., Holton, E. F., & Swanson, R. A. (2011). *The adult learner: The definitive classic in adult education and human resource development* (7th ed.). Burlington, MA: Elsevier.
- Kolb, A. Y., & Kolb, D. A. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning & Education*, 4(2), 193-212. doi: 10.5465/AMLE.2005.17268566
- Louv, R. (2013). "Sitting is the new smoking" - What we can do about killer couches, sedentary schools, and the pandemic of inactivity. *The New Nature Movement*.
- Maehr, M. L., & Sjogren, D. D. (1971). Atkinson's theory of achievement motivation: First step toward a theory of academic motivation? *Review of Educational Research*, 41(2), 143-161. doi: 10.3102/00346543031002143
- Martin, L. M., & Tew, M. (2006). Ergonomic report for Grey Bruce County: Addressing the ergonomics for the sonographers. Ontario, Canada: Occupational Health Clinic for Ontario Workers Inc.
- Maudsley, G., & Strivens, J. (2000). Professional knowledge, experiential learning and critical thinking for medical students. *Medical Education*, 34(7), 535-544. doi: 10.2046/j.1365-2923.2000.00632.x
- Merriam, S. B. (2001). Something old, something new: Adult learning theory for the twenty-first century. *New Directions for Adult and Continuing Education*, 89, 93-96. doi: 10.1002/ace.12
- Mezirow, J. (1997). Transformative learning: Theory to practice. *New Directions for Adult and Continuing Education*(74), 5-12. doi: 10.1002/ace.7401

- Mezirow, J. (2000). *Learning as transformation: Critical perspectives on a theory in progress*. San Francisco, CA: Jossey-Bass.
- Mezirow, J. (Ed.). (1990). *Fostering critical reflection in adulthood: A guide to transformative and emancipatory learning*. San Francisco, CA: Jossey-Bass.
- Morrison, J. L., Forbes, L., & Wilkinson, G. (2006, July 3). Common sense management. *Horizon*. Retrieved from <http://horizon.unc.edu/projects/CSM/>
- Morse, T., Bruneau, H., Michalak-Turcotte, C., Sanders, M., Warren, N., Dussetschleger, J., . . . Cherniack, M. (2007). Musculoskeletal disorders of the neck and shoulder in dental hygienists and dental hygiene students. *Journal of Dental Hygiene*, 81(1), 1-16.
- Mosby's Medical Dictionary. (2009). Health belief model. Retrieved January 30, 2013, from <http://medical-dictionary.thefreedictionary.com/health+belief+model>
- Murphey, S. L., & Coffin, C. T. (2002). Ergonomics and sonographer well-being in practice. Retrieved from Sound Ergonomics website: <http://soundergonomics.com/pdf/ErgSonWellBeing.pdf>
- Murphy, C., & Russo, A. (2000). An update on ergonomic issues in sonography. *Healthcare Benefit Trust Employee Health and Safety Services*. Retrieved from <http://www.biodes.com/sites/default/files/report-ergonomics-sono-issues.pdf>
- National Institute for Occupational Safety and Health. (2011). *Workplace safety & health topics: Safe patient handling*. Cincinnati, OH: Centers for Disease Control and Prevention. Retrieved from <http://www.cdc.gov/niosh/topics/safepatient>.
- National Institute for Occupational Safety and Health. (2012). *Workplace safety & health topics: Ergonomics and musculoskeletal disorders*. Cincinnati, OH: Center for Disease Control and Prevention. Retrieved from <http://www.cdc.gov/niosh/topics/ergonomics/>.
- National Institute for Occupational Safety and Health, Department of Health and Human Services. (2006). *Preventing work-related musculoskeletal disorders in sonography*. (NIOSH Publication No. 2006-148). Centers for Disease Control and Prevention. Retrieved from <http://www.cdc.gov/niosh/docs/wp-solutions/2006-148/pdfs/2006-148.pdf>.
- Nelson, A., Matz, M., Chen, F., Siddharthen, K., Lloyd, J., & Fragalad, G. (2006). Development and evaluation of a multifaceted ergonomics program to prevent injuries associated with patient handling tasks. *International Journal of Nursing Studies*, 43(6), 717-734. doi: 10.1016/j.ijnurstu.2005.09.004
- Nordander, C., Ohlsson, K., Akesson, I., Arvidsson, I., Balogh, I., Hansson, G. A., & Skerfving, S. (2009). Risk of musculoskeletal disorders among females and males in repetitive /constrained work. *Ergonomics*, 52(10), 1226-1239. doi: 10.1080/00140130903056071

- Nowicki, S., Adame, D., Johnson, T. C., & Cole, S. P. (1997). Physical fitness as a function of psychological and situational factors. *The Journal of Social Psychology, 137*(5), 549-558. doi: 10.1080/0022454970955477
- O'Donnell, A. M., & King, A. (1999). *Cognitive perspectives on peer learning*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Orenstein, B. W. (2009a, August). Latest survey shows musculoskeletal injuries among sonographers not abating. *SDMS News Wave, 1*-4.
- Orenstein, B. W. (2009b). Scanning in pain - Sonographers seek relief from job-related hazard. *Radiology Today, 10*(18), 24.
- Parhar, G. (2004). Another perspective: Ultrasound ergonomics - Designed with the sonographer in mind. *Imaging Economics*, (December). Retrieved from Imaging Economics website: http://www.imagingeconomics.com/issues/articles/MI_2004-12_08.asp
- Patten, M. L. (2009). *Understanding research methods: An overview of the essentials* (7th ed.). Glendale, CA: Pyrczak Publishing.
- Philips Medical Systems. (2007). *Understanding work-related musculoskeletal disorders in sonography: CME education workbook*. USA: Royal Philips Electronics.
- Phillipi, J. (2010). Transformative learning in healthcare. *PAACE Journal of Lifelong Learning, 19*, 39-54.
- Popham, W. J. (2008). *Transformative assessment*. Alexandria, VA: Association for Supervision and Curriculum Development.
- Pratt, D. D. (2002). Good teaching: One size fits all? New directions for adult and continuing education. *Contemporary Viewpoints on Teaching Adults Effectively, Spring*(93), 5-16. doi: 10.1002/ace.45
- Quick, T. L. (1988). Expectancy theory in five simple steps. *Training & Development Journal, 42*(7), 30-32.
- Ransom, E. (2002, June). The causes of musculoskeletal injury amongst sonographers in the UK. *The Society of Radiographers*. Retrieved from <http://www.biindex.com/sites/default/files/report-ergonomics-sor-msi-book.pdf>
- Rosenstock, I. M. (1966). Why people use health services. *Milbank Memorial Fund Quarterly, 44*(3), 94-127. doi: 10.2307/3348967
- Rosenstock, I. M., Strecher, V. J., & Becker, M. H. (1988). Social learning theory and the Health Belief Model. *Health Education Quarterly, 15*(2), 175-183. doi: 10.1177/109019818801500203

- Ross, J. A., & Starling, M. (2008). Self-assessment in a technology-supported environment: The case of grade 9 geography. *Assessment in Education, 15*(2), 183-199. doi: 10.1080/09695940802164218
- Ross, T. P., Ross, L. T., Rhaman, A., & Cataldo, S. (2010). The bicycle helmet attitudes scale: Using the health belief model to predict helmet use among undergraduates. *Journal of American College Health, 59*(1), 29-36. doi: 10.1080/07448481.2010.483702
- Sahrman, S. A. (2002). *Diagnosis and treatment of movement impairment syndromes*. St. Louis, MO: Mosby Inc.
- Schein, E. H. (2010). *Organizational culture and leadership* (4th ed.). San Francisco: Jossey-Bass.
- Schunk, D. H. (2008). *Learning theories: An educational perspective* (5th ed.). Upper Saddle River, NJ: Pearson Education, Inc.
- Seddon, G. M. (1978). The properties of Bloom's taxonomy of educational objectives for the cognitive domain. *Review of Educational Research, 48*(2), 303-323. doi: 10.3102/00346543048002303
- Sennott-Miller, L. (1994). Using theory to plan appropriate interventions: Cancer prevention for older Hispanic and non-Hispanic white women. *Journal of Advanced Nursing, 20*, 809-814. doi: 10.1046/j.1365-2648.1994.20050809.x
- Shelly, G. B., Cashman, T. J., Gunter, G. A., & Gunter, R. E. (2004). *Teachers discovering computers: Integrating technology and digital media in the classroom* (3rd ed.). Boston, MA: Thomson Learning, Inc.
- Simonson, M., Smaldino, S., Albright, M., & Zvacek, S. (2000). *Teaching and learning at a distance: Foundations of a distance education*. Upper Saddle River, NJ: Prentice-Hall.
- Sivan, A. (2000). The implementation of peer assessment: An action research approach. *Assessment in Education, 7*(2), 193-213. doi: 10.1511/2012.94.1
- Skinner, B. F. (1957, 2012). The experimental analysis of behavior: The 1957 American Scientist article, reproduced in full. *American Scientist, 100*(1), 54. doi: 10.1511/2012.94.1
- Smaldino, S. E., Russell, J. D., Heinich, R., & Molenda, M. (2005). *Instructional technology and media for learning* (8th ed.). Upper Saddle River, NJ: Pearson Education, Inc.
- Society of Diagnostic Medical Sonography. (2003). *Industry standards for the prevention of work-related musculoskeletal disorders in sonography*. Paper presented at the Consensus Conference on Work-Related Musculoskeletal Disorders in Sonography, Dallas, TX. <http://www.biodex.com/sites/default/files/report-ergonomics-wrmds.pdf>

- Sound Ergonomics. (2008). Scanner/sonographer interface. *Sound Ergonomics*. Retrieved from Sound Ergonomics website: <http://www.soundergonomics.com/dev/info-pubs-interface.php>
- Stolovitch, H., & Keeps, E. (2011). *Telling ain't training* (2nd ed.). United States: American Society for Training & Development.
- Strobino, J., Gravitz, K., & Liddle, C. (2002). Student perceptions of grades: A systems perspective. (The scholarship of teaching and learning). *Academic Quarterly Exchange*, 6(1), 145-150.
- Tanner-Smith, E. E., & Brown, T. N. (2010). Evaluating the health belief model: A critical review of studies predicting mammographic and pap screening. *Social Theory & Health*, 8, 95-125. doi: 10.1057/sth.2009.23
- Taylor, E. W. (2003). Attending graduate school in adult education and the impact on teaching beliefs: A longitudinal study. *Journal of Transformative Education*, 1, 349-368. doi: 10.1177/1541344603257239
- Taylor, E. W. (2007). An update of transformative learning theory: A critical review of the empirical research (1995-2005). *International Journal of Lifelong Education*, 26(2), 175-191. doi: 10.1080/02601370701219475
- Taylor, E. W. (2008). Transformative learning theory. *New Directions for Adult and Continuing Education*, 119, 5-15. doi: 10.1002/ace.301
- The Center for New Discoveries in Learning, Inc. (2013). Learning styles quiz. *HowToLearn.com*. Retrieved April 18, 2013, from <http://www.howtolearn.com/learning-styles-quiz>
- Tolman, E. C. (1938). The determiners of behavior at a choice point. *Psychological Review*, 45, 1-41. doi: 10.1037/h0062733
- United States Department of Labor, Occupational Safety and Health Administration. (2010). *Ergonomic injuries*. Washington, DC: OSHA. Retrieved from <http://www.osha.gov/ergonomics/FAQs-external.html>.
- Venugopal, P., & Kakani, R. K. (2002). Management education: A framework for grading. *Management and Labour Studies*, 27(3), 177-188. doi: 10.1177/0258042X0202700303
- Viale, R. (2011). Brain reading social action. *International Review of Economics*, 58(3), 319-336. doi: 10.1007/s12232-011-0130-0
- Walker-Bone, K., & Cooper, C. (2005). Hard work never hurt anyone: Or did it? A review of occupational associations with soft tissue musculoskeletal disorders of the neck and upper limb. *Annals of the Rheumatic Diseases*, 64(10), 1391-1396. doi: 10.1136/ard.2003.020016

- Wheatley, M. J. (1994). *Leadership and the new science: Learning about organization from an orderly universe*. San Francisco: Berrett-Koehler Publishers, Inc.
- Wihlidal, L. M., & Kumar, S. (1997). An injury profile of practicing diagnostic medical sonographers in Alberta. *International Journal of Industrial Ergonomics*, *19*, 205-216.
- Williams, S. M. (2012). Technology in education - School, higher education: Current trends. *Education Encyclopedia*. Retrieved February 7, 2012, from <http://education.stateuniversity.com/pages/2497/Technology-in-Education.html>
- Yorks, L., & Sharoff, L. (2001). An extended epistemology for fostering transformative learning in holistic nursing education and practice. *Holistic Nursing Practice*, *16*(1), 21-29.

APPENDIX A
INSTITUTIONAL REVIEW BOARD
APPROVALS

Chattanooga State

September 23, 2010

University of Tennessee at Chattanooga
Lindsay Pardue, Institutional Review Board and Director of Research Integrity
615 McCallie Avenue
Chattanooga, TN 37403

Dear Ms. Pardue:

The request by Jody Hancock to conduct a research project on the Chattanooga State Community College (ChSCC) campus has been approved through the ChSCC Institutional Review Board process, ensuring student/ subject confidentiality and ethical behavior. Ms. Hancock, a graduate student at the University of Tennessee at Chattanooga and employee of ChSCC, may proceed to conduct the project, "Scan Technique Assessment Related to Ergonomics Issues in Sonography," through the entirety of the 2010 fall semester. She may work with current and former students, graduates, and instructors of the diagnostic medical sonography program at ChSCC and all study activities will rely upon consent of the students and patients.

Upon obtaining written consent from the student, Ms. Hancock, through observational scans of techniques and interviews regarding ergonomic issues, may perform blood flow or ergonomic studies that attach sensors to the participants' shoulders, wrists, hands, or fingers, and collect data. Videotaping or still photography may be used. This research will be conducted within laboratory or clinical settings while program students are actively on duty.

No monetary or grade-related compensation will be offered to any participants in the research program. Ms. Hancock will confidentially maintain a copy of this letter and the University of Tennessee at Chattanooga's Institutional Review Board approval notification, as well as her findings from the research. No identifying information for individuals involved with this project will be kept for any data or findings that may be shared. Copies of these documents and findings will be made available upon request. Also, ChSCC will incur no changes in regard to costs or resources that will be used for the study, nor will there be modifications to facilities.

If there are further questions, please contact my office at 423-697-3267.

Sincerely,



Eva Lewis
Associate Vice President of Institutional Effectiveness, Research, Planning,
and SACS Liaison

c: Jody Hancock, Associate Professor of Diagnostic Medical Sonography

MEMORANDUM

TO: Jody Hancock **IRB # 10 – 130**
Dr. John Freeman

FROM: Lindsay Pardue, Director of Research Integrity
Dr. Bart Weathington, IRB Committee Chair

DATE: October 26, 2010

SUBJECT: IRB # 10-130: Short Term Scan Technology Assessment Related to Ergonomics
Issues in Sonography

The Institutional Review Board has reviewed and approved your application and assigned you the IRB number listed above. You must include the following approval statement on research materials seen by participants and used in research reports:

The Institutional Review Board of the University of Tennessee at Chattanooga (FWA00004149) has approved this research project # 10 – 130.

Please remember that you must complete a Certification for Changes, Annual Review, or Project Termination/Completion Form when the project is completed or provide an annual report if the project takes over one year to complete. The IRB Committee will make every effort to remind you prior to your anniversary date; however, it is your responsibility to ensure that this additional step is satisfied.

Please remember to contact the IRB Committee immediately and submit a new project proposal for review if significant changes occur in your research design or in any instruments used in conducting the study. You should also contact the IRB Committee immediately if you encounter any adverse effects during your project that pose a risk to your subjects.

For any additional information, please consult our web page <http://www.utc.edu/irb> or email instrb@utc.edu

Best wishes for a successful research project.



July 29, 2011

University of Tennessee at Chattanooga
Lindsay Pardue, Institutional Review Board and Director of Research Integrity
615 McCallie Avenue
Chattanooga, TN 37403

Dear Ms. Pardue:

The request by Jody Hancock to continue to conduct a research project on the Chattanooga State Community College (*ChSCC*) campus has been approved through the ChSCC Institutional Review Board process, ensuring student/ subject confidentiality and ethical behavior. Ms. Hancock, a graduate student at the University of Tennessee at Chattanooga and employee of ChSCC, may continue to conduct the project, "Scan Technique Assessment Related to Ergonomics Issues in Sonography," through the entirety of the 2011 fall semester. She may work with current and former students, graduates, and instructors of the diagnostic medical sonography program at ChSCC and all study activities will rely upon consent of the students and patients.

Upon obtaining written consent from the student, Ms. Hancock, through observational scans of techniques and interviews regarding ergonomic issues, may perform blood flow or ergonomic studies that attach sensors to the participants' shoulders, wrists, hands, or fingers, and collect data. Video-taping or still photography may be used. This research will be conducted within laboratory or clinical settings while program students are actively on duty.

No monetary or grade-related compensations will be offered to any participants in the research program. Ms. Hancock will confidentially maintain a copy of this letter and the University of Tennessee at Chattanooga's Institutional Review Board approval notification, as well as her findings from the research. No identifying information for individuals involved with this project will be kept for any data or findings that may be shared. Copies of these documents and findings will be made available upon request. Also, ChSCC will incur no changes in regard to costs or resources that will be used for the study, nor will there be modifications to facilities.

If there are further questions, please contact my office at 423-697-3267.

Sincerely,

A handwritten signature in cursive script that reads "Eva Lewis".

Eva Lewis

Associate Vice President of Institutional Effectiveness, Research, Planning, and SACS Liaison

c: Jody Hancock, Associate Professor of Diagnostic Medical Sonography

MEMORANDUM

TO: Jody Hancock **IRB # 11-111**
Dr. Hinsdale Bernard

FROM: Lindsay Pardue, Director of Research Integrity
Dr. Bart Weathington, IRB Committee Chair

DATE: August 3, 2011

SUBJECT: IRB # 11 – 111: Pilot Study: Short-Term Scan Technique Assessment
Related to Ergonomics Issues in Cardiac and Vascular Sonography

The Institutional Review Board has reviewed and approved your application and assigned you the IRB number listed above. You must include the following approval statement on research materials seen by participants and used in research reports:

The Institutional Review Board of the University of Tennessee at Chattanooga (FWA00004149) has approved this research project # 11-111.

Please remember that you must complete a Certification for Changes, Annual Review, or Project Termination/Completion Form when the project is completed or provide an annual report if the project takes over one year to complete. The IRB Committee will make every effort to remind you prior to your anniversary date; however, it is your responsibility to ensure that this additional step is satisfied.

Please remember to contact the IRB Committee immediately and submit a new project proposal for review if significant changes occur in your research design or in any instruments used in conducting the study. You should also contact the IRB Committee immediately if you encounter any adverse effects during your project that pose a risk to your subjects.

For any additional information, please consult our web page <http://www.utc.edu/irb> or email instrb@utc.edu

Best wishes for a successful research project.

January 23, 2012

University of Tennessee at Chattanooga
Lindsay Pardue, Institutional Review Board and Director of Research Integrity
615 McCallie Avenue Chattanooga, TN 37403

Dear Ms. Pardue:

The request by Jody Hancock to conduct a research project on the Chattanooga State Community College (ChSCC) campus has been approved through the ChSCC Institutional Review Board process, ensuring student/ subject confidentiality and ethical behavior. Ms. Hancock, a graduate student at the University of Tennessee at Chattanooga and employee of ChSCC, may proceed to conduct the project, "Integrating iPads to Enhance Student Conceptualization of Ergonomics," through the entirety of the 2012 spring and summer semesters. She may work with current and former students, graduates, and instructors of the Diagnostic Medical Sonography program at ChSCC and all study activities will rely upon consent of the students and patients.

No monetary or grade-related compensation will be offered to any participants in the research program. Ms. Hancock will confidentially maintain a copy of this letter and the University of Tennessee at Chattanooga's Institutional Review Board approval notification, as well as the individual identifying information from the research. No identifying information for individuals involved with this project will be kept for any data or findings that may be shared. Copies of these documents and findings will be made available upon request. Also, ChSCC will incur no changes in regard to costs or resources that will be used for the study, nor will there be modifications to facilities.

If there are further questions, please contact my office at 423-697-3267.

Sincerely,

Eva Lewis

Eva Lewis
Associate Vice President of Institutional Effectiveness, Research, Planning,
and SACS Liaison

c: Jody Hancock, Associate Professor of Diagnostic Medical Sonography

MEMORANDUM

TO: Jody Hancock **IRB # 12-020**
Dr. Jennifer Ellis

FROM: Lindsay Pardue, Director of Research Integrity
Dr. Bart Weathington, IRB Committee Chair

DATE: January 22, 2012

SUBJECT: IRB # 12-020: Integration iPads to Enhance Student Conceptualization of Ergonomics

The Institutional Review Board has reviewed and approved your application and assigned you the IRB number listed above. You must include the following approval statement on research materials seen by participants and used in research reports:

The Institutional Review Board of the University of Tennessee at Chattanooga (FWA00004149) has approved this research project #12-020.

Please remember that you must complete a Certification for Changes, Annual Review, or Project Termination/Completion Form when the project is completed or provide an annual report if the project takes over one year to complete. The IRB Committee will make every effort to remind you prior to your anniversary date; however, it is your responsibility to ensure that this additional step is satisfied.

Please remember to contact the IRB Committee immediately and submit a new project proposal for review if significant changes occur in your research design or in any instruments used in conducting the study. You should also contact the IRB Committee immediately if you encounter any adverse effects during your project that pose a risk to your subjects.

For any additional information, please consult our web page <http://www.utc.edu/irb> or email instrb@utc.edu

Best wishes for a successful research project.



June 18, 2013

University of Tennessee at Chattanooga
Lindsay Pardue, Institutional Review Board and Director of Research Integrity
615 McCallie Avenue
Chattanooga, TN 37403

Dear Ms. Pardue:

The request by Jody Hancock to continue to conduct a research project on the Chattanooga State Community College (ChSCC) campus has been approved through the ChSCC Institutional Review Board process, ensuring student/ subject confidentiality and ethical behavior. Ms. Hancock, a graduate student at the University of Tennessee at Chattanooga and employee of ChSCC, may continue to conduct the project "A Comparative Analysis of Instructional Techniques Toward Long-Term Positive Ergonomics Transformation for the Early Career Sonographer" and associated research from July, 2013 through June, 2014. She may work with current and former students, graduates, and instructors of the diagnostic medical sonography program at ChSCC. All study activities will rely upon consent of the students and patients.

Upon obtaining written consent from the student or patient participants, Ms. Hancock, through observational scans of techniques and interviews regarding ergonomic issues, may perform blood flow or ergonomic studies that attach sensors to the participants' shoulders, wrists, hands, or fingers, and collect data. Video-taping or still photography may be used upon obtaining specific consent. This research will be conducted within laboratory or clinical settings while program students are actively on duty.

No monetary or grade-related compensations will be offered to any participants in the research program. Ms. Hancock will confidentially maintain a copy of this letter and the University of Tennessee at Chattanooga's Institutional Review Board approval notification, as well as her findings from the research. No identifying information for individuals involved with this project will be kept for any data or findings that may be shared. Copies of these documents and findings will be made available upon request. Also, ChSCC will incur no changes in regard to costs or resources that will be used for the study, nor will there be modifications to facilities.

If there are further questions, please contact my office at 423-607-3267.

Sincerely,

A handwritten signature in black ink that reads "Eva Lewis".

Eva Lewis
Associate Vice President of Institutional Effectiveness, Research, and Planning, SACS COC Liaison

c: Jody Hancock, Associate Professor of Diagnostic Medical Sonography

MEMORANDUM

TO: Ms. Jody Love Hancock **IRB # 13-094**
Dr. David Rausch

FROM: Lindsay Pardue, Director of Research Integrity
Dr. Bart Weathington, IRB Committee Chair

DATE: August 1, 2013

SUBJECT: IRB # 13-094: Comparative Analysis of Instructional Techniques Toward Long Term
Positive Ergonomics Transformation for the Early Career Sonographer

The Institutional Review Board has reviewed and approved your application and assigned you the IRB number listed above. You must include the following approval statement on research materials seen by participants and used in research reports:

The Institutional Review Board of the University of Tennessee at Chattanooga (FWA00004149) has approved this research project #13-094

Please remember that you must complete a Certification for Changes, Annual Review, or Project Termination/Completion Form when the project is completed or provide an annual report if the project takes over one year to complete. The IRB Committee will make every effort to remind you prior to your anniversary date; however, it is your responsibility to ensure that this additional step is satisfied.

Please remember to contact the IRB Committee immediately and submit a new project proposal for review if significant changes occur in your research design or in any instruments used in conducting the study. You should also contact the IRB Committee immediately if you encounter any adverse effects during your project that pose a risk to your subjects.

For any additional information, please consult our web page <http://www.utc.edu/irb> or email instrb@utc.edu

Best wishes for a successful research project.

APPENDIX B
PARTICIPANT CONSENT
FORM

UNIVERSITY OF TENNESSEE AT CHATTANOOGA INFORMED CONSENT FORM

Scan Technique Assessment Related to Ergonomics Issues in Sonography

Participant Name (printed or typed): _____

You are being asked to take part in a research study regarding ergonomic issues and scan technique for sonographers. You are being asked to take part in this study because you are either early in your scanning career or some potential effects are being considered related to exposure of ergonomics early in your scanning career. Please read this form carefully and ask any questions you may have before you agree to take part in this study.

Description of Activities to which you are consenting: If you agree to take part in this study, you will be observed scanning, you will be interviewed and asked questions related to scan technique and any musculoskeletal complaints, and you may be asked to perform additional blood flow or therapy exercises while performing simulated scan techniques, which will require that either your shoulder, wrist and hand or fingers are hooked up to external sensors. The researcher may also request to photograph or videotape your scan technique (when all parties present have consented), so you may review it and provide feedback. In the event a photograph or videotape is made of your scan technique, you consent to your images being shared for the purpose of research findings being shared. Sonography students will complete these activities during scheduled program time, either in the laboratory or clinical environment.

Risks and Benefits: There is the risk that the researcher may identify specific scan techniques that place you at a higher risk for future musculoskeletal injuries and may not immediately specify these to you early in the study, while pertinent documentation is still being gathered.

However, the benefit to you is that the researcher will share data with you at the conclusion of the study, if you choose to receive it. In this way, you can identify and assess potentially hazardous scan technique habits that you are developing or have developed, so that you might adjust these in the hope of lessening the risk of future repetitive musculoskeletal injuries.

Compensation: There is no monetary or grade-related compensation for participating in this study.

Your data and answers will remain anonymous. The data records of this study will be kept anonymous. In any sort of report that is made public, the researcher will not include any information that will make it possible to identify you, beyond the fact that you may be a current or past student of the Chattanooga State Diagnostic Medical Sonography program. The only information that may be shared that could potentially identify you will be photographed or videotaped images that you allow to be shared for the purpose of research reporting.

Please signify here, *by your initials*, your preference in regards to sharing photographs or videotapes of you involved in this research:

_____ I give my permission for you to share photographs or videotapes of activities of me involved in this research.

_____ I DO NOT give my permission for you to share photographs or videotapes of activities of me involved in this research.

All photographs and videotapes will remain locked in the program director's office until they are destroyed, unless permission has been granted for utilization for research reporting purposes. In such case, selected segments may be included in the reported research, even if the original documentation is locked and/or destroyed.

Taking part is voluntary: Taking part in this study is completely voluntary. You do not have to participate in any part of this study in which you do not wish to take part. If you decide not to take part, it will not affect your current or future relationship with Chattanooga State or the sonography program. If you decide to take part, you are free to withdraw from the study at any time.

If you have questions: The researcher conducting this study is Jody Hancock, Director of the Sonography Programs at Chattanooga State Community College. Please ask any questions you may have now. If you have questions later, you may contact Jody Hancock at jody.hancock@chattanoogastate.edu or at 423-697-3341.

If you have any questions or concerns regarding your rights as a subject in this study, you may contact Lindsey Pardue, Director of Research Integrity with the Institutional Review Board (IRB) at the University of Tennessee at Chattanooga at 423-425-4443 or access the IRB Web site at <http://www.utc.edu/Administration/InstitutionalReviewBoard/>.

The Federal Wide Assurance number for UTC's IRB, with whom this research application has been submitted, is FWA00004149.

You will be provided with a copy of this consent form to keep for your records.

Statement of Consent: I have read the above information and have received answers to any questions I have asked. I consent to take part in this study.

Participant Signature: _____ Date: _____

Participant Name (printed or typed): _____

In addition to agreeing to participate, I also consent to having segments of activities photographed or videotaped. I have already signified within this document whether the researcher may share these images and/or videos to report certain components of this research.

Participant Signature: _____ Date: _____

Signature of Individual Obtaining Consent: _____ Date: _____

Name of Person Obtaining Consent (printed or typed):

Jody Hancock, MAEd, RDMS, RVT, RT(R)

This consent form will be maintained by the researcher for a period of at least three (3) years beyond the end of the study.

IRB Research Identification No.: 13-094

Approval was received by the IRB on (DATE): 08/01/2013

APPENDIX C
ASSURE PLANNING MODEL FOR
TRANSFORMATIVE EVENT

Introduction to the ASSURE Model

Each step of the ASSURE model is addressed within the scope of the transformative ergonomics peer assessment plan of this study. Instructional designers recognize that the design steps of Figure C.1 do not always necessarily occur sequentially and rarely can be considered apart from one another (Smaldino et al., 2005). Nevertheless, it is helpful for the components of each step within an instructional model, such as ASSURE, to be procedurally identified separately for assurance of a systematic approach (Biswalo, 2001). Such separation of components may be of greatest importance when addressing the final step of evaluation and revision, whereby specific issues may more readily be pinpointed for refinement needs according to the segmented design considerations (Kirkpatrick & Kirkpatrick, 2006).

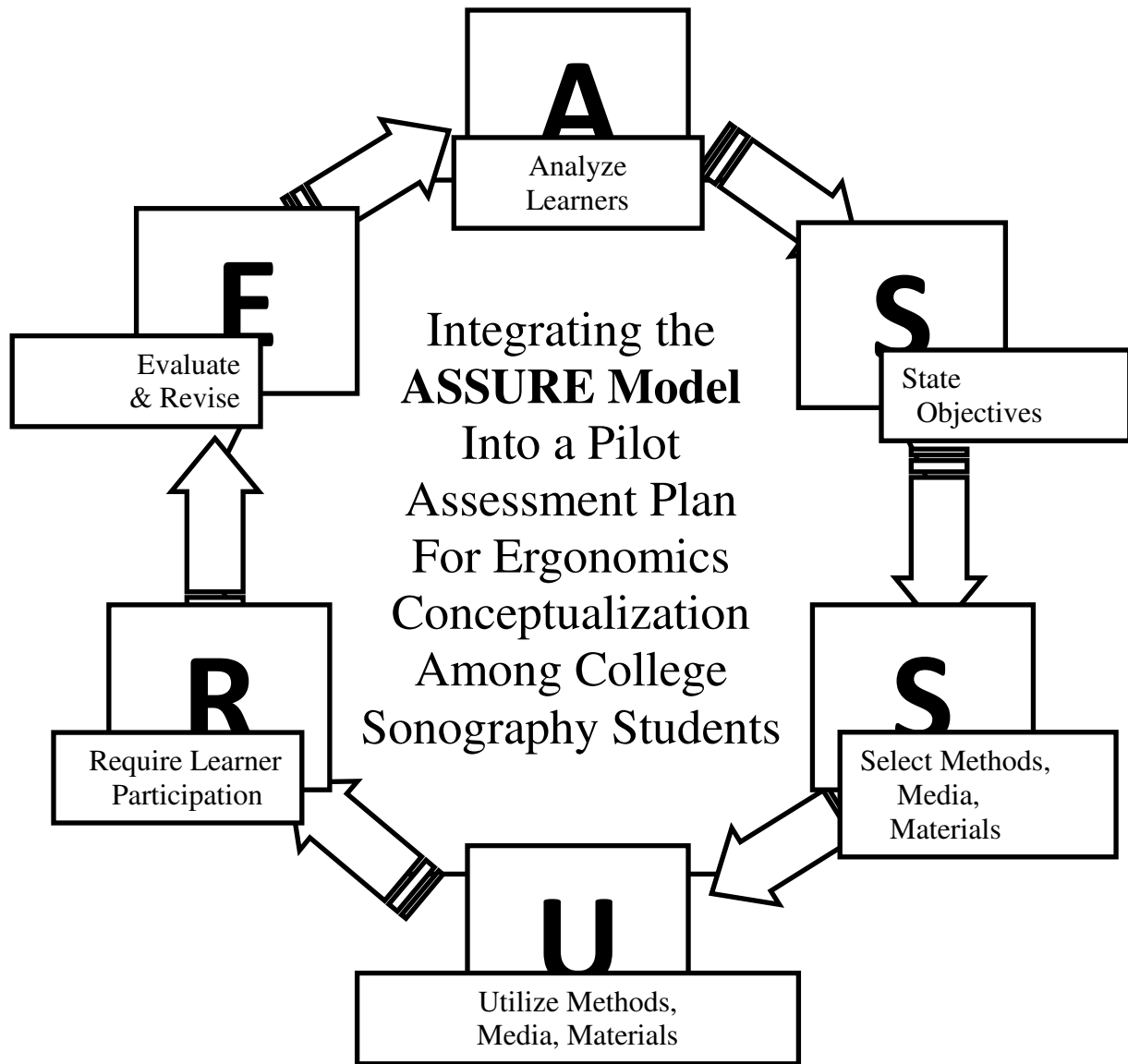


Figure C.1 The Six Steps of the ASSURE Instructional Planning Model

Following, in Table C.1, is an explanation of considerations that were made by Hancock & Ellis (2012) when adapting the steps of the ASSURE model for specific design decisions in development of the longer term transformative peer assessment plan toward ergonomics conceptualization among early career sonographers.

Table C.1 Procedural Considerations of ASSURE

ASSURE Steps	Descriptions of Related Considerations
Analyze Learner	Learner Characteristics Learner Needs and Responses Learner Competence (Current Knowledge, Skills, Attitudes) Learner Preferences Learner Cultural Traits
State Objectives	Communicate to Learners: -Learning Strategy and Outcomes -Learner Action Conditions -Level of Criteria (Degree or Extent of Performance Expected)
Select Methods, Media, Materials	Suitable for maximum achievement of objectives within reason of necessary, available, and valid resources. Existing or modified resources are valid if chosen through systematic criteria.
Utilize Methods, Media, Materials	Tools and technology should not distract from learning. Ensure user comfort, familiarity and appropriate use by: -both facilitators and learners; -within the learning context; -by conducting a mock performance with end users.
Require Learner Participation	Active Involvement with Behavioral Consequences. Creates Learning Motivation.
Evaluate and Revise	Formatively and Summatively Assess: -Learner emotional response and perceived value; -Degree of learner impact; -Measurable return on investment; -Critique of components of standards.

Procedure for the ASSURE Model

A - Analysis of Learners

Analysis Considerations

When analyzing learners, many general characteristics may be considered, not to exclude anticipating how the members of a particular group might respond to needs or expectations within the learning context. The level of the learners' competence (e.g., current knowledge, skills, and attitudes), learning preferences, and particular traits associated with the culture (whether socioeconomic or work-related) are but a few possibilities. However, only those characteristics vital to the learning methodology should be given credence in making decisions about the learning event (Smaldino et al., 2005).

Learner Analysis for Research Study

All participants within the study were early career sonographers, entering a post-associate level advanced technical certificate sonography program. Those engaging in the ASSURE process were in the mid semester of their certificate program year, as part of the transformational learning group (Group C). Students within the sonography career field utilized highly specialized, computerized technology daily within the clinical work setting. As student sonographers, they operated within an imaging field as part of a healthcare environment. As such, visual assessment and kinesthetic computer functions were daily requirements of job performance expectations, and professional social interactions were considered essential to the completion of diagnostic work-related responsibilities as listed within clinical competency

fulfillments. Each of these factors was important to consider when planning an instructional event in which long-term transformation would ultimately be the desired outcome.

Informal online learning styles quizzes, accessed through The Center for New Discoveries in Learning, Inc. (2013), have been used for the past several years during the Chattanooga State Sonography Program's orientation sessions, historically revealing that the vast majority of sonography students entering the program tend to select visual and kinesthetic learning (V-KL) preference choices. Though job responsibilities within the field likely further enhance V-KL inclinations among the population of imaging professionals, since the learners assessed have not yet engaged in scanning at the time of the orientation period, an instructional assumption was made that many early career sonography learners may actually be drawn toward the field due to strong V-KL preferences.

Though short term positive work habitus was assessed at the end of the first semester period in both Groups B and C, the instructional goal for mid semester became to reinforce further potential of longevity of positive transformative scan habit development. The themes of V-KL preferences among the sample groups, the professional ability of the learning group to manipulate technologic devices, the necessity for peer interaction within a diagnostic patient care setting, and the importance of reflective learning opportunities toward transformational sustainability were all considered when analyzing these specific learners while planning for the transformative ergonomic learning event.

S - Stated Objectives

Objective Considerations

Biswalo (2001) expressed the importance of informing learners of objectives as a key instructional strategy. To do so, objectives of the learning event should be clearly stated, leaving no doubt about outcomes the learners are anticipated to accomplish as a result. Objectives should denote expected behaviors through action on the part of the learner (Smaldino et al., 2005). The conditions or provisions by which such actions occur should also be specified, as should some level of criterion (though, admittedly, in research, this is often implied, rather than exact, since results are merely hypothesized during the design phase). Seddon (1978) emphasized the importance of defining action within learning objectives through Bloom's hierarchical categorizations within the cognitive, affective and psychomotor domains. Heinich, Molenda, Russell, & Smaldino (1996) later provided a practical explanation to writing action-based objectives using the ABCD Method, by which all components of a well-written objective could easily be systematically tested on the basis of this mnemonic:

- Audience - identifying who the learners are;
- Behavior - explaining what the learning audience will be able to accomplish as an observable behavior;
- Condition - providing the contextual expectation of the learning event; and
- Degree - specifying to what extent (how well or how much) the behavior must be performed to consider the objective has been satisfied.

Objectives developed by such standards can easily be compared to the learner analysis within the ASSURE model to establish if any pre-instructional competencies should first be met. Popham (2008) stressed, as an assessment consideration, that determining whether prerequisite

knowledge and skills are in place prior to proceeding with instruction was essential to assure the potential for success in the planned learning event.

Stated Objectives for Research Study

Ultimately, the learning goal was to determine if this group of early career sonography learners would utilize and positively adopt as work habitus the ergonomics principles introduced early in the sonography program into their sonography careers to reduce the behaviors associated with risk incidence of repetitive MSIs. The length of any one semester learning event was considered too compressed to address long-term transformation, so additional incremental research was necessary to continue further analysis. The mid semester learning event for Group C was designed to investigate further learning opportunities within the scanning laboratory environment, while specifically building upon ergonomics transformative research methodology and instructional protocol through a deeper understanding of personal habits and beliefs reinforced during collaborative critical reflection (Yorks & Sharoff, 2001).

Incorporating the ideas from the learner analysis of V-KL preferences, social engagement in problem solving, and a technology-rich environment, three major objectives were established for the learning technique that was designated by the researcher as Video Mirroring Adjustment (VMA) Assessments (J. L. Hancock & Ellis, 2012). These objectives became much more specific in anticipated behaviors and conditions only in conjunction with the next steps of the ASSURE model, in which methods, media and materials selection took place. The objectives were stated as follows.

Working in pairs or small groups during each mid-semester scan laboratory, each sonography student will:

- cooperatively engage in reinforcement of positive ergonomic behaviors through peer formative assessment, using an observation survey tool and a padcam (*iPad* camera) for video archiving and mirroring adjustments;
- collaboratively develop an immediate and ongoing ergonomic plan of adjustment, following each scan lab, from the archived video and peer information obtained through the peer assessment process;
- complete an individual survey component through an *iPad* application, following each VMA assessment, to reflect upon the perceived benefits of the cooperative peer assessment activity.

Prerequisites for Research Study

Prior to engagement in the peer VMA assessment events, it was determined that all earlier learning progressions of the other learning groups in the first semester should be met for appropriate preparation, which included the transmissional and transactional learning events. Thus, the transformational learning event was a scaffolding instructional approach.

Beyond assurance of earlier learning progressions, each learning participant received an in-service on the use of the *Apple iPad* with the padcam tool and the survey application. Every participant of Group C also engaged in viewing one's own personal final scan observation from the prior semester as a self-assessment, which had been archived on video and evaluated by an expert ergonomics observer. In this way, the study participants were able to reflect upon and

gauge personal ergonomic behaviors as a pre-assessment to this mid-semester instructional event. Figure C.2 demonstrates a sonography student reviewing the expert video observation assessment and making a personal reflective comparison of identified ergonomic behaviors, both positive and negative.



Figure C.2 Student Review of Expert Observation

S - Selection of Methods, Media, and Materials

Selection Considerations

Instructional materials are often selected strictly on availability or ease in modification of existing resources (Smaldino et al., 2005). If accessible items meet necessary criteria, not only

should it not be viewed as problematic to use such articles, it may be more useful in terms of establishing validity of selected tools. However, if available items are simply being used for the sake of convenience, rather than the event designer making the selection based upon systematic criteria, it stands to reason that validity may not be established for this particular use. Patten (2009) emphasized that “an instrument is valid to the extent that it measures what it is designed to measure and accurately performs the function(s) it is purported to perform” (p. 61). Materials and media should be suitable for carrying out the method, while the method should be designed to allow for maximum potential of achievement of the objectives, within reason of necessary resources that can be legitimately and practically obtained (Shelly, Cashman, Gunter, & Gunter, 2004).

The concept of students reinforcing their knowledge, skills and behaviors through analyses of self and peers in a critical reflective process is an established practice used by professionals in the field to support one another in continuing development (Eisen, 2001; Harlen, 1999). Modifications occurring on the basis of social learning and self-reflective considerations have the potential to increase the likelihood of transformative adjustments (J. Mezirow, 2000), especially in the adult where instructor modification may be perceived as reprimanding in nature (Strobino et al., 2002); whereas learning resistance toward change may be lessened through chosen self-adjustment (Venugopal & Kakani, 2002). Self-regulated motivation often results in learners who are more accepting of change (Schunk, 2008).

Selection of Methods, Media and Materials for Research Study

The selection of a transformative assessment technique has been explained on the basis of the social learning aspect in the learner analysis and the learning goal for longer-term transformative attitudes and behaviors. Popham (2008) clarified the need for formative assessment as part of a transformative process, explaining it as "...a planned process in which teachers or students use assessment-based evidence to adjust what they're currently doing" (p. 6). Among high V-KL preferences of learners, the researcher determined that if sonography students can visually detect personal and peer ergonomic scan concerns through the use of the video mirror (the padcam), as part of a shared reflective assessment process, learner levels of perceptual objectivity and influenced corrective action might be positively enhanced (J. L. Hancock & Ellis, 2012).

The *iPads* were selected based upon current student technology trends (Williams, 2012), as well as practical accessibility of a mobile *iPad* unit made available through research partnership with the University of Tennessee at Chattanooga. Accessibility, alone, would not have guaranteed this was the appropriate technology to meet the established instructional plan. The systematic ASSURE model approach assisted in revealing that the *iPads* readily allowed for peer video mirroring assessments, with ease of immediate visual feedback (whether in still or video imaging format). Those learners scanning could briefly be interrupted by the peer assessor and shown the action in need of correction through the padcam's video mirror. Video mirroring adjustments could be instantly made by the transformational learning group participants during scanning in an attempt to immediately interrupt any further habitual development of negative ergonomic behaviors through self-awareness of the detected issue.

U - Utilization of Methods, Media, and Materials

Utilization Considerations

Once all materials, media and methodology have been selected, it is important to ensure each is used appropriately by all parties. This means the facilitators of instruction, the environment where instruction will take place, and those who will receive the instruction must all be well prepared for the learning experience to take place as close to planned as can be controlled (Smaldino et al., 2005). Brickner, Russell, & Sorge (1994) specified the importance of instructing for the purpose of implementation. A wise instructional designer will first stage a mock performance with some end users to search for unanticipated findings; then the designer will be readily available to assist during initial execution to address further unexpected or uncertain implementation issues. Learners must have time to become comfortable with the media and materials they are expected to use, as well as become familiar with the methodology they are responsible for executing. Otherwise, the actual learning goal may not be realized due to distractions associated with using the tools and technology.

Utilization of Methods, Media and Materials for Research Study

First, the transformational learning event participants (Group C) were appropriately prepared for engagement in self and peer ergonomics assessment activities because they previously achieved all prior (transmissional and transactional) learning progressions. Popham (2008) explained these learning progressions as being mapped out as levels of mastery for knowledge or skills achievement, or engagement in specified behaviors for completion.

Beyond the base transmissional instruction that was provided to all learning groups, Level 1 pre-instructional assessments occurred for all Group B (transactional) and Group C (transformational) group participants early in the learning phase through pre-instructional expert observation during learner scanning, an attitudinal and early base knowledge interview, and pre-instructional scaled learner perceptions of personal work-related musculoskeletal injury (WRMSI) risk. Further progressive, or Level 2, instructional assessments took place at the conclusion of the first semester learning event, which included self and peer scanning evaluations and work station design evaluations for Groups B and C. The Level 3 post-instructional learning progression assessments included a secondary expert observation at the conclusion of transmissional and transactional learning events, with additional post-instructional scaled learner perceptions recorded of personal WRMSI risk. Participants of all learning groups also submitted a reflective personal prevention plan (PPP) for comparison purposes.

For the transformational learning participants (Group C), instructional plans revolved around an advanced Level 4 learning progression, focusing on reinforcement of ergonomics learning toward sustainability of positive transformative work habitus using sequenced peer VMA assessments, followed by reflective journaling in electronic surveys. The reflective journaling included expectations for the learners not only to assess perceptions of the activity, but to again provide scaled perceptions of personal WRMSI risks and cooperative ergonomic plans of adjustment for oneself and a laboratory partner. At the completion of this mid-semester period, the expert observer completed a third checkpoint scanning observation to assess the learner for sustainability of positive (or fewer negative) transformative ergonomic behaviors. The expert observation tool corresponded directly with the peer observation tool used by the learners throughout the Level 4 learning progression exercises.

Description of Level 4 Methodology

A sufficient number of *iPads*, equipped with the standard padcam application for still and video imaging, were made available for instant formative peer feedback during each scheduled student scan laboratory as part of the Level 4 student transformative learning progression. The *iPads* were also available for completion of collaborative reflective surveys immediately following each of these scheduled laboratory sessions.

Transformational study participants were placed in laboratory groups of at least three participants to allow for rotation of one scan volunteer, one scan participant, and one peer reviewer conducting the observation assessment on a designated peer within each group. The peer assessor was instructed to log the frequency of specific ergonomic behaviors which were described in text on the survey tool with visual cues available on a poster at the scan station (Figure 2.3). The peer assessor was to use the padcam to demonstrate negative or positive ergonomic behaviors to the lab partner being observed and also to log whether adjustments were made or explanations given for each specific behavior. Following the scan session with the peer review, lab group participants were to collaborate upon primary areas of concern that should be addressed within personal ergonomic adjustment plans. Figure C.3 shows sonography students using *iPads* to collaborate on video mirroring adjustment (VMA) survey data to develop and enhance ergonomic adjustment plans following a lab during a later program semester.



Figure C.3 Learner *iPad* Collaboration on Video Mirroring Adjustment (VMA) Exercise

Each participant then individually completed the VMA reflective survey, still using the *iPad* to do so, while journaling attitudinal perceptions of both self and partner, as well as outlining individualized ergonomic adjustment plans. Multiple laboratory assessment opportunities were provided throughout the semester to allow for reinforcement of both the process and transformative learning engagement.

R - Requirements of Learner Participation

Requirement Considerations

Active learning has not only been shown to have significance for skill-based masteries; it assists in the development of knowledge and attitudes (Smaldino et al., 2005). Shelly et al. (2004) recommended that “[c]lassroom lessons should motivate students to be active learners

who are involved in the process of learning, such as practicing, performing, solving, building, creating, and manipulating” (p. 6.24). Learning is ultimately influenced by the combination of “...the content of the instruction, the method used to promote learning, and the involvement of the learner in the instructional experience” (Simonson, Smaldino, Albright, & Zvacek, 2000, p. 8). Even observational assessment can be designed as an active learning event (Bandura & McDonald, 1963; Sivan, 2000).

Bandura (1986) outlined four observational learning processes that are not, in any sense, dormant surveillance.

- The first process involves gaining learner Attention, through meaningful and perceived value. This means activating the brain through a relevant task, such as assessing a situation.
- The second process, Retention, occurs through active rehearsal, allowing the memory to code and more efficiently store the information for future access.
- Production, the third process, denotes action as behaviors, even if initial behaviors are not quite correct. In this way, deficiencies may be further assessed for correction.
- Finally, Motivation is enhanced based upon consequences of these behaviors. The learner is more likely to become motivated because of success in outcomes achieved through active attentiveness, rehearsal-based retention, and the ability to demonstrate a product from the learning.

Maehr & Sjogren (1971) extended Atkinson’s expectancy-value theory of achievement motivation into the classroom to attempt to better understand behavioral productivity in the educational arena. Keller’s (2010) ARCS Model of Motivational Design emphasized four steps specifically related to learning motivation. Within this model, Keller emphasized the need to:

- arouse Attention in an active manner;
- establish Relevance through experience, whether built upon or modeled;
- assist the learner in developing Confidence through a likelihood to succeed; and
- finally, to reinforce learner achievement by encouraging Satisfaction.

For learning to actually be satisfying, it must consist of a challenge to be overcome.

Though tasks that are beyond the grasp of the learner's preparation will create frustration that will lessen motivation, tasks that are too simple will create boredom and disdain (Atkinson, 1957). Satisfaction, then, consists of a balance between a learner's sense of challenge and that of accomplishment.

Learner Requirements for Research Study

The learning event was systematically designed for formative peer assessment of behaviors through partnered cooperative reinforcement of ergonomics learning and self-reflection of beliefs using the electronic journal survey format. This study was designed to encourage learners to purposefully practice ergonomic behaviors collaboratively while reflecting upon the results of this practice to reinforce the development of appropriate cognitive schemata through a collective value system. Pugh (2002, as cited in Taylor, 2007) discussed this process as part of perspective transformation, whereby "[i]ndividuals undergo transformative experiences when they actively use a concept, find that it allows [them] to see aspects of the world in a new way, and personally value this way of seeing" (p. 180).

Student attention was directed through relevant assessment tasks which offered both individual and social feedback (J. Mezirow, 2000; Phillipi, 2010) on the practice of developing

ergonomics knowledge and skills. Students could begin developing confidence through rehearsal of recognition of ergonomics behaviors to assist in retention of the beneficial ones. As negative behaviors were produced and recorded, adjustments could be made based upon immediate formative assessment feedback and collaborative reflective feedback (Popham, 2008). Students further became motivated based upon the consequences of positive action and feedback while working to produce cooperative adjustment plans (Maehr & Sjogren, 1971). Satisfaction could then be enhanced at the time of the concluding expert and self-reflective video observations, through which students received feedback as to whether their active efforts produced fewer negative ergonomic behaviors with transformation toward positive work habitus (Atkinson, 1957). If so, then value was affirmed in the students' earlier assessment and adjustment attempts.

E - Evaluation and Revision of Plans

Evaluation Considerations

Four levels of evaluation were well represented in the Kirkpatrick Model (Kirkpatrick & Kirkpatrick, 2006) to include:

- Level 1, Reaction - addressing emotional response to learning;
- Level 2, Learning - assessing learner's perceived value and effect on knowledge, skills and attitude;
- Level 3, Behavior - demonstrating the degree to which learners were impacted through application; and
- Level 4, Results - emphasizing the return on investment, as measurable into the future, for involved stakeholders.

Summative evaluation of the entire learning event should be scheduled to take place at its conclusion, with considerations of value determined through learner outcome achievement; analysis compared with standards; and critiquing the effectiveness of various components, including the selected media, methodology, materials, and instructional facilitators. Formatively, both learners and facilitators have the ability to learn much throughout the instruction through reflective evaluation of the process (Shelly et al., 2004). Evaluation should not be performed with the mere intent of providing confirmation of approval to a learning event (Popham, 2008). Rather, it should be conducted in an objective manner, searching for any needs for revision, whether in present or future context (Smaldino et al., 2005). Such a responsive attitude from the learners, the event facilitator, and the instructional designer serves to further enhance learning potential toward return on investment (Kirkpatrick & Kirkpatrick, 2006), which is the overriding premise to expectancy in value (Atkinson, 1957; Becker, 1974; Quick, 1988), the theory encompassed within this transformational learning event.

Evaluation and Revision Considerations for Research Study

The following considerations were eventually made from the instructional designer/facilitator's standpoint, and many from the participants' standpoints, when reflecting upon this learning event.

- Did the post-event expert observation demonstrate significance in either retention of ergonomics learning progressions from the prior semester or even further improvement in behaviors?

- Did participants find the activities to be beneficial in developing better ergonomic habits (e.g., could value expectancy be established), based upon reflective survey feedback?
- Did learners offer valuable survey insight? If not, what are possible reasons and what adjustments might be considered for the future?
- Was peer assessment perceived as threatening? Could adjustments be made to make peer assessment less threatening, if cited to be perceived in such a way?
- Were there concerns with assigned facilitators of the scan sessions? If so, what were they? How might these be resolved?

Media and materials evaluation considerations included:

- Did learners use the padcams and *iPads* to complete the activities, as instructed? If not, then why not?
- Are *iPads* still considered the most effective available media resource for conducting this study? Why or why not?
- Are there more suitable survey tools available for use? If so, please explain.

The blame game should be avoided, at all costs, during any evaluation process. This can be achieved by including all participants in a problem-solving capacity. Especially in the adult learning population, where past experiences are abundant (Knowles et al., 2011; Popham, 2008), designers may gain great insight by seeking revision suggestions from their learners (Kirkpatrick & Kirkpatrick, 2006). If, after all, educators are unwilling to transform a learning event, how, then, can it be expected for learners to see value and to be motivated toward transformation?

In regards to this particular study, research testing may provide some of the answers to the questions considered as part of this evaluation process.

APPENDIX D
PERSONAL PREVENTION PLAN
RUBRIC

GRADING RUBRIC FOR PERSONAL PREVENTION PLAN

Please use the rubric below as a guide for the components that are expected within your Personal Prevention Plan.

Also, please use appropriate headings and sub-headings in your reports to clearly define the elements that you are including.

Beyond the rubric standards and those requests, there are no further specific guidelines. You are free to be creative in your presentation format and length of your report. Remember that this should be written as a reflection for your personal benefit, so that you can use the new knowledge that you've gained for your future benefit.

Student Name: _____ Fall _____ Grade: _____

10	8	6	3	0
Grade Points Assigned in Above Row will be Awarded According to Content as Assessed by Column Description				
Diet & Nutrition				
The learner goes above and beyond expectations of explaining the importance of a balanced diet within the prevention plan, by providing an example of a personal dietary plan that is being followed (as a supplement), along with appropriate explanations.	The learner includes balanced dietary guidelines, as well as the importance of a personal dietary plan in regards to MSI prevention, as part of the prevention plan.	The importance of a balanced diet is addressed within the plan, yet the learner does not substantiate this with a personal dietary plan.	The learner alludes to the importance of a balanced diet, but never goes into full detail for the reason.	A balanced diet is not included as part of the learner's personal prevention plan.

Personal Fitness				
Prevention plan contains a personalized work-out plan that demonstrates considerable thought of learner's own abilities, with explanations included of why specific exercises were selected.	Prevention plan provides a work-out plan that would be considered personally feasible for the learner, but may not contain complete explanations of selected exercises.	Prevention plan provides a work-out plan that would be considered feasible for the average sonographer, but gives no personal justification for choosing specific exercises.	Though an exercise program is included, the plan does not seem feasible for the average sonographer nor does it give supporting examples of the learner's specific needs.	The prevention plan does not include adequate consideration, if any, for exercise.
Relaxation Techniques				
Prevention plan description of relaxation techniques describes how the learner has utilized these to understand their personal effectiveness, with exemplary provision of examples and discussion.	Prevention plan contains specific examples of relaxation techniques that will be utilized by the learner, according to personal interests and identified effectiveness.	Prevention plan provides adequate discussion of effective relaxation techniques, but does not specify those that would be particularly effective with the learner in mind.	The plan includes relaxation techniques, but there is no supporting discussion as to their effectiveness in relation to the goal of prevention.	The prevention plan does not adequately discuss relaxation techniques or provide examples to be effectively utilized.

Work Loads & Work Breaks				
The learner thoroughly explained the importance of appropriate workloads in the prevention plan, and included scheduling policies and personal solutions for one's own department.	The learner adequately explained the importance of appropriate workloads in the prevention plan, including personal scheduling concerns and possible solutions.	The learner has sufficiently covered methods for developing adequate workloads and scheduling demands in the department.	The learner has minimally addressed methods for developing adequate workloads and scheduling demands within the department.	The learner did not address any methods for assuring adequate workloads or patient scheduling demands within the department.
Mini-Break times during the workday are addressed specifically for the learner and how these will be accomplished, as well as a discussion of their importance.	Mini-Break times during the workday are addressed specifically for the learner and how these will be accomplished, but the importance or how these times will best be utilized may not readily be present.	Mini-break times are included within the discussion, but there is no plan for how these will be personally achieved (e.g., scheduling and administrative concerns).	Documentation of the need for mini-breaks throughout the workday is included, but is not necessarily substantiated as a personal habit.	No documentation of the need for mini-breaks or personally scheduled times are included within the prevention plan.

Work Environment Evaluation (use findings from Work Station Evaluation form, which should also be submitted with assignment)

<p>The learner completed an outstanding discussion of the personal ergonomic work station findings and how each of the sonographers will personally be impacted by these findings (to a maximum of 3 individuals).</p>	<p>The learner included comprehensive discussion from the personal work station evaluation and how findings will personally impact the learner and others within the department.</p>	<p>The learner included adequate discussion from the personal work station evaluation and how findings will create a personal impact to sonographers, in general.</p>	<p>The learner included a discussion from the personal work station evaluation, but did not include personal impact to anyone.</p>	<p>The learner did not include discussion or impact from the personal work station evaluation.</p>
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Scan Habits Evaluation (use findings from Self & Peer Review form, which should also be submitted with assignment)

<p>The learner completed an outstanding discussion of personal ergonomic scan habits on self and peers, and how each will personally be impacted by these findings (to a maximum of 3 individuals).</p>	<p>The learner included a comprehensive discussion from the personal scanning habits evaluation and how findings will personally impact the learner and others within the department.</p>	<p>The learner included adequate discussion from the personal scanning habits evaluation and how findings will create a personal impact to those working in sonography, in general.</p>	<p>The learner included a discussion from the personal scanning habits evaluation, but did not include personal impact to anyone.</p>	<p>The learner did not include discussion or impact from the personal scanning habits evaluation.</p>
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Monitoring & Reporting MSI-Related Work Concerns				
The learner includes an outstanding discussion of the importance of reporting procedures for MSIs and work station/prevention concerns to administration, and how these procedures could impact various sonographers within the department (up to 3, including the learner).	The learner includes a comprehensive discussion of the importance of reporting procedures for MSIs and work station/prevention concerns to administration, and how these will personally impact the learner and others within the department.	The learner includes adequate discussion of the importance of reporting procedures for MSIs and work station/prevention concerns to administration, explaining how findings could affect sonographers within a department, in general.	The learner explains the importance of reporting procedures for MSIs and work station/prevention concerns to administration, but does not address these for his/her specific work environment within the plan.	A method for reporting MSIs and work station/prevention concerns to administration is not included within the prevention plan.
Report Writing Skills				
The prevention plan demonstrates mastery of report writing skills, with very minimal to no grammatical, punctuation or spelling errors. Topics are readily distinguishable and thoroughly discussed.	The report is well-written with minimal, if any, grammatical or spelling errors. The content transitions well from one topic to the next.	The report contains a few grammatical and/or spelling errors, OR the content does not always flow well from one topic to the next.	Grammatical and/or spelling errors make the prevention plan somewhat difficult to read, AND the content does not always flow well from one topic to the next.	The report is difficult to follow, due to extensive errors in grammar, spelling and/or punctuation. Topic areas are difficult to define and are not well demarcated.

Comprehension of Ergonomics Concepts

<p>All concepts within the prevention plan correspond directly with learning content, discussion and findings of the learner while participating within the course. The learner presents these findings with factual correctness, integrating learning concepts in a superior fashion.</p>	<p>The learner has provided information within the plan that can be factually substantiated through the learning that has taken place in the materials and discussion, or other related resources, with evidence of integration of these concepts.</p>	<p>The learner has provided adequate evidence of facts, but has not gone in-depth to substantiate the claims or connect these with personal learning from the course content or discussions. Evidence of integration of concepts is minimal.</p>	<p>Though the learner has provided information within the personal plan, some of the concepts are questionable and are not substantiated through instructional materials or additional references. The facilitator questions some of these facts.</p>	<p>Though the learner has provided information within the personal plan, many of the concepts cannot be substantiated through either instructional materials or additional references. The facilitator is left to question a substantial portion of the validity of the information.</p>
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APPENDIX E
QUALITATIVE PRE-INSTRUCTIONAL
INTERVIEW QUESTIONS

Qualitative Pre-Instructional Interview Questions

- Q1. Have you been experiencing any areas of pain or discomfort that you have associated with scanning and have not ordinarily been experiencing in your daily activities otherwise? (If so, where?)
- Q2. Do you understand the term “ergonomics” as related to the scanning responsibilities of sonographers? (Interviewer should have the participant define this term and listen for key aspects of his/her understanding related to improper OBP, scan actions sustained or utilized repetitively, or any association with increased risk factors for MSIs.)
- Q3. Are you personally aware of any sonographers who have experienced injuries related to repetitive scanning in the ultrasound environment? (If answered in the affirmative, interviewer should ask for a description.)
- Q4. Do you believe there were individual, personal circumstances surrounding this sonographer’s injuries (or if you do not know of a sonographer with personal injuries, do you believe there are individual, personal circumstances that would surround such an injury), or do you believe any sonographer’s duties place her/him at the same risk for a work-related injury?
- Q5. Do you believe that you are presently at risk for a musculoskeletal injury related to your professional duties? Why or why not?

Q6. What circumstances do you believe would place you at risk either now or at some point in the future? (And, if not now, at what point in the future?)

Q7. Do you know the published rate of musculoskeletal injuries among all sonographers? (If not, the interview should ask for an estimate.)

Q8. What if you were told the MSI rate is approximately 80-90% among sonographers? Does that change your opinion of your own personal risk factor?


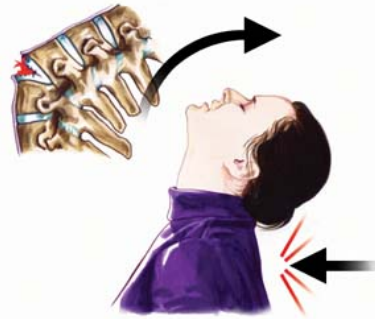
Q9. Does that percentage of injuries cause you to believe that you will still be able to scan, pain-free and injury-free, as a sonographer 20 years from now? Why or why not?


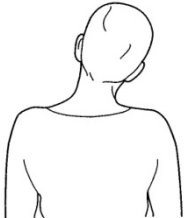

Q10. Let's look at your personal results from the pre-instructional expert observation. (Review the findings from Question #1. Discuss the observer's findings during the first observation with the participant, or allow the learner to self-assess to decide if these findings correspond with the areas identified in Question 1.) In your opinion, do these findings seem to correspond with any areas of pain or discomfort that you earlier described to me?


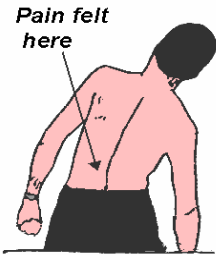

Q11. Are you willing to engage in an experimental blood flow study to determine if there are any observable vascular effects associated with certain musculoskeletal injuries attributed to the approximate 80-90% sonographer injury rate of repetitive MSIs? (If selected, the participant will also be asked to engage in Part B of the interview following this study. If not, another random participant will be approached as a replacement, until no such additions exist.)

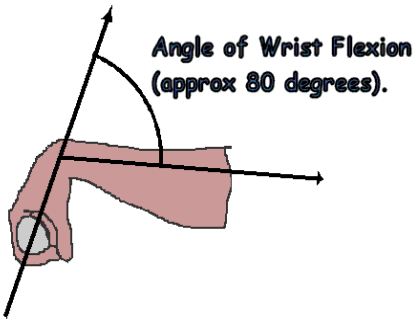

APPENDIX F
EXPERT OBSERVATION
GUIDE



Participant Name:	Participant No.:	Date(s):				
Observer's Initials:	Scan Mentor:	Video Log Number(s):				
Yrs. Scan Experience:	Scan Equipment:					
Categorical Description of Directional Susceptibility of Movement (DSM) for Observation of Events with Associated Criteria	Diagram of DSM, if available, to assist in defining observation of recording the event	Observation Frequency and Notes				
		T₁ P.S. LA (C) or M.S. GV (G)	T₂ P.S. SA (C) or M.T. GV (G)	T₃ Apical 4/5-ch (C) or T.O. Ceph (G)	T₄ Apical 2-ch (C) or Cor. RK (G)	T₅ Sub-Costal (C) or Cor. LK (G)
RECORDED START TIMES FOR EACH MANEUVER:						
1. Record whether the Participant sat or stood during the study.	SAT / STOOD					
If sitting, record whether the Participant utilized the chair's back and height adjustment settings (including foot rest) to maintain appropriate posture or whether the participant did not use Optimal Body Positioning (OBP) (e.g., thoracic flexion/slumping at shoulders, spinal torsion/twisting in chair).						
If standing, record whether the Participant maintained an appropriate upright posture (e.g., weight equally distributed on both feet, neutral spine) or whether the participant did not use OBP (e.g., thoracic flexion/slumping at shoulders).						
Record whether the Participant asked to make height adjustments to the ultrasound unit and/or the monitor. (If so, were the adjustments appropriate?)						



<p>2. Number of Times the Participant engaged in (cervical spine) neck hyperflexion (approximately 20 degrees or more beyond neutral position) for at least 15 seconds concurrently or at least 30 seconds cumulatively per task/minute. (Note: usually caused by improper monitor adjustment; is not as prominent as the diagram.)</p>	 <p>The diagram shows a person's head and neck in profile, tilted forward. A curved arrow indicates the range of motion. An inset shows a cross-section of the cervical spine with red lines indicating strain. A vertical red line and an arrow point to the neck area.</p> <p>http://www.spineuniverse.com/conditions/whiplash/causes-whiplash</p>					
<p>3. Number of Times the Participant engaged in (cervical spine) neck hyperextension (approximately 20 degrees or more beyond neutral position) for at least 15 seconds concurrently or at least 30 seconds cumulatively per task/minute. (Note: usually caused by improper monitor adjustment; is not as prominent as the diagram.)</p>	 <p>The diagram shows a person's head and neck in profile, tilted backward. A curved arrow indicates the range of motion. An inset shows a cross-section of the cervical spine with red lines indicating strain. A vertical red line and an arrow point to the neck area.</p> <p>http://www.spineuniverse.com/conditions/whiplash/causes-whiplash</p>					

<p>4. Number of Times the Participant engaged in (cervical spine) neck rotation/twisting (of at least 20 degrees beyond neutral position) for at least 15 seconds concurrently or at least 30 seconds cumulatively per task/minute.</p>	 <p>http://www.hrsdc.gc.ca/eng/labour/publications/health_safety/identify_ergonomics/page04.shtml</p>					
<p>5. Number of Times the Participant engaged in (cervical spine) neck lateral extension (approximately 15 degrees or more beyond neutral position) for at least 15 seconds concurrently or at least 30 seconds cumulatively per task/minute.</p>	 <p>http://www.hrsdc.gc.ca/eng/labour/publications/health_safety/identify_ergonomics/page04.shtml</p>					
<p>6. Number of Times the Participant engaged in over-abduction/hyperextension of the scanning shoulder (due to reaching across the patient). This would be defined as over 30 degrees for at least 15 seconds concurrently or at least 30 seconds cumulatively per task/minute.</p>	 <p>Shoulder Abduction</p> <p>Of angles greater than 30 degrees</p>					

<p>7. Number of Times the Participant engaged in over-abduction/hyper-extension of the NON-scanning shoulder (due to reaching for the ultrasound instrumentation/keyboard). Defined as over 30 degrees for at least 15 seconds concurrently or at least 30 seconds cumulatively per task/minute.</p>	 <p style="text-align: center;">Shoulder Abduction</p>					
<p>8. Number of Times the Participant engaged in lateral flexion of the spine (side-bending) while reaching (toward the patient) during scanning. Defined as obvious lateral side bending for at least 15 seconds concurrently or at least 30 seconds cumulatively per task/minute.</p>	 <p style="text-align: center;">http://www.easyvigour.net.nz/fitness/h_LumbarSideBend.htm</p>					
<p>9. Number of Times the Participant engaged in spinal torsion/twisting the back during the study. Defined as obvious twisting of the waistline for at least 15 seconds concurrently or at least 30 seconds cumulatively per task/minute.</p>	 <p style="text-align: center;">http://www.hrsdc.gc.ca/eng/labour/publications/health_safety/identify_ergonomics/page04.shtml</p>					

<p>10. Number of Times the Participant engaged in DSM of the wrist joint: with the wrist in hyperflexion. This would be defined as at least 30 degrees for at least 15 seconds concurrently or at least 30 seconds cumulatively per task/minute. (Note that slight flexion beyond wrist extension is acceptable.)</p>	 <p>Angle of Wrist Flexion (approx 80 degrees).</p> <p>http://www.easyvigour.net.nz/fitness/hOBP2_Cures_Tennis_Elbow.htm</p>					
<p>11. Number of Times the Participant engaged in DSM of the wrist joint: with the wrist in dorsiflexion. This would be defined as at least 20 degrees for at least 15 seconds concurrently or at least 30 seconds cumulatively per task/minute. (Note that slight flexion beyond wrist extension is acceptable.)</p>	 <p>http://www.easyvigour.net.nz/fitness/hOBP2_Cures_Tennis_Elbow.htm</p>					

<p>12. Number of Times the Participant engaged in DSM of the wrist joint: with the wrist in outward lateral flexion (ulnar deviation as associated with the radiographer's navicular view). Defined as at least 20 degrees for at least 15 seconds concurrently or at least 30 seconds cumulatively per task/minute.</p>	 <p>http://www.rcsed.ac.uk/fellows/ivanrensburg/classification/hand/scaphoid.htm</p>					
<p>13. Number of Times the Participant pronated the wrist with full arm extension during scanning (thus adding extreme pressure to the elbow joint). Defined in observation for at least 15 seconds concurrently or at least 30 seconds cumulatively per task/minute.</p>	 <p>http://www.easyvigour.net.nz/fitness/hOBP2_Cures_Tennis_Elbow.htm</p>					
<p>14. Number of Times the Participant supinated the wrist with full arm extension during scanning (thus adding extreme pressure to elbow joint). Defined in observation for at least 15</p>						

<p>seconds concurrently or at least 30 seconds cumulatively per task/minute.</p>	 <p>http://www.easyvigour.net.nz/fitness/hOBP2_Cures_Tennis_Elbow.htm</p>					
<p>15. Whether the Participant often engaged in either resting the scanning forearm on the patient's body (with protective measures and permission) or scan table or requested/developed some sort of alternative arm rest. (Often is measured by the subject utilizing this option at least 3 out of every 5 tasks).</p>	 <p>Figure 6: Positioning closer to the patient</p> <p>http://www.medeserv.com.au.asum/open/bulletin/v1_n4_3.htm</p>					
<p>Number of Times in which the Participant engaged in a micro-break (small components of time to rest the arm or stretch) throughout the study.</p>						
<p>Number of Times the Patient was asked to move closer to the Participant to prevent reaching (overextension of the shoulder) and/or back torsion.</p>						
<p>The observer also has the option of recording any occurrence that has not been anticipated, yet repeats itself frequently enough by a</p>						

particular participant or among the sample group that it should not be ignored.	
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General Sonography Views:

T₁ M.S. GV = Task 1 Mid-Sagittal Plane (sagittal great vessel/s)

T₂ M.T. GV = Task 2 Mid-Transverse Plane (great vessels /or/ may substitute with celiac axis /or/ combination of splenic vein, SMA, left renal vein, aorta transverse view)

T₃ T.O. Ceph = Task 3 Transverse (reverse) oblique with cephalic angle (Playboy bunny sign of hepatic veins coursing from liver)

T₄ Cor. RK = Task 4 Coronal plane of right kidney at mid-measurement

T₅ Cor. LK = Task 5 Coronal plane of left kidney at mid-measurement

Echocardiography Views:

T₁ P.S. LA = Task 1 Parasternal Long-axis

T₂ P.S. SA = Task 2 Parasternal Short-axis

T₃ Apical 4/5-ch = Task 3 Apical 4 or 5 chamber

T₄ Apical 2-ch = Task 4 Apical 2 chamber

T₅ Subcostal = Task 5 Subcostal

T₆ Suprastern.= Task 6 Suprasternal

Universal Scan Conditions to address with Participant in the study feedback:

- Laboratory scan table (and scan chairs) can be ergonomically height adjusted and have a drop leaf for closer access to patient's body during some positioning maneuvers.
- No support sponges or towels should have been offered by the participant's scanning mentor. (The research observer should note if this occurs in the feedback, as bias will have been introduced involving arm support and wrist positioning.)
- All laboratory monitors had the capability to height adjust or tilt to the sonographer's field of view (though few participants asked about this or attempted to manipulate during any time that the initial research observations were made).
- There were other potential ways in which the scan mentors could have biased the study by adjusting the scanning participant's wrist or suggesting changing the scan table height for the participant, though they were instructed not to do so. (The observer should make any notes of such occurrences.)

Methodology Notes:

- The observer set out to observe each maneuver for 1 minute (or until the Task was completed, if less than 1 minute).
- If more than 1 minute appears to have lapsed between Tasks (views), this means there was an instructional pause time that was not counted in the observation period.
- None of the participants scanned the T₆ suprasternal view during the observation period.

APPENDIX G
PPG QUASI-EXPERIMENT

PPG Handout – Participant Should Read Prior to Quasi-Experiment

Why Plethysmography for the Beginning Sonographer?

Photoplethysmography (PPG) assesses the volume of blood flow to the dermis of the finger by using a pulse oximeter to illuminate the skin, so light absorption can be measured. Although the wave shape may be different from one participant to the next, each participant's own volumetric measurement can be calibrated and recorded in a neutral position and can then be compared from that initial recording on other exercises that may change the volume of blood flow to that same finger. That is the purpose of our PPG study today – to view whether particular sonographer functions and positions create any change in that blood flow volume.

This research is seeking to determine whether certain arm movement used in daily scanning that may not be ergonomically ideal could create positional compression of blood vessels and/or nerves; or if particular static scan activities, involving the gripping of the transducer and the pressure on the patient's body, could create muscular compression to certain vessels or nerves. In either case, repetition of such compression could potentially damage the nerves over time, if evidenced by a reduction in blood flow that might result from lack of Optimal Body Positioning (OBP) or the requirements of scanning functions (e.g., application of pressure over an extended time to obtain a diagnostic image).

The study participant may wish to further research a compression disorder, such as Thoracic Outlet Syndrome (TOS), to better understand the premise of arterial, venous and/or nerve compression issues of the upper extremity.

The researcher is seeking to establish whether there is significance in the amount of blood flow reduction during potential compression activities. Furthermore, this exercise is being conducted to assist the study participant in deciding whether personal results suggest a detrimental outcome during the performance of scanning.

Articles:

<http://ejcts.ctsnetjournals.org/cgi/content/full/30/2/232> - A positive test was defined as the disappearance of pulsatility (<5% remaining amplitude) in the PPG recording of the digit perfusion of one (or both) finger/s in at least two of the positions or maneuvers.

<http://occmcd.oxfordjournals.org/content/53/5/331.full.pdf> - **TOS Risk Factors:** There may be occupational influences to provoke or exacerbate symptoms, such as working repeatedly with the arms at or above shoulder height.

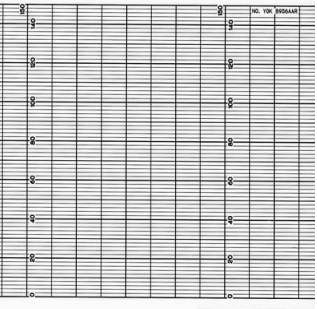
PPG Methodology:

A plethysmography sensor will be placed on the middle fingertip of the participant’s dominant scanning hand for calibration and experimental exercises. The participant will first be instructed to sit comfortably and relax for approximately 30-60 seconds in the neutral position, with palms facing upward and hands resting on the thighs, before a baseline strip is run.

The participant will then be instructed to stand with the scan shoulder in neutral position (less than 20 degrees) while gripping a 5.0 MHz linear transducer with the scan hand and all fingers without making contact with the PPG sensor. At approximately 15-20 seconds of sustained pressure on the phantom, which should be compressed to approximately 2 cm (as marked), another PPG flow recording will be conducted.

The participant will then be asked to relax for another 30-60 seconds for blood flow volume to return to normal baseline, before getting into a sitting position with the shoulder hyper-extended toward the phantom. The researcher will assure that the participant’s shoulder is abducted approximately 80 degrees with a partially pronated elbow. The participant will then be asked to grip the transducer and apply scan pressure on the phantom to the 2 cm mark. At approximately 15-20 seconds of sustained pressure, another PPG flow recording will be conducted.

At any time that the participant reports experiencing pain that exceeds a slight discomfort (tingly sensation) level, the study will be discontinued immediately and record made of this fact.

Blood Flow Volumes Are Established According to PPG Scaled Amplitude Lines on Available Strip Recorder Paper	Description of Experimental Exercise	PPG Scaled Amplitude Flow	% of Original Scaled Amplitude Baseline Flow
	Neutral Calibration Position (Subject Sitting, Palms up, Hands resting on thighs)	Ex: 7	100.0
	Subject Standing Neutral Shoulder Position (less than 20 degrees), Transducer gripped, Scan pressure applied to ~2 cm on phantom		
	Subject Sitting Shoulder Hyperabducted (approximately 80 degrees) with partially pronated elbow, Transducer gripped, Scan pressure applied to ~2 cm on phantom		

APPENDIX H
POST QUASI-EXPERIMENTAL
PHOTOPLETHYSMOGRAPHY (PPG)
INTERVIEW QUESTIONS

Post Quasi-Experimental Photoplethysmography (PPG) Interview Questions

Q1. Please explain what the PPG blood flow findings mean to you. (Assess the participant's understanding of the diminished blood flow meaning, whereby vascular supply has been temporarily decreased in that area, which means nerves and muscles are not receiving necessary blood supply and can atrophy and become damaged if habitually repeated over time, thus increasing the risk factor of repetitive MSIs and nerve damage.)

Q2. (If the participant did not fully understand the meaning of question #1, the researcher should explain it now. The researcher should refer the participant to the handout, provided prior to the exam, which explains PPG findings related to blood flow and the effects of reduced blood flow on nerves and muscles. Using the handout may lessen bias through any inflections or body language the participant perceives being used by the researcher.) After the assessment of your personal findings in this experiment, do you believe that you are presently at risk for a musculoskeletal injury related to your professional duties? Why or why not?

Q3. After assessment of your personal findings from the initial expert observation of your scan technique, as well as your personal findings in this experiment, do you believe you can make any changes in your scanning technique to reduce your likelihood of injury related to your professional duties? Why or why not?

Q4. What is your response to the findings of this experiment and the results you have received thus far, in general?

Q5. Due to the nature of this study, if you share these results with your classmates at this time, it could bias the results. Will you commit to keeping your personal results to yourself until after this pilot study is completed, which is scheduled for the end of your first semester/program year (depending upon the learner's classification)?

APPENDIX I
SELF AND PEER
EVALUATION SURVEYS

ERGONOMICS PEER OBSERVATION CHECKLIST

Participants

Observer Name:

Peer Scanner Name:

Please refer to Categorical Descriptions and Representative Images of Ergonomic Scan Maneuvers that will be available for you to reference at your scan station throughout the exercise.

Negative Ergonomic Scan Behaviors Recorded

Negative Behaviors Observed: Neck (C-Spine)

Description of Behavior	Number of Times Peer Engaged in Behavior = 0 (NONE)	Number of Times Peer Engaged in Behavior = 1 to 3 times	Number of Times Peer Engaged in Behavior = 4 or more times	PADCAM Demonstration Made Available to Lab Partner	Lab Partner Made an Attempt to Correct Concern Following PADCAM Demonstration
HyperFLEXION (Neck prominently bent DOWNward)					
HyperEXTENSION (Neck prominently bent UPward)					
Rotation (twisting neck 20 degrees or beyond to either side)					
Lateral Extension (tilting neck laterally at least 15 degrees toward shoulder)					

Negative Ergonomic Scan Behaviors Recorded					
Negative Behaviors Observed: Back/Spine					
Description of Behavior	Number of Times Peer Engaged in Behavior = 0 (NONE)	Number of Times Peer Engaged in Behavior = 1 to 3 times	Number of Times Peer Engaged in Behavior = 4 or more times	PADCAM Demonstration Made Available to Lab Partner	Lab Partner Made an Attempt to Correct Concern Following PADCAM Demonstration
Back (T- or L-spine) Lateral Flexion (bending sideways)					
Spinal (T- or L-spine) Torsion (twisting the back around from waistline)					
Negative Ergonomic Scan Behaviors Recorded					
Negative Behaviors Observed: Shoulders & Elbow					
Description of Behavior	Number of Times Peer Engaged in Behavior = 0 (NONE)	Number of Times Peer Engaged in Behavior = 1 to 3 times	Number of Times Peer Engaged in Behavior = 4 or more times	PADCAM Demonstration Made Available to Lab Partner	Lab Partner Made an Attempt to Correct Concern Following PADCAM Demonstration
SCAN Shoulder Over-Abduction (hyperextension upwards beyond 30 degrees)					
NON-SCAN Shoulder Over-Abduction (hyperextension upwards beyond 30 degrees)					

Elbow PRONATION with Full Arm Extension (hand turned PALM DOWN)					
Elbow SUPINATION with Full Arm Extension (hand turned PALM UP)					
Negative Ergonomic Scan Behaviors Recorded Negative Behaviors Observed: Wrist					
Description of Behavior	Number of Times Peer Engaged in Behavior = 0 (NONE)	Number of Times Peer Engaged in Behavior = 1 to 3 times	Number of Times Peer Engaged in Behavior = 4 or more times	PADCAM Demonstration Made Available to Lab Partner	Lab Partner Made an Attempt to Correct Concern Following PADCAM Demonstration
Wrist HYPER-flexion (hand bent DOWNward from wrist at least 30 degrees)					
Wrist DORSI-flexion (hand bent UPward from wrist at least 20 degrees)					
Wrist OUTward Lateral flexion (hand flexed from wrist toward pinky)					
Wrist INward Lateral flexion (hand flexed from wrist toward thumb)					

Positive Ergonomic Scan Behaviors Recorded					
Description of Behavior	Number of Times Peer Engaged in Behavior = 0 (NONE)	Number of Times Peer Engaged in Behavior = 1 to 3 times	Number of Times Peer Engaged in Behavior = 4 or more times	PADCAM Demonstration Made Available to Lab Partner	Lab Partner Made an Attempt to Explain Procedure for Achieving Positive Behavior Following PADCAM Demonstration
Resting of Scan Arm on table or patient's body					
Microbreaks (Ex: shaking out hand, stretching)					
Asking patient to move to improve peer's Optimal Body Positioning					

VIDEO MIRRORING ADJUSTMENT (VMA) REFLECTION SURVEY

This survey is meant to serve as your journal of today's laboratory learning progression on ergonomics, using the collaborative peer review assessment exercise in which you've been engaged. Please respond to the following questions thoughtfully and candidly, as there are no correct or incorrect responses. This reflective survey is meant to assist you in establishing any personal benefit this semester in working with other sonography students to identify and offer one another solutions for ergonomic scan concerns.

1. The number of times I utilized the Padcam (for still and/or video imaging) during today's VMA scan assessment to collaborate with my peer(s) on possible ergonomic issues that I was able to identify as my lab partner scanned. (This can be determined by reviewing your observation checklist.)

0 (none) 1-3 4-6 7-10 over 10 times

Comments – If either you or your partner did NOT use the Padcam, what do you believe the reason to be?

2. I found today's experience in receiving ergonomic Padcam feedback from my laboratory partner regarding my scan behavior to be informative and beneficial.

___ (5) strongly agree
___ (4) somewhat agree
___ (3) uncertain
___ (2) somewhat disagree
___ (1) strongly disagree

Comments –

3. I perceived that my laboratory partner found today's experience in receiving ergonomic Padcam feedback from me regarding his/her scan behavior to be informative and beneficial.

- ___ (5) strongly agree
- ___ (4) somewhat agree
- ___ (3) uncertain
- ___ (2) somewhat disagree
- ___ (1) strongly disagree

Comments –

4. In regards to assisting me in identifying and discussing ergonomic behaviors, I found the addition of the Padcam demonstrations in this activity to add benefit in enhancing visual and conceptual understanding.

- ___ (5) strongly agree
- ___ (4) somewhat agree
- ___ (3) uncertain
- ___ (2) somewhat disagree
- ___ (1) strongly disagree

Comments –

5. I could have as readily made adjustments to my ergonomics behavior by someone verbally explaining what should be corrected, rather than viewing myself engaged in those activities through video archiving.

- ___ (5) strongly agree
- ___ (4) somewhat agree
- ___ (3) uncertain
- ___ (2) somewhat disagree
- ___ (1) strongly disagree

Comments –

6. Lessons Learned - Cooperative Ergonomic Plan of Adjustment for ME, based upon today's collaborative findings:

7. Lessons Learned - Cooperative Ergonomic Plan of Adjustment for MY LAB PARTNER, based upon today's collaborative findings:

8. Following today's VMA assessment, I believe my musculoskeletal injury (MSI) risk rating for my 10-year future to be as follows:

1	2	3	4	5	6	7	8	9	10
I absolutely will NOT be scanning with any injuries or pain.									I absolutely WILL be scanning as injured and in pain.

Comments –

9. Additional Reflections – How might I improve my ergonomic performance or progression?

In what ways could this Padcam exercise be improved to enhance my learning?

10. Demographic information to assist students in maintaining progression learning logs throughout the semester for their own reference. (The instructor can maintain these separately for individual review, if a program cannot be obtained that will allow the student electronic access throughout the semester.)

APPENDIX J
STATISTICAL TESTING
BY HYPOTHESES

Table J.1 Statistical Testing by Hypotheses

Number	Description of Null Hypothesis	Statistical Test
1	Research Question only (no null hypothesis): How closely did sonographers' pre-instructional scan complaints and risk behaviors correspond with final musculoskeletal complaints and risk behaviors of prior published professional injury rates?	Descriptive / Cross-Tabulations
2a	Transmissional knowledge regarding other sonographers' incidences of work-related musculoskeletal disorders (WRMSDs) demonstrated no relationship to belief patterns held by early career sonographers regarding personal risk perception of musculoskeletal injuries (MSIs).	Chi-square
2b	Transmissional knowledge regarding other sonographers' published rates of work-related musculoskeletal disorders (WRMSDs) demonstrated no relationship to belief patterns held by early career sonographers regarding personal risk perception of musculoskeletal injuries (MSIs).	Chi-square
3a	The photoplethysmography (PPG) flow study participants' mean self-susceptibility rating for MSI risks was the same as for those who did not participate in the quasi-experimental study.	<i>t</i> test for mean difference
3b	No significant difference existed between the mean personal prevention plan (PPP) score of the PPG flow study participants and the PPP mean score of those who did not participate in the PPG study.	<i>t</i> test for mean difference
3c	The PPG flow study participants exhibited the same frequencies of observed ergonomic risk behaviors from the pre-instruction observation stage to the transactional post-instruction observation stage, as compared to those who did not participate in the quasi-experimental blood flow study.	Independent-samples <i>t</i> test
4a	The observed behavioral incidences recorded at the final observation event (post-graduation) were the same for the transformational learning group (Group C) as compared to the other study groups (Groups A and B). 4a-i – tested negative behaviors 4a-ii – tested positive behaviors	One-way ANOVAs
4b	The PPP scores demonstrated no difference between the transformational learning group (Group C) as compared to the other study groups (Groups A and B).	One-way ANOVA
5a	Research Question only (no null hypothesis): Did learner self-reflections and collaborative peer reflections demonstrate a positive impact on learner attitudes concerning longer-term transformative assessment benefit?	Descriptive

(Table continued)

Table J.1 Statistical Testing by Hypotheses (cont.)

Number	Description of Null Hypothesis	Statistical Test
5b	The mean MSI risk ratings from the end of the transactional stage of learning to the end of the transformational stage of learning exhibited no attitudinal differences among the transformational learners of Group C.	<i>t</i> test for mean difference
6a	Sonographers who expressed concerns of work-related musculoskeletal disorders (WRMSDs) were perceived by the evaluator to demonstrate the same level of responsiveness to ergonomic feedback at the final observation stage as sonographers who did not express WRMSD concerns.	Independent-samples <i>t</i> test
6b	No difference existed between the evaluator responsiveness ratings of graduates regarding final observation feedback based upon the learning classification (Group A, B or C) in which the graduates had been formally engaged while in school.	One-way ANOVA

APPENDIX K
VARIABLES ANALYSIS

Table K.1 Variables Analysis

Variable Type	Variable Label	Levels of the Variable	Scale of Measurement	Statistical Test
Primary Dependent Variable	1a. Differences in Ergonomic Risk Behavior Changes: pre- to post-instruction Primary Hypothesis Hypothesis 3c (Groups B & C)	Frequency (0-5 in each category) with Overall Comparison of Values among all categories (Pre-instruction vs. post-instruction frequency differences) 2 groups; Differences in pre- to post- instructional changes of Negative Behaviors	Ratio (0/5 to 5/5 in each category)	Independent samples <i>t</i> test (combine with Independent Variable 2)
	1b. Differences in Ergonomic Behaviors: post-graduation / final observation stage Primary Hypothesis Hypothesis 4a (Groups A, B & C)	Frequency (0-5 in each category) with Overall Comparison of Values among all categories 3 groups; Differences in Negative & Positive Behaviors	Ratio (0/5 to 5/5 in each category)	One-way ANOVA (combine with Independent variable 1)
Secondary Dependent Variables	2. The reported ergonomic pain locations & risk behavior concerns observed Research Question 1	Categorical locations (neck, back, shoulder, wrist)	Nominal (categorical)	Descriptive Statistics – Contingency Tables (See Figure K.1 for variable relationships)
	3. Learner Personally Perceived Present MSI Risk expressed in Interview (relates to pre-instructional Interview Question 5) Hypothesis 2a	0 = Does not believe is presently at personal risk 1 = Uncertain if presently at risk 2 = Believes is presently at personal risk	Nominal (categorical)	Chi-square (Combine with Independent Variable 3)

(Table continued)

Table K.1 Variables Analysis (continued)

Variable Type	Variable Label	Levels of the Variable	Scale of Measurement	Statistical Test
Secondary Dependent Variables (cont.)	4. Learner Personally Perceived MSI Risk Reconsideration in Interview (relates to pre-instructional Interview Question 8) Hypothesis 2b	0 = No change in MSI Risk Perception 1 = Belief in Increased Risk based on population statistic	Nominal (categorical)	Chi-square (Combine with Independent Variable 4)
	5. Learner Ratings of Perceived MSI Risk Factor (during instruction) Hypothesis 3a	1-10 on Likert Scale 1 = Least Perceived Risk 10 = Greatest Perceived Risk	Interval	<i>t</i> test for mean difference (combine with Independent Variable 2)
	6. Personal Prevention Plan Scores (post-instruction) Primary Hypothesis Hypothesis 4b (Groups A, B & C) Hypothesis 3b (Groups B & C)	Rubric-Based Scores 0-100%	Interval	One-way ANOVA (original scores) (combine with Independent Variable 1) Independent samples <i>t</i> test (combine with Independent Variable 2)
	7. Perceived MSI Risk Factor (End of final instruction) Hypothesis 5b (Groups B & C)	1-10 on Likert Scale 1 = Least Perceived Risk 10 = Greatest Perceived Risk	Interval	<i>t</i> tests for mean difference (combine with Independent Variable 1)

(Table continued)

Table K.1 Variables Analysis (continued)

Variable Type	Variable Label	Levels of the Variable	Scale of Measurement	Statistical Test
Unanticipated Additional Dependent Variable	8. Evaluator's Perception Rating of Graduate Responsiveness to Final Observation Feedback Hypotheses 6a, 6b	0 = resistant 1 = ambivalent 2 = responsive	Interval	<i>t</i> test (combine with Independent Variable 5) ANOVA (combine with Independent Variable 1)
Primary Independent Variable	1. Type of Learning Engagement Primary Hypothesis Hypotheses 4a,b & Hypothesis 6b (Groups A, B & C) <hr/> Hypothesis 5b (Group C only*)	0 = transmissional (Class of 2009, 2010) 1 = transactional (Class of 2011) 2 = transformational (Class of 2012) <hr/> Stage of Engagement, 1 or 2 only*	Nominal (categorical)	(combine with Dependent Variables 1a, 1b, 6, 7 & 8)
Secondary Independent Variables	2. Learner engagement in PPG study Hypotheses 3a, 3b & 3c (Groups B & C only)	0 = control group 1 = quasi-experimental PPG group	Nominal (categorical)	(combine with Dependent Variables 1a, 5 & 6)
	3. Personal knowledge (Awareness) of sonographer injury(ies) (relates to pre-instructional interview question 3) Hypothesis 2a (Groups B & C only)	0 = Unaware of sonographer MSIs 1 = Aware of at least 1 sonographer's MSI 2 = Aware of 2 or more sonographers' MSIs	Nominal (categorical)	(combine with Dependent Variable 3)

(Table continued)

Table K.1 Variables Analysis (continued)

Variable Type	Variable Label	Levels of the Variable	Scale of Measurement	Statistical Test
Secondary Independent Variables (cont.)	4. Awareness of Published Professional Rate of Sonographer MSIs (relates to pre-instructional Interview Quest. 7) Hypothesis 2b (Groups B & C only)	0 = Unaware of published rate (will not attempt a guess or estimates below 50%) 1 = Attempts a guess and estimates above 50%, but is incorrect 2 = Knows the published rate of MSIs	Nominal (categorical)	(combine with Dependent Variable 4)
Unanticipated Additional Independent Variable	5. Graduate-reported MSIs at time of Final Observation Hypothesis 6a	0 = No pain or injuries reported 1 = Pain or injury areas reported	Nominal (categorical)	(combine with Dependent Variable 8)
Extraneous Variables	1. Perception of Personal benefit of assessment activities of ergonomic behaviors (VMA survey question 2) Question 5a (Group C only)	Likert Item (1-5): 1 = Strongly Disagree 2 = Somewhat Disagree 3 = Uncertain 4 = Somewhat Agree 5 = Strongly Agree	Ordinal (or Interval)	Descriptive
	2. Perception of Peer's benefit of assessment activities of ergonomic behaviors (VMA survey question 3) Question 5a (Group C only)	Likert Item (1-5): 1 = Strongly Disagree 2 = Somewhat Disagree 3 = Uncertain 4 = Somewhat Agree 5 = Strongly Agree	Ordinal (or Interval)	Descriptive
	3. Perception of added visual benefit (through the use of the Padcam) Question 5a (Group C only)	Likert Item (1-5): 1 = Strongly Disagree 2 = Somewhat Disagree 3 = Uncertain 4 = Somewhat Agree 5 = Strongly Agree	Ordinal (or Interval)	Descriptive

(Table continued)

Table K.1 Variables Analysis (continued)

Variable Type	Variable Label	Levels of the Variable	Scale of Measurement	Statistical Test
Extraneous Variables (cont.)	4. Perception that ergonomics adjustments could have easily been described & made without visual demo (using the padcam) Question 5a (Group C only)	Likert Item (1-5): 1 = Strongly Disagree 2 = Somewhat Disagree 3 = Uncertain 4 = Somewhat Agree 5 = Strongly Agree	Ordinal (or Interval)	Descriptive
	5. Number of times using the Padcam to demonstrate ergonomic issues (VMA survey question 1) Question 5a (Group C only)	0 = none 1 = 1-3 times 2 = 4-6 times 3 = 7-10 times 4 = over 10 times	Ratio (0-10/10 times)	Descriptive

Figure K.1 designates the potential association of relationships between the reported pain location variables and observed scan risk behavior categories among subjects in this study. The arrows in the figure direct the anticipated dependency of these relationships. Categorical locations of early pain and discomfort is considered to be dependent upon early observed scan behavior locations; while categorical locations of post-graduate WRMSD reports are considered to have dependence upon early pain report locations and early and persistent observed risk behaviors. Persistent negative risk behaviors may have dependence upon both early discomfort areas and early observed risk behavior locations. The association of such relationships has been analyzed in Chapter IV, in related to Research Question 1.

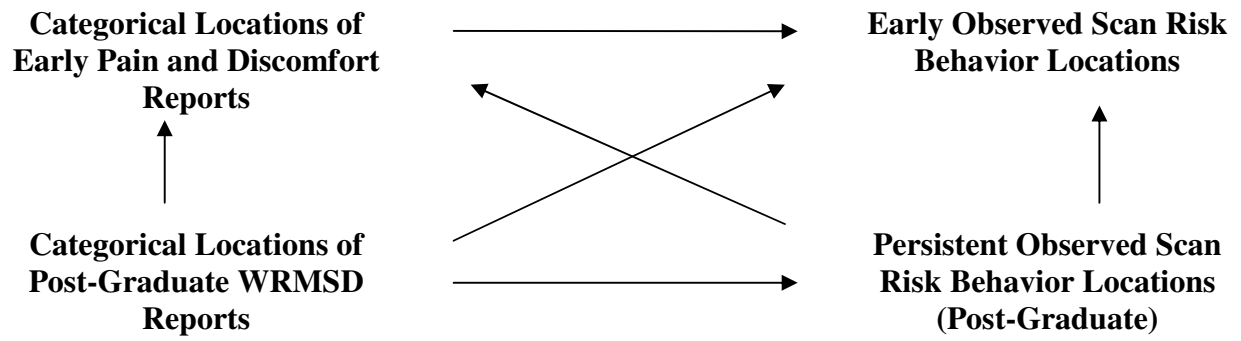


Figure K.1 Relationships of Research Question 1's Variables

APPENDIX L
SUPPORTING QUANTITATIVE DATA

Supplementary Data for Chapter IV

Research Question 1

Table L.1 Abbreviated Record of Observed Scan Risk Behaviors

Categorical DSM	Task 1	Task 2	Task 3	Task 4	Task 5
Scan Shoulder	X		X	X	
Non-Scan Shoulder		X		X	X
Wrist Hyperflexion			X		
Wrist Dorsiflexion	X				
Wrist Lateral Flexion					

Explanation for Table L.1

In the example of Table L.1, the subject demonstrated six DSM negative scan behaviors among both shoulder descriptions, or $P = .60$ (representing 6 reports among 10 potential task behaviors, or 60.0%). In the case of wrist behaviors, the subject only demonstrated $P = .13$ (representing two DSMs of 15 potential task behaviors). Even though the probability values were not numerically displayed in the table, these probability values were important for visually recording the most highly observed incidences on the upcoming comprehensive graphic.

Table L.2 Comparisons of Reported and Observed Incidences from the Early Pre-Instructional Stage to the Final Post-Graduate Stage at 2 to 5 Years Scan Experience

Group	Subject	Reported Concerns by Subject				Observed Incidences by Expert			
		Shoul- der	Neck	Wrist/ Hand	Back	Shoul- der	Neck	Wrist	Back
Group A	A	+	+		+	+++	+++	+++	+++
	B	+					++	+	+
	C						+	+	+++
	D	+				+++	+	+	+++
	E	+				+	+	++	+
	F	+	+	+		+	+	+	+++
	G	+					+	+	++
	H	+			+	+	+	+	+++
	I		+		+	++	+	+	++

For reported incidence by category, + denotes presence of complaint

For expert observation incidence to be recorded within a category, + denotes $P \geq .20$

++denotes categorical negative scan behavior most commonly observed in the subject, $P \leq .70$

+++denotes categorical negative scan behavior observed in the subject, $P \geq .70$

(Table continues)

Table L.2 Comparisons of Reported and Observed Incidences from the Early Pre-Instructional Stage to the Final Post-Graduate Stage at 2 to 5 Years Scan Experience (continued)

Group	Subject	Reported Concerns by Subject				Observed Incidences by Expert			
		Shoul- der	Neck	Wrist/ Hand	Back	Shoul- der	Neck	Wrist	Back
Group A	J				+	+	+	+	+++
	K					+++	+	+	+
	L				+		+++	+	+++
	M	+			+		+	+	+++
	N		+			+	+	+	+++
	O					+	+	+	++
	P	+			+		+	+	+++
	Q					+++		+	+
	R					+++	+		+

For reported incidence by category, + denotes presence of complaint

For expert observation incidence to be recorded within a category, + denotes $P \geq .20$

++denotes categorical negative scan behavior most commonly observed in the subject, $P \leq .70$

+++denotes categorical negative scan behavior observed in the subject, $P \geq .70$

(Table continues)

Table L.2 Comparisons of Reported and Observed Incidences from the Early Pre-Instructional Stage to the Final Post-Graduate Stage at 2 to 5 Years Scan Experience (continued)

Group	Subject	Reported Concerns by Subject				Observed Incidences by Expert			
		Shoul- der	Neck	Wrist/ Hand	Back	Shoul- der	Neck	Wrist	Back
Group A	S	+					++	+	+
	T					+		+	+++
Groups B & C	U	+			+	+++ +	+	+	++
	V	+	+	+			+	+	+++ +
	W	+	+			+	+		++
	X	+				+	+		+++ +
	Y	+	+	+	+	+++ +	+	++	+
	Z	+				+			++ +

For reported incidence by category, + denotes presence of complaint

For expert observation incidence to be recorded within a category, + denotes $P \geq .20$

++denotes categorical negative scan behavior most commonly observed in the subject, $P \leq .70$

+++denotes categorical negative scan behavior observed in the subject, $P \geq .70$

(Table continues)

Table L.2 Comparisons of Reported and Observed Incidences from the Early Pre-Instructional Stage to the Final Post-Graduate Stage at 2 to 5 Years Scan Experience (continued)

Group	Subject	Reported Concerns by Subject				Observed Incidences by Expert			
		Shoulder	Neck	Wrist/Hand	Back	Shoulder	Neck	Wrist	Back
Groups B & C	AA	+	+			+	+	+	+++
							+	+	+++
	BB	+		+		+++	+	+	+++
					+		+		++
	CC	+	+				+		+++
				+			+	+	++
	DD					+++	+		+
						+	+		++
EE	+	+			+++	+		+++	
					+	+	+	++	
FF				+			+	+	
			+	+					
GG						+	+	+	
					+				
HH	+	+					+		
							+		

For reported incidence by category, + denotes presence of complaint

For expert observation incidence to be recorded within a category, + denotes $P \geq .20$

++denotes categorical negative scan behavior most commonly observed in the subject, $P \leq .70$

+++denotes categorical negative scan behavior observed in the subject, $P \geq .70$

(Table continues)

Table L.2 Comparisons of Reported and Observed Incidences from the Early Pre-Instructional Stage to the Final Post-Graduate Stage at 2 to 5 Years Scan Experience (continued)

Group	Subject	Reported Concerns by Subject				Observed Incidences by Expert			
		Shoul- der	Neck	Wrist/ Hand	Back	Shoul- der	Neck	Wrist	Back
Groups B & C	II	+					++	+	+
			+	+	+		+	+	
	JJ	+					+	+	+++
			+					+	
	KK						++	+	+
		+			+				+
LL		+				+		+++	
							+		
MM							+	+++	
					+			+	
NN							+	+	++
			+			+			

For reported incidence by category, + denotes presence of complaint

For expert observation incidence to be recorded within a category, + denotes $P \geq .20$

++denotes categorical negative scan behavior most commonly observed in the subject, $P \leq .70$

+++denotes categorical negative scan behavior observed in the subject, $P \geq .70$

Legend Explanation for Table L.2

Reported and observed concerns have been included in Table L.2, developed as a dual visual comparison between early and late pain reports paired with early and late observation risk behaviors. It must be pointed out that early pain reports and observations were not conducted with Group A's subjects in this study, so only post-graduate WRMSD complaints and observed risk behaviors can be compared for Subjects A through T. Groups B and C begin with Subject U, in which early complaint reports can be compared to both post-graduate complaint reports and early and late observational behaviors; and early to late observational comparisons may also be made and compared back to reported complaints in each individual thereafter, through Subject NN.

The rows in Table L.2 represent individual study subjects. The first column heading depicts the group from which the subject was derived, and the second column represents an alphabetical designation of the subject arbitrarily assigned by the researcher to mask identification other than the subjects' grouping. The next broad column heading encompasses the categorical MSI complaints reported by study subjects, with the upper left corner of a subject's categorical box designating early reports during the pre-instructional period, and the lower right corner of the same categorical box designating the subject's post-graduate categorical WRMSD complaint at the two-to-five-year final observation stage. A + symbol in the upper left corner of the categorical box represents an early reported pain or discomfort. A + symbol in the lower right corner of that same categorical box represents a corresponding reported WRMSD at two to five years of scan experience. Absence of a symbol designates no reported complaint in that category. Such findings might represent some predictive value. In cases where a portion of the categorical

box has a symbol and the other portion does not, it may be assumed that no predictive value was evidenced.

The final broad column heading represents risk incidences that were observed categorically as repetitive and sustained scan behaviors that may habitually contribute to sonographer MSIs within those same DSM categories. The left upper corner of the categorical box still represents the early scan period, only of observed behaviors (rather than reported discomfort); the right lower corner again designates the post-graduate observation findings. However, the symbols within this set of columns provide richer meaning than simply the presence or absence of behaviors, according to the methodology related to Table L.1. For ease in visual graphic interpretation, the researcher chose to maintain the + symbol structure, rather than numerically recording all observed behavioral proportions. With this in mind, a + symbol represents any behavioral categorical occurrence that was sustained and repeated with $P \geq .20$. If the symbol designates ++, this is meant to represent the highest percentage of incidences reported among the categories, if more than one category is represented, though with $P \leq .70$. (Two ++ symbols in different categories would designate a tie in the highest percentage value.) If the percentage of categorical incidences was $P \geq .70$, the symbol will be designated as +++ (which will designate the greatest proportions of behavior, as well and could also be represented by multiple categories).

Admittedly, a claim could be made that the lower probability threshold of 20.0% for recording any incidence within a category was arbitrarily selected by the researcher, although this proportion was chosen to acknowledge that negative behaviors occurring on an infrequent basis do not necessarily signify that a sonographer will sustain permanent injury. Conversely, the same allegation could be made toward arbitrary selection of the upper probability threshold of

70.0% to signify more perilous incidence rates, although the researcher made this decision based upon the ergonomic risk condition of repetitive and sustained behavior concerns. The reader should be cautioned that formal testing for these proportions was beyond the scope of this study and could represent an incorrectly applied assumption on the part of the researcher. These values are to be used for comparative purposes only.

A single + symbol in one observation heading, or multiple + symbols in different categories of the same observational row, simply signifies at least 20.0% of proportions of observed behaviors existed in any category containing that designation. A dual ++ symbol indicates the most commonly observed categorical behavior, proportionally, for that individual, though still less than 70.0%. Multiple dual ++ symbols signify a tie between the highest proportion of behaviors between at least two categories. A triplicate +++ symbol indicates 70.0% of proportions or greater of observed behaviors existed within that category, meaning also that greater than 70.0% could exist in multiple categories. In such instances, no dual ++ could exist on that row.

Under the reported concerns heading, singular + symbols only exist for reported complaints, designating either the presence or absence of pain or discomfort in a categorical area. Shaded boxes signify that the reader should take notice and look for a match either between that subject's reported complaints and observed incidences (lighter shaded boxes) or between early and late repetitive negative behavioral incidences that have been observed but have not (to date) resulted in any complaint reports (darker shaded boxes). Again, Subjects A through T (from Group A) only demonstrate late reports and observations.

Practical Examples of Table L.2 Interpretation

Figure L.1 provides the graphic representation of data from Subject A in Table L.2 from the final observation stage, at which time Subject A reported WRMSD complaints of the shoulder, neck, and back. The expert observer logged repetitive and sustained negative behaviors of at least 70.0% proportionality (+++ symbol) in all of the major categories of shoulder, neck, wrist, and back. Three of the reported areas appear to be associated with three of the problematic observational categories. Longer term monitoring would be required to evidence any association between documented wrist behaviors and a career wrist injury. The light shading in the categorical boxes calls to the reader’s attention the apparent associations taking place between the career-engaged sonographers’ reports of WRMSD complaints with the behavioral incidences logged by the expert evaluator at the two to five year scan period.

Subject	Reported Concerns by Subject				Observed Incidences by Expert			
	Shoulder	Neck	Wrist/ Hand	Back	Shoulder	Neck	Wrist	Back
A	+	+		+	+++	+++	+++	+++

Figure L.1 Diagrammatic Example of Subject A from Table L.2

The next example is more complex, comparing early (pre-instructional) and later (2 to 5 years of experience) reports and behaviors. Figure L.2 provides the graphic representation of data from Subject BB in Table L.2 from both the early stage, at which time the subject self-reported discomfort in the shoulder and wrist/hand areas; and the later stage, at which time

Subject BB reported WRMSD complaints of the back. The expert observer logged repetitive and sustained negative behaviors of at least 70.0% proportionality (+++ symbol) in the shoulder and back categories during the early observation stage, as well as lower percentages of negative neck and wrist behaviors; but then later logged only neck and back risk behaviors at the final observation, with back being the most prevalent, though lower than 70.0% (++ symbol). The back categorical boxes are shaded in light gray to represent a reported injury associated with observed repetitive behaviors. (Early discomfort areas that were not re-reported have not been acknowledged by shading to signify any association, though further monitoring throughout career longevity might provide evidence of the importance of these data). The dark shading in the neck observational category signifies that the subject has continued to repeat the same problematic behaviors from early to late observation periods, which may also increase future risk of injury to the neck, though no neck complaints have been reported, to date.

Subject	Reported Concerns by Subject				Observed Incidences by Expert			
	Shoulder	Neck	Wrist/ Hand	Back	Shoulder	Neck	Wrist	Back
BB	+		+	+	+++	+	+	+++ ++

Figure L.2 Diagrammatic Example of Subject BB from Table L.2

Research Question 3

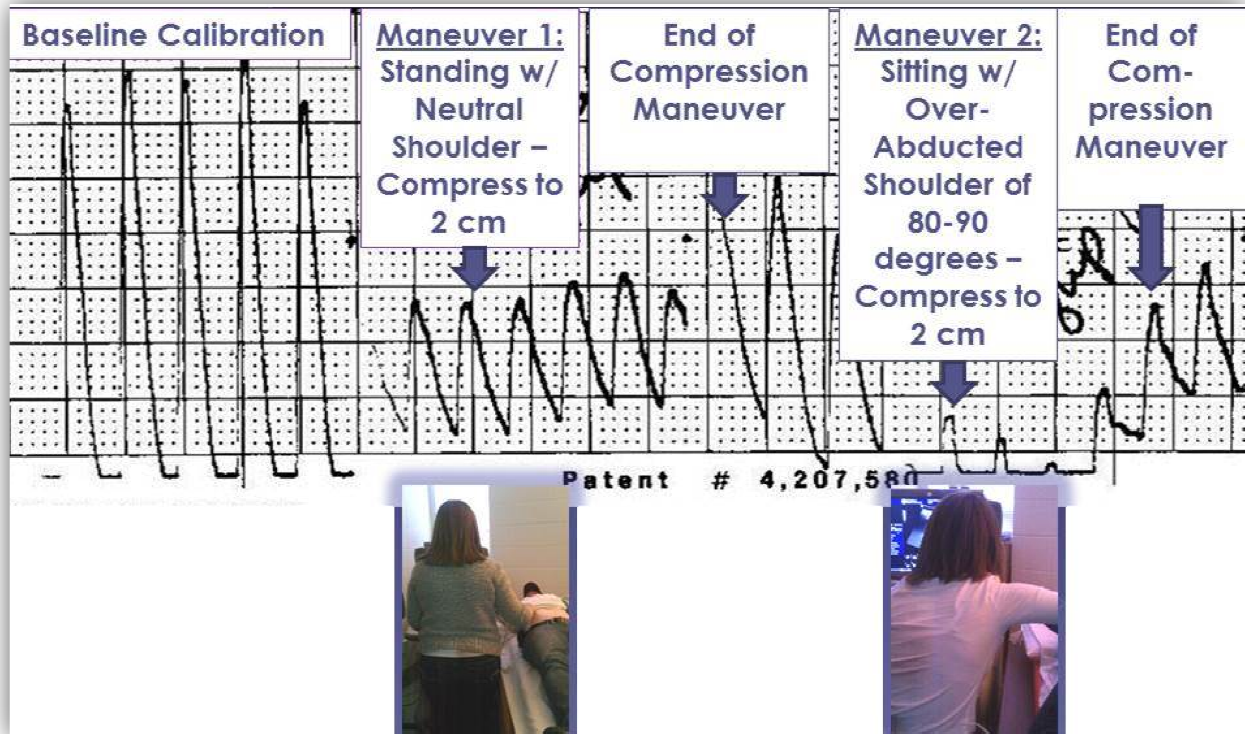


Figure L.3 PPG Blood Flow Volume from Baseline through Experimental Maneuvers

Explanation for Figure L.3

Baseline calibration was recorded on the strip chart during the photoplethysmography (PPG) study. Figure L.3 captures the customary response of diminished flow during each maneuver, followed by an increase in blood flow occurring at the end of both scan maneuvers. This increased flow represents the period in which the subject released compression and returned to a relaxed, neutral position. Note that the increase in blood flow did not occur as rapidly following Maneuver 2, in which the shoulder was hyperabducted, as it did following Maneuver 1, in which compression was applied with the shoulder in a neutral scan position. The strip

recording of Figure L.3 is provided only as an abbreviated example for reader comprehension. In actual case subjects, baseline blood flow was reestablished to original value prior to performing the second maneuver, and the study was not ended until the researcher assured that blood flow had returned to normal baseline value following the second maneuver.

PPG Experimental Comparison

Figure L.4 provides a boxplot comparison of the three scan positions (baseline, neutral with compression, and hyperabduction with compression). As can be seen in this diagram, there were two outliers for Scan Maneuver 2. It should be noted that both subjects with outlying values exhibited difficulty maintaining adequate pressure for the designated test period of 15 to 20 seconds with the hyperabducted shoulder.

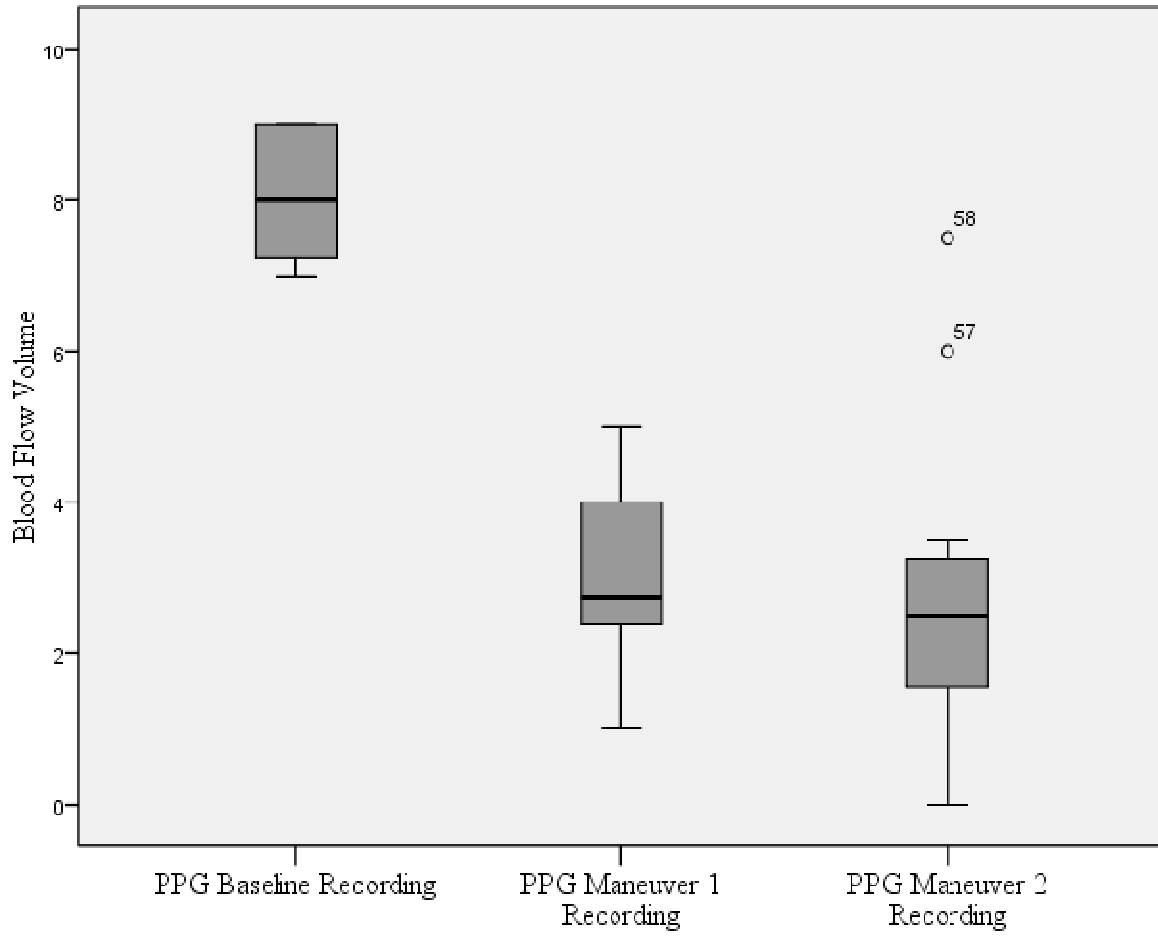


Figure L.4 Baseline Blood Flow Volume Comparison to Scan Maneuvers 1 and 2

Research Question 5

VMA Survey Feedback

Table L.3 Frequencies of Padcam Usage for Peer Feedback per VMA Session

Frequency of Padcam Usage	Lab 1		Lab 2		Lab 3		Total	
	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>N</i>	<i>%</i>
None	0	0.0	0	0.0	0	0.0	0	0.0
1-3 times	5	45.4	5	50.0	5	50.0	15	48.4
4-6 times	2	18.2	3	30.0	3	30.0	8	25.8
7-10 times	3	27.3	1	10.0	2	20.0	6	19.4
Over 10 times	1	9.1	1	10.0	0	0.0	2	6.4
Total	11	100.0	10	100.0	10	100.0	31	100.0

Table L.4 Frequencies of Responses for Self Benefit based on Padcam Use in VMA Survey

Level of Statement Agreement	Lab 1		Lab 2		Lab 3		Total	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>N</i>	%
Strongly Disagree	0	0.0	0	0.0	0	0.0	0	0.0
Somewhat Disagree	0	0.0	0	0.0	0	0.0	0	0.0
Uncertain	0	0.0	0	0.0	0	0.0	0	0.0
Somewhat Agree	3	27.3	2	20.0	4	40.0	9	29.0
Strongly Agree	8	72.7	8	80.0	6	60.0	22	71.0
Total	11	100.0	10	100.0	10	100.0	31	100.0

Table L.5 Frequencies of Responses for Peer Benefit based on Padcam Use in VMA Survey

Level of Statement Agreement	Lab 1		Lab 2		Lab 3		Total	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>N</i>	%
Strongly Disagree	0	0.0	0	0.0	0	0.0	0	0.0
Somewhat Disagree	0	0.0	0	0.0	0	0.0	0	0.0
Uncertain	0	0.0	0	0.0	0	0.0	0	0.0
Somewhat Agree	3	27.3	3	30.0	4	40.0	10	32.2
Strongly Agree	8	72.7	7	70.0	6	60.0	21	67.8
Total	11	100.0	10	100.0	10	100.0	31	100.0

Table L.6 Frequencies of Responses for Visual and Conceptual Description Benefit to Padcam Use in VMA Survey

Level of Statement Agreement	Lab 1		Lab 2		Lab 3		Total	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>N</i>	%
Strongly Disagree	0	0.0	0	0.0	0	0.0	0	0.0
Somewhat Disagree	0	0.0	0	0.0	0	0.0	0	0.0
Uncertain	0	0.0	0	0.0	0	0.0	0	0.0
Somewhat Agree	3	27.3	2	20.0	2	20.0	7	22.6
Strongly Agree	8	72.7	8	80.0	8	80.0	24	77.4
Total	11	100.0	10	100.0	10	100.0	31	100.0

Table L. 7 Frequencies of Responses for Padcam Benefit as Compared to Verbal Peer Description

Level of Statement Agreement	Lab 1		Lab 2		Lab 3		Total	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>N</i>	%
Strongly Disagree	1	9.1	1	10.0	0	0.0	2	6.5
Somewhat Disagree	1	9.1	3	30.0	4	40.0	8	25.8
Uncertain	3	27.3	1	10.0	1	10.0	5	16.1
Somewhat Agree	4	36.3	1	10.0	5	50.0	10	32.3
Strongly Agree	2	18.2	4	40.0	0	0.0	6	19.3
Total	11	100.0	10	100.0	10	100.0	31	100.0

APPENDIX M
SUPPORTING QUALITATIVE DATA

Supplementary Data for Chapter V

Pre-Instructional Interview Responses

Pre-Instructional Interview Question 5 Responses

IQ5 asked: Do you believe that you are presently at risk for a musculoskeletal injury related to your professional duties? Why or why not?

When questioned, three subjects provided responses as to why each did not possess a personal risk attitude:

- 1) "I'm too young."
- 2) "I haven't scanned enough."
- 3) "No one has corrected me, and I don't hurt after scanning."

Three additional responses were from learners who indicated uncertainty of personal risk:

- 1) "Because I'm so early into this, I don't know the best way yet."
- 2) "I guess I need to focus on loosening my grip."
- 3) "Not knowing proper body mechanics for scanning could be a problem."

Some of the responses from those who hesitated to admit personal injury risk from scanning included:

- 1) "I know I don't have good posture."
- 2) "My posture isn't the best, but I think I could improve on it."
- 3) "Maybe, because of body positioning when scanning."
- 4) "Um, sure, because I can't always think of positioning when imaging."
- 5) "Well, I sustained a past cut through the tendons in my forearm."
- 6) "Yes, probably, since I already have a neck injury."

- 7) The most direct response in this final category was, “Yes, because I don’t practice what I know.”

Pre-Instructional Interview Question 6 Responses

Table M.1 lists the subjects’ responses to IQ6: What circumstances do you believe would place you at risk either now or at some point in the future? (And, if not now, at what point in the future?) These responses are compared to risk behaviors noted during the expert observations.

Table M.1 Early Participant Responses of Problematic Risk Behaviors compared with Expert Observational Findings

Study Participant Responses*	Expert Observations
Poor posture and improper body mechanics	<p>Poor posture and improper body mechanics -</p> <p>When sitting:</p> <ul style="list-style-type: none"> • Forward slump with chin jut • Failing to use chair back • Bending of trunk • Torsion of trunk • Leaning off the side of the chair/stool • Failure to align feet on ground or footrest <p>When standing:</p> <ul style="list-style-type: none"> • Hip jut • Misalignment of feet (often crossed) • Leaning of trunk • Torsion of trunk
Poor transducer grip or extended grip compression	<p>Poor transducer grip or extended grip compression (with two prominently identified grip behaviors):</p> <ul style="list-style-type: none"> • Talon grip • Knuckle ball grip <p>Fifth digit (prominent) grip maneuvers:</p> <ul style="list-style-type: none"> • Tea cup grip • Pinky press grip <p>Wrist maladjustments:</p> <ul style="list-style-type: none"> • Wrist hyperflexion • Wrist dorsiflexion • Wrist lateral flexion (outward and inward)
Shoulder hyperabduction (described as over-reaching)	<p>Shoulder hyperabduction (sometimes with anterior shoulder roll)</p> <p>Posteroinferior shoulder displacement</p>
Lack of arm support while scanning	<p>Lack of arm support while scanning</p> <p>Elbow hyper-pronation</p>
Lack of microbreaks (described as a failure to stop and/or reposition while scanning)	<p>Lack of microbreaks</p>
Prolonged repetitive movements	<p>Prolonged repetitive movements (of any of the above listed activities)</p>

*Appropriately related terms for subjects' descriptions were provided by the researcher.

(Table continues)

Table M.1 Early Participant Responses of Problematic Risk Behaviors compared with Expert Observational Findings (continued)

High work productivity demands	High work productivity demands Communication failure between sonographers and administration Failure of administration to respond to sonographer needs
(No neck-specific concerns listed)	Lateral cervical rotation Cervical hyperflexion Cervical hyperextension Lateral cervical extension

*Appropriately related terms for subjects' descriptions were provided by the researcher.

Pre-Instructional Interview Questions 7 and 8 Responses

IQ7 asked, Do you know the published rate of musculoskeletal injuries among all sonographers? IQ8 followed up by providing the published rate and then asking, Does that change your opinion of your own personal risk factor? Comments among those citing lack of certainty in changed risk included:

- 1) "I would definitely want to know the benefits, so I don't fall into that category."
- 2) "I probably wouldn't be too surprised. I have seen very few [sonographers] practice safe positioning for themselves. They're focused on the quickest way to image."
- 3) "I'm a little speechless...wow...sonographers really are sacrificing themselves."
- 4) "I do have it in my mind that, with every job, there's some level of risk."
- 5) "Makes me want to learn what I need to do to avoid injuries like that."

Initial responses generally (in 20 of the remaining 23 instances) began with the filler sounds or phrases:

- 1) Nervous laughter, chuckling (7 instances)
- 2) "Whew."

- 3) "That's a lot."
- 4) "Um..."
- 5) "Kind of scary" or "That's scary." (2 responses)
- 6) "Really?"
- 7) "Wow." (2 responses)
- 8) "Oh" or "Oh heck." (2 responses)
- 9) "Surprising."
- 10) "I can't believe that."
- 11) "I don't believe this. I left my last profession because of this same problem."

Pre-Instructional Interview Question 9 Responses

IQ9 was an attempt to get study participants to consider future consequences, in the event the early learners could not yet relate to injury susceptibility in the immediate timeframe, when asking, Does that percentage of injuries cause you to believe that you will still be able to scan, pain-free and injury-free, as a sonographer 20 years from now?

Statements offered to minimize future injury or pain belief included:

- 1) "Probably not."
- 2) "If I'm not careful."
- 3) "It probably won't prevent me from scanning."

A sampling of non-committed responses to IQ9 included:

- 1) "I plan to retire before that time."
- 2) "I hope to be scanning pain-free."
- 3) "I'm not sure what the future holds."

Pre-Instructional Interview Question 10 Responses

IQ10 asked the learner to look at the personal results from the pre-instructional expert observation. A sampling of the feedback received from transactional participants included:

- 1) "This makes me want to be more aware."
- 2) "I want to pay attention to those things."
- 3) "I have some improving to do."
- 4) "I'm glad we're being taught proper ways."

A sampling of the feedback from transformational participants who expressed relief included:

- 1) "I'm so glad my negative behaviors have gone down from the first observation."
- 2) "I'm glad we're learning appropriate ergonomic techniques."
- 3) "I think this is going to make a difference in how long I'll be scanning."
- 4) "I think I'll be okay because of what I'm learning here."
- 5) "I'm starting to get better at catching myself doing the wrong things and fixing them."
- 6) "Whenever I feel sore, I look at what I'm doing now."

PPG Quasi-Experimental Interview Findings

PPG Interview Question 1 Findings

Table M.2 lists subjects' comprehension levels to PPG Question 1: Please explain what the PPG blood flow findings mean to you.

Table M.2 PPG Learners' Explanations of Personally Visualized Blood Flow Volumes

Group B	Group C	Narrative Theme Categorizations*
6	5	General recognition of decreased/interrupted blood flow
5	4	Increased strain (pressure) creates a loss of sensation of blood flow (e.g., cold/ tingly fingers)
3	1	Increased strain was uncomfortable, created muscle fatigue

Group B = transactional learners; Group C = transformational learners

*Includes multiple responses per participant

PPG Interview Question 2 Findings

PPG Question 2 asked, After the assessment of your personal findings in this experiment, do you believe that you are presently at risk for a musculoskeletal injury related to your professional duties? Why or why not? The following comments were made by transformative subjects in explaining reasons for reducing personal risk factors, according to personal empowerment beliefs. Representative comments to denote the ability to take corrective action that came from Group C participants included:

- 1) "I don't think I'm going to be part of that injury statistic anymore because I'm going to be taught how to prevent it."
- 2) "You're teaching me to correct what I'm doing wrong, and I plan to pay attention and change it."
- 3) "Keep showing me what I'm doing wrong. I'll fix this problem."

- 4) “I might be at higher risk, but if I pay more attention to my work habits, I can reduce it.”

Three of the transformational learners went on to explain the urgency to make a change, stating:

- 1) “If I hadn’t learned to adjust my scan position (with my arm close), I know I would be headed toward being a statistic.”
- 2) If I wasn’t cognizant of my own scan concerns that I’m learning to adjust, I’d really be worried.”
- 3) “I feel that I’m already classified at risk, and I barely even scan yet.”

Table M.3 includes learner explanations of behaviors or sensations perceived to denote greatest personal concern toward risk susceptibility.

Table M.3 PPG Learners’ Explanations of Greatest Personal Risk Susceptibility Behavioral Concerns

Group B	Group C	Narrative Theme Categorizations*
6	1	Sustained compression (pressure, force), especially with obese patients
2	2	Scanning positions (of arms and wrists)
0	2	Scan posture
0	1	Pain experienced in the first few seconds of compression

Group B = transactional learners; Group C = transformational learners

*Includes multiple responses per participant

PPG Interview Question 3 Findings

PPG Question 3 extended on the theme of corrective actions, asking the participant to identify what changes could be made to reduce the likelihood of work-related injuries. Table M.4 lists all the suggested corrective personal action themes verbalized by the PPG participants, with frequencies identified within each of the learning groups.

Table M.4 PPG Learners' Assessment of Personal Risk Adjustment Behaviors

Group B	Group C	Narrative Theme Categorizations*
5	6	Reduce reaching for patients and equipment or better position self closer to the patient and equipment
3	3	Use forearm support to reduce negative shoulder, elbow and wrist behaviors
2	3	Adjust scanning stance/posture
2	2	Take microbreaks during scanning, particularly when scanning difficult or obese patients
1	3	Use back rest of scan chair
0	4	Adjust equipment height (scan table, monitor, instrumentation)
0	2	Work out to become stronger
1	0	Learn to alternate hands for scanning throughout the day (admitting to difficulty in early attempts)
0	1	Pay attention to the discomfort signals from own body
0	1	Keep wrist in a neutral position

Group B = transactional learners; Group C = transformational learners

*Includes multiple responses per participant

PPG Interview Question 4 Findings

PPG Question 4 asked the learner: What is your response to the findings of this experiment and the results you have received so far, in general? Table M.5 provides a comprehensive listing of thematic responses, designated by frequencies within the learning groups.

Table M.5 PPG Learners’ Post-Experiment Comprehensive Reflective Comments

Group B	Group C	Narrative Theme Categorizations*
6	5	Increased awareness of personal injury risk
2	4	Surprised (“shocked”) at the number of sonographers with MSIs
3	2	Prevention of injury risk must begin immediately
0	2	Concerned (“scared”) of the loss of blood flow during extended days with excessive numbers of patients over any extended career period
1	0	Increased number of obese patients creating additional ergonomic scan risks for sonographers
1	0	Injury risk appears greater than in other professions
0	1	Surprised by the lack of flow during shoulder hyperextension

Group B = transactional learners; Group C = transformational learners

*Includes multiple responses per participant

Personal Prevention Plan Findings

PPP Theme 1 Findings

Appendices M.6 to M.8 contain subjects’ specific statements denoting third person (as opposed to first person) writing patterns, categorized by group classification, with the individual number designating nothing more than the order in which the assignment was recorded from any particular group (A, B, or C). Table M.6 provides pertinent examples for transmissional learners, while Table M.7 contains the examples of the transactional learners, and Table M.8 of the transformational learners.

Table M.6 Examples from Transmissional Learners to Denote Third Person Writing Patterns

Individual Numerical Designation	Pertinent Comment Examples
A-1	<p>“As a sonographer, you should always check your workstation.” “A sonographer should...” (RN: sentences began in this manner multiple times)</p>
A-2	<p>“...you need a good diet and exercise plan.”</p>
A-3	<p>“Hopefully, this plan [will]...help other sonographers realize the importance of a healthy lifestyle and correct ergonomics.” “A balanced diet is important for a sonographer to help them...”</p>
A-4	<p>“There are many ways that you can strengthen yourself to avoid an injury while in ultrasound school and when working in the near future.” “...the workload should be equally divided between each of them.” “...can help you have enough energy...”</p>
A-5	<p>“...[T]here are exercise workouts and scanning techniques that should be used to keep the sonographer from long-term wearing [and] injury to the body.” “...you can find yourself in awkward positions....You also must be aware...”</p>
A-6	<p>“If you have a patient...”, “You need to have...”, “If your diet consists of...”, “...you will continue to work in an environment that is doing harm to you and your health.” “...if your employer does not know the importance of [ergonomics].”</p>
A-7	<p>“It is not healthy to become stressed because it [places] unnecessary tension and strain on your body, making you more susceptible for injury or sickness.” “If you overeat you may become tired and not perform as well as you could at work.”</p>
A-8	<p>“During good posture your shoulders should be back.” “While sonographers are performing exams, it is important to evenly distribute your body weight.”</p>
A-9	<p>“If you set a certain time out each week for exercising then you are more likely to see it through. These exercises can easily fit into your schedule before and after work.” “Relaxation is also essential to the sonographer.” “Also, do not forget to rest your eyes periodically.”</p>
A-10	<p>“A balanced diet will help you in the long run to maintain your health.”</p>
A-11	<p>“Your head should not be tipped forward or backward, but should be in a comfortable position.”</p>
A-12	<p>“If you do not report MSI’s and other issues as soon as you notice them, they could develop into a substantial problem that you will have to deal with in the future.”</p>

RN = Researcher’s Note

(Table continues)

Table M.6 Examples from Transmissional Learners to Denote Third Person Writing Patterns (continued)

A-13	<p>“Scanning ergonomics is of great importance to a [sonographer].” “Keeping your body in shape and healthy along with good ergonomic practices, scanning shouldn’t become a problem for you.”</p>
A-14	<p>“It is important that each sonographer be provided with or [develop] their own work out plan.” “There are several important considerations to keep in mind while scanning your patient in regards for your shoulder and elbow.”</p>
A-15	<p>“You always run the risk of work related injury being a sonographer.”</p>
A-16	<p>“All in all I think it is a good idea for everyone to have a daily routine of stretches and healthy eating to keep the mind, body and muscles working at their best.”</p>
A-17	<p>“It will make sonographers more aware of how they are affected by improper scanning and possibly help their own ergonomic scanning habits while in the workplace.”</p>

Table M.7 Examples from Transactional Learners to Denote Third Person Writing Patterns

Individual Numerical Designation	Pertinent Comment Examples
B-1	<p>“When the sonographer is in the comfort of their home it’s not a bad idea for them to take some time and exercise after their long day of scanning.”</p> <p>“Another technique a sonographer should take into consideration is dieting.”</p>
B-2	<p>“Perform stretches slowly and gently; avoid extreme postures and stop stretching if you feel pain or discomfort.”</p> <p>“As you can see, it is of great importance for the sonographer to become self aware of their posture and scanning habits.”</p>
B-3	<p>“...your body...your arm...your eyes...your muscles...your arm...your reach”</p>
B-4	<p>“...you can...you can...you do not necessarily...”</p>
B-5	<p>“...I believe along with exercising this will help the sonographer perform better and more proficiently.”</p>
B-6	<p>“Work stations for sonographers should be excellent in the fact that they are versatile. The monitor should be able to be adjusted for the sonographer who is scanning [while] sitting or standing in order to reduce eye strain and neck pain.”</p> <p>“So take breaks whenever you can so that your patient does not feel they are [unimportant] because you are so busy and have to get the next one scanned and done, which could cause you to miss something very important.”</p>
B-7	<p>“A prevention plan should include taking care and preparing yourself while you are not scanning as well as being ergonomically smart while you are scanning.”</p> <p>“There are several factors important to your body while you are not scanning that can prevent future musculoskeletal injuries from occurring.”</p> <p>“Not only can a sonographer prevent future injuries while not scanning, they can also do certain things while they are actually scanning.”</p>

Table M.8 Examples from Transformational Learners to Denote Third Person Writing Patterns

Individual Numerical Designation	Pertinent Comment Examples
C-1	“While scanning a patient your hand can become very tired and weak.”
C-2	“As a sonographer, you will have to apply a lot of pressure depending on the exam and when you do, the shoulder is taking the brunt of the force, so the stronger your shoulder the better it is...” “Physical fitness is probably the most beneficial thing you can do for your body...”
C-3	“One may ask himself, what does nutrition have to do with ergonomics?” “Taking oneself out of the working environment for short periods of time should ease stress effectively. For some...”
C-4	“Most employers need the sonographer to be knowledgeable in this area, so it is important for the sonographer to express concerns of potential injury.” “Eating properly and supplying your muscle with the appropriate vitamins...”
C-5	“As I learned by doing this topic, the ideal workstation should allow the sonographer to have a good posture to minimize the risk of musculoskeletal injuries....The sonographer should be able to work with his/her arms and elbows close to the body...”
C-6	“Using a meal plan with an exercise plan allows you to track your intake of calories along with burned calories during exercise to manage a healthy balance.” “It is important after a long day of work to take time to decompress, and give your body and mind a chance to relax from the day’s tension.”
C-7	“Sonographers are very active people, who need lots of energy and stamina to perform their job well. Sonographers may often work long hours and/or many consecutive days at a time. This being said, sonographers need to have balanced and nutritious meal routines.” “If there is a situation that may arise, the sonographer should be proactive in protecting him/herself from serious injury in the future.”

PPP Theme 2 Findings

Appendices M.9 to M.11 contain subjects' specific statements denoting rote repetition patterns, categorized by group classification, with the individual number designating nothing more than the order in which the assignment was recorded from any particular group (A, B, or C). Table M.9 provides pertinent examples for transmissional learners, while Table M.10 contains the examples of the transactional learners, and Table M.11 of the transformational learners.

Table M.9 Examples from Transmissional Learners to Denote Rote Repetition

Individual Numerical Designation	Pertinent Comment Examples
A-1	Listing of facts found in the presentation: “push-ups will...; sit-ups will...; work-related injuries are extremely common...”
A-2	“Sonographers need to take it upon ourselves to take care of our own bodies by...We will have less injuries...if we follow those things.” “I have learned...”
A-3	“[Employee health] can then tell you what precautions should be taken...” “It is important to...” <i>(RN: statement never discloses whether or not the learner has acted upon this importance)</i>
A-4	“I have realized...” <i>(RN: but the learner never describes taking any action about this realization)</i> “Do things I enjoy!” <i>(RN: The learner never shares what these things are)</i> “In the past few weeks, I have seen why it is so important to practice good ergonomics when scanning.” <i>(RN: no additional explanation provided)</i>
A-5	“A sonographer should not over scan; this can lead to fatigue.”
A-6	“According to labor laws...” “The scanning habits that I have picked up from this lesson...” “...enough of each of these can make your day go well for you.”
A-7	“Exercise is essential for a healthy lifestyle.” “The arms and shoulders of a sonographer often become sore if proper ergonomics are not performed.” “It is very important to take time to relax.”
A-8	“[N]ot having a balanced diet causes you to be tired and fatigued...”

(Table continues)

Table M.9 Examples from Transmissional Learners to Denote Rote Repetition (continued)

A-9	<p>“Working out is very important in preventing work related injuries.”</p> <p>“Stretching increases flexibility...”</p>
A-10	<p>“It is very important to have a scheduled work out plan to prevent injury when on the job.”</p> <p>“Another important factor in maintaining health for the sonographer is a balanced nutrition plan.”</p>
A-11	<p>“A recommended 8 hours [of sleep] a night is what I believe I should get.”</p> <p>“Carpal tunnel syndrome is one of the leading injuries in this field.”</p>
A-12	<p>“It is important to have a nutritious diet and the right amount of exercise when working in health care.”</p>
A-13	<p>“It’s very important to eat as healthy as possible throughout the day to ensure you get the energy you need to help you do your job efficiently and keep you feeling good!”</p> <p>“It’s important to get eight hours of sleep a night to ensure you are well rested for the next day.”</p>
A-14	<p>“Work-related injuries are extremely common for sonographers.”</p>
A-15	<p>“Sonographers need to take it upon ourselves to take care of our own bodies.”</p> <p>“We will have less injuries...if we follow those things.”</p> <p>“I have learned...”</p>
A-16	<p>“84% of sonographers scan in pain with 20% having career ending injuries.”</p> <p>“Neck and shoulder are the areas most affected.”</p>
A-17	<p>“Good scanning ergonomics can prevent work related injury.”</p> <p>“The sonographer should exercise regularly and eat a well-balanced diet.”</p>
A-18	<p>“A balanced diet is extremely important.”</p>
A-19	<p>“Minimizing the amount of reaching that you do is essential.”</p> <p>“The most common injury of the wrist is carpal tunnel.”</p>
A-20	<p>“One should always practice good ergonomics while scanning.”</p> <p>“A workout plan is important in a sonographer’s ability to maintain correct scanning ergonomics in the workplace. A regular workout routine can be performed daily to prevent musculoskeletal disorders.”</p> <p>“Neck and back pain are major complaints of a sonographer.”</p>

RN = Researcher’s Note

Table M.10 Examples from Transactional Learners to Denote Rote Repetition

Individual Numerical Designation	Pertinent Comment Examples
B-1	“Relaxation is a process that decreases the wear and tear on your mind and body from the challenges and harassments of day to day life. Relaxation techniques are a crucial part of managing stress.”
B-2	“Currently in class, the importance of stretching and taking micro breaks has been brought to our attention.” “The sonographer’s vision needs to be keen and precise in order to distinguish abnormalities, variants, etc.” “Maintaining overall health is very important because it can reduce your risk of injury on the job.”
B-3	“Strain injuries and musculoskeletal injuries are being recognized as a problem for many sonographers.”
B-4	“Ergonomics comes from the Greek words...” “...[S]onographers are in a high risk group in the medical profession for WRMSD and career ending injuries.”
B-5	“Use the Scanning Ergonomics Workstation Checklist and Musculoskeletal Injury Checklist, by Arnold Hancock, (attached) once a month to check progress in ergonomics in better detail.”
B-6	“Ergonomics comes from the Greek words...”
B-7	“Many factors influence the health and wellbeing of today’s sonographer. Factors include...” “In addition to core exercises, stretching the back muscles daily can help to avoid injury.”
B-8	“According to the U.S. Department of Labor, the average workers compensation claim is \$29,000.”

Table M.11 Examples from Transformational Learners to Denote Rote Repetition

Individual Numerical Designation	Pertinent Comment Examples
C-1	“Musculoskeletal injuries affect over 80% of sonographers.”
C-2	“Personal fitness not only reduces one’s stress, but also prevents work related injuries. Simple core exercises...”
C-3	“Because of repetitive movements of this profession, proper diet and regular stretching become even more important.” “Sonography is a very demanding profession; therefore, fitness for the sonographer should include strengthening exercises, stretching, and relaxation.”
C-4	“The best exercise for cardio or aerobic exercise is running or jogging. The best exercise for toning shoulders is to use dumbbells for shoulder presses...”
C-5	“Good nutrition is best obtained by having a plan for meals and knowing the nutritional value of the foods you eat. A balanced diet is one that consists of proper portions of...” “Exercises that promote stretching and increasing strength in these areas are...”

PPP Theme 3 Findings

Appendices M.12 to M.14 contain subjects’ specific statements denoting lack of personal empowerment toward change, categorized by group classification, with the individual number designating nothing more than the order in which the assignment was recorded from any particular group (A, B, or C). Table M.12 provides pertinent examples for transmissional learners, while Table M.13 contains the examples of the transactional learners, and Table M.14 of the transformational learners.

Table M.12 Examples from Transmissional Learners to Denote Statements Lacking Personal Empowerment toward Change

Individual Numerical Designation	Pertinent Comment Examples
A-1	“I try...” (RN: repeated multiple times)
A-2	“I like to...” (RN: Idea does not express whether the learner does perform the action – just that the learner would like to do so) “I think I will from now on...”
A-3	“This can be avoided...” (RN: The learner does not designate if it has been avoided or how so)
A-4	“I used the sonography station to the best of my ability.” “Hopefully, this will end up working to my [benefit]...” “It will build you up quicker than it can tear you down.”
A-5	“I would do...” (RN: Then why isn’t the learner actively doing it?) “A suggestion was made...”
A-6	“I try to take...”, “I try to give myself...” “I may watch...”
A-7	“I try to avoid...”
A-8	“With our schedules, it’s hard to find time.” “I usually try...”
A-9	“I know I should start exercising...” “I try to...eat healthy...” “I would like to become more aware...”
A-10	“I plan on doing...” “My plan on relaxation is to try...” “I try and ensure that I adjust...” “I try and pass this along...”
A-11	“I try to support my arm and elbow...” “I try not to twist around the patient...” “I try to use a power grip...”
A-12	“I plan to break the habit I have already formed of trying to hold my arm in the air.” (RN: When and how does the learner plan to do so?) “I will be trying to make a conscious effort not to do this in clinic.”
A-13	“I know it sounds silly and probably not always do-able, but I think this will help me...”
A-14	“I would repeat the stretches...” “I would stretch...” (RN: The learner does not make clear if actually engaging in these activities.)

RN = Researcher’s Note

Table M.13 Examples from Transactional Learners to Denote Statements Lacking Personal Empowerment toward Change

Individual Numerical Designation	Pertinent Comment Examples
B-1	“A proper 30 min to an hour exercise could help strengthen and possibly reduce pain risks.”
B-2	“I think stretches when waking up in the morning [are] a good way to loosen the muscles.” “I feel when I start rock climbing again, I will gain more strength and feel healthier.”
B-3	“Most of the sonographers are mothers, with a full time job, which makes it much more difficult to have a daily exercise routine.”
B-4	“...and hopefully notice a difference while scanning.”
B-5	“Manufacturers have tried to improve on what they can for this high percentage of workers for injury but the numbers have just been on the rise since 1995.” “A good workout plan could be something you do....Something like...”
B-6	“With everybody working together, I do believe that the high percentage of injuries could eventually start to decline.”
B-7	“...a sonographer should do everything possible....relaxation of the wrist and arm should be taken...” “Weight lifting and pushups are some of the best ways to increase stability and flexibility.” (RN: Unclear if these are being done by the learner.) “I am also going to start an exercise program...” (RN: without explanation of why the learner is waiting to do so.)
B-8	“Push-ups would help...” “...[T]here are many strength training exercises for the back muscles that should be implemented...” “All these suggestions should be considered...and cardio should be a main component...” “...[O]ne could try...” “...a sonographer may want to take time...”
B-9	“The keyboard should be....the chair should be....”
B-10	“Any healthy workout plan should always begin with...” A minimum of thirty minutes of cardio exercise should begin every session.” “Three sets of ten would be acceptable.”
B-11	“I plan on...” (RN: multiple times) “Another common area I think is important...”

RN = Researcher's Note

Table M.14 Examples from Transformational Learners to Denote Statements Lacking Personal Empowerment toward Change

Individual Numerical Designation	Pertinent Comment Examples
C-1	“...I try my hardest...”
C-2	“...will try to make an effort...”
C-3	“I believe that raising awareness about prevention is an important step...” “It’s not always possible, especially when doing portables, but I try my best.”
C-4	“I plan to take...”

PPP Theme 4 Findings

Appendices M.15 to M.17 contain subjects’ specific statements denoting misinterpretation or fear, categorized by group classification, with the individual number designating nothing more than the order in which the assignment was recorded from any particular group (A, B, or C). Table M.15 provides pertinent examples for transmissional learners, while Table M.16 contains the examples of the transactional learners, and Table M.17 of the transformational learners.

Table M.15 Examples from Transmissional Learners to Denote Misinterpretation or Fear Statements

Individual Numerical Designation	Pertinent Comment Examples
A-1	“Reporting things such as improper scanning habits can often come back to harm the department. ...[I]t is apparent with OSHA that they sometimes come in and show the people how they are doing things wrong and give them citation for this violation.”
A-2	“There shouldn’t be any more exams added on to a full schedule....the patient should be taken to another facility.” <i>(RN: Would be viewed by administration as an impractical statement, viewed more as an agenda and met with immediate resistance. Practical limits should be negotiated for add-ons.)</i>
A-3	“Sonographers that have practiced poor ergonomics over time have had to have rotator cuff surgery.” <i>(RN: worded as an absolute for all behaviors, thus classified as a misinterpretation)</i> “I researched the cost [of] OB/Gyn tables; it seems that their average price is over \$5,000 for one table.” <i>(RN: was stated in the context of fear to request an ergonomic table.)</i>
A-4	“It has been found that 80% of sonographers are affected by ergonomics.” <i>(RN: 100% of them are likely AFFECTED by ergonomics.)</i>
A-5	“Exams have also become longer and more physically difficult. For this reason, breaks should be taken throughout the day.” “Because there [is] now an increased number of ultrasound exams performed daily, approximately 80 percent of sonographers are affected by MSIs.” <i>(RN: Learner has established a cause/effect.)</i>

RN = Researcher’s Note

Table M.16 Examples from Transactional Learners to Denote Misinterpretation or Fear Statements

Individual Numerical Designation	Pertinent Comment Examples
B-1	<p>“Typically, at my clinical site, we have four full-time sonographers that balance work flow very well....It is also helpful that scheduling is based around the daily lunch so that from 12:00 pm to 1:00 pm, the schedule is blocked and each sonographer can take a break to regain, have lunch, and still have a few minutes to relax.” <i>(RN: Why would administration free the scan room for an entire hour of productivity when lunches could be staggered and possible overtime avoided? Sonographers should take care to enhance a system for the benefit of patients and the facility, not simply one’s singular social benefit. This is a misinterpretation of sufficient break time.)</i></p>
B-2	<p>“...[I]t is the responsibility of the employer to try to prevent these types of injuries.”</p>
B-3	<p>“Employers should always be aware of ergonomic issues going on inside their departments so that they can insure [sic] the safety of their employees.” <i>(RN: What about the sonographer ensuring one’s own safety? Does administration just know what’s going on? Who relays this information?)</i></p>

RN = Researcher’s Note

Table M.17 Example from Transformational Learner to Denote Misinterpretation or Fear Statement

Individual Numerical Designation	Pertinent Comment Examples
C-1	<p>“Employers are subject to law if breaks are not provided with certain amount of hours worked....Sometimes these required breaks are not taken because workloads are so high and staffing is so low. This is the current status of our economy and we as employees must learn to adjust.”</p> <p>“...[T]here are some problems within the work environment that need attention. One must be a good salesman/woman to accomplish this.”</p>

PPP Theme 5 Findings

Appendices M.18 to M.20 contain subjects' specific statements denoting strong, definitive ergonomics learning, categorized by group classification, with the individual number designating nothing more than the order in which the assignment was recorded from any particular group (A, B, or C). Table M.18 provides pertinent examples for transmissional learners, while Table M.19 contains the examples of the transactional learners, and Table M.20 of the transformational learners.

Table M.18 Examples from Transmissional Learners to Denote Strong, Definitive Ergonomic Learning Statements

Individual Numerical Designation	Pertinent Comment Examples
A-1	“This is why I have made up my own personal prevention plan that I believe will strengthen me physically so that I can be a better sonographer in the long run.”
A-2	“By eating [healthy], I feel better, I have more energy, and my mind is working at its best.”
A-3	“The main goal of this Prevention Plan is to prevent injury before it occurs!”
A-4	“Scanning techniques I utilize are scanning close to the patient and not abducting my arm over 30 degrees.”
A-5	“While some days are busier than others, we all try to work together to lighten the load for each other.” “My personal prevention plan for ergonomics is to always stay conscious of this issue.” “I know if I develop these habits now, they will stick and my chances of work injuries will decrease.”
A-6	“A sonographer should avoid excessive twisting of the spine while scanning. This is actually something I feel I do properly.” “If you get in a good ergonomic scanning pattern from the very beginning, I believe it should just become a habit for you from day to day.”
A-7	“When working in ultrasound, it is a myth to believe that personal injury due [to] physical exertion isn't possible.”

Table M.19 Examples from Transactional Learners to Denote Strong, Definitive Ergonomic Learning Statements

Individual Numerical Designation	Pertinent Comment Examples
B-1	<p>“I have learned that there are several areas that I will need to work on to prevent injury. Therefore, I am implementing my own personal prevention plan.”</p> <p>“I have a gym membership and intend to be more diligent in using it.”</p> <p>“The supervisor is very receptive to ideas about how to make our department more ergonomically friendly.”</p> <p>“I intend to work very hard at implementing the above plan into my training and long term career in this field. I am also very excited to teach others what I have learned and challenge them to improve their scanning habits. Hopefully they will share their knowledge and maybe someday we can bring the 80% number down significantly of the [sonographers] that suffer from injury due to scanning. I think it is a very realistic expectation if we all work together and share what we know.”</p>
B-2	<p>“I would like to have a long and pain free career as a sonographer. Making a prevention plan will help me reach this goal.”</p> <p>“I believe if you can have a plan of action, you can catch potential problems before they happen.”</p>
B-3	<p>“The exercise routine that I have chosen for myself is as follows...”</p> <p>“I also feel that due to time constraints, dividing these into sections will make it much more reasonable to fit into my schedule and not overwork any of the muscles at one time.”</p>
B-4	<p>“It was very interesting to find out the different results of my personal ergonomic work station and personal ergonomic scanning habits. I believe these are things that I would have found out eventually with time, but maybe too late and already been experiencing WRMSD for myself. I am so appreciative that our program covers ergonomics and prevention plans like this. ...I feel like now I am aware of the way I was performing my scans and habits that I may have been forming, I can take this knowledge and put into practice a better and more detailed work plan and daily nutrition.”</p> <p>“I will come to realize more and more the importance of not taking this lightly and sticking with a prevention plan for the rest of my sonography career and being a good example to others of how what I have done to prevent injury to myself has truly made a difference.”</p>
B-5	<p>“...[I]t is very important that we covered this topic so thoroughly. It will definitely be useful in the future.”</p>

Table M.20 Examples from Transformational Learners to Denote Strong, Definitive Ergonomic Learning Statements

Individual Numerical Designation	Pertinent Comment Examples
C-1	“The benefits of good nutrition go beyond weight. Good nutrition can also: improve cardiovascular and other body system functions, mental well-being, cognitive performance, and wound healing or recovery from illness or injury; reduce the risk for diseases, including heart disease, diabetes, stroke, some cancers, and osteoporosis; increase energy and the body’s ability to fight off illness.”
C-2	“My personal example of a good simple workout follows...”
C-3	“My personal prevention plan initiative to avoid musculoskeletal injuries is a three part plan that will incorporate the constant monitoring, and improvement of the following principles...”
C-4	“My personal prevention plan includes several ways to both prevent and be more aware of the stresses and strains I place on my body while being a sonographer. My personal prevention plan is fivefold: 1) exercise including stretching, 2) being more aware of stresses I’m placing on my body, 3) micro breaks during the study, 4) manipulating equipment and the patient for a more comfortable scan, 5) working with my coworkers on a prevention plan.”
C-5	“I recently became aware of how important it is for me to maintain my arms and elbows close to my body; in this way, I can scan for a long period of time without getting tired and especially to prevent possible injuries.” “I really became more aware of my positioning, and I believe this is a very important prevention step.”
C-6	“By having diet, exercise programs, relaxation techniques, and proper work habits in place, work related injuries can be greatly reduced.”

PPP Theme 6 Findings

Appendices M.21 to M.23 contain subjects’ specific statements denoting corrective action plans, categorized by group classification, with the individual number designating nothing more than the order in which the assignment was recorded from any particular group (A, B, or C). Table M.21 provides pertinent examples for transmissional learners, while Table M.22 contains the examples of the transactional learners, and Table M.23 of the transformational learners.

Table M.21 Examples from Transmissional Learners to Denote Corrective Action Statements

Individual Numerical Designation	Pertinent Comment Examples
A-1	“I recommend that each staff member should [perform] no more than 10 exams in an eight hour day. This may help prevent stress on the muscles and tendons.”
A-2	<p>“At my clinical site, in one of my rotations the height adjustment for the console is broken. I can start an exam with the machine completely lowered and before I realize it, the console has gradually floated back up to its maximum height. The department has just ordered the part to fix this problem. Until then, I just need to take the time to stop and lower the console back down, so I am not having to reach as far as my arm will let me at the end of an exam.”</p> <p>“Being a student, I am always thinking I need as much practice as possible. This results in me trying to perform as many exams that I can through the day. Although I am sure it’s a great thing for learning, it is probably really hard on my body not to take breaks. I will accomplish taking small breaks throughout the day by not scanning every patient that comes through the department.”</p>

(Table continues)

Table M.21 Examples from Transmissional Learners to Denote Corrective Action Statements
(continued)

A-3	<p>“Strength exercises are necessary to build up our muscles and even help with metabolism. My personal prevention plan includes these exercises...” <i>(RN: Learner goes on to specifically describe which exercises and why.)</i></p> <p>“There should be two or three sonographers working every day to help with the patient load, and each sonographer should switch between portables, outpatients and inpatients, so one person isn’t always imaging the harder patients or moving the machine around.”</p> <p>“There should also be meetings on the proper scanning techniques, so the sonographers can share ideas.”</p>
A-4	<p>“The place [where] I do my echo rotation only allows each sonographer to do only 10 exams a day. Now I know in some places that is not possible, but I do think it is a great concept.”</p>

RN = Researcher’s Note

Table M.22 Examples from Transactional Learners to Denote Corrective Action Statements

Individual Numerical Designation	Pertinent Comment Examples
B-1	“It would be helpful to provide annual education to all users on the risk and prevention of musculoskeletal disorders.”
B-2	<p>“Since I use my hands, wrists, forearms, and shoulders to scan and control the ultrasound unit, I will add some exercises to strengthen those areas.” <i>(RN: Learner goes on to specifically describe which exercises and why.)</i></p> <p>“The workstations at my clinic site are relatively good except the chairs. The chairs are heavy with a wide seat and the back rests seem to be located too far back. There are at least 3 of our [sonographers who] are very short and it seems that these chairs would not be ideal for them. I stand because the chairs are not comfortable for me.” <i>(RN: The learner identified this important finding long before the expert observer confirmed it as a repetitive issue to be addressed.)</i></p>
B-3	<p>“I took a survey of one of the ultrasound rooms that I use to see if I could notice if any of the equipment in use was not in compliance. The chair...”</p> <p>“Catching a flaw in the work environment before an injury happens is the goal. A workplace injury can be very costly for the employer. Injuries usually involve expensive procedures ordered and paid leave. These expenses come out of the employer’s pocket. Administration would rather incur the price of fixing equipment or adding an accessory to help alleviate strain than to incur the price of worker’s compensation.”</p>
B-4	“I often find myself flipping the chair around during exams to a different position so that [my] weight can be shifted off my back and I can rest my chest against the back of the chair.”
B-5	“It is extremely important to mentally go through the musculoskeletal work list before beginning the scan. These few steps will ensure that you are not in an awkward position throughout the scan and should help prevent injury.”
B-6	“When somebody thinks of working out specifically to help prevent injury in this career, they may think that you only need to work out and build muscle in your arms and shoulders. I would have also thought this, except...First off, our core is most important when thinking of strengthening muscles....Good posture accompanied by strong core muscles result in less lower back injury.”
B-7	“Workloads within the ultrasound department should be varied because some exams take much longer than others. Doing the same exam [repeatedly] uses the same muscles and can...cause a much greater risk for stress and injury.”

RN = Researcher’s Note

Table M.23 Examples from Transformational Learners to Denote Corrective Action Statements

Individual Numerical Designation	Pertinent Comment Examples
C-1	<p>“Maintaining a diet full [of] the appropriate fruits, vegetables, grains, meat, dairy, and sugars is very important. I personally have changed my eating habits over the past 4 years. I have cut out a large amount of fats and sweets that I consumed daily.”</p>
C-2	<p>“I have a rule that I try to follow when I go to the grocery store: ...stick to the perimeter of the store. This is where all [the] healthier and more natural foods are, such as fruits, vegetables, proteins, and dairy.”</p> <p>“Exercising is like “meditation in motion”; it pumps up your endorphins, actually makes you forget about the irritations...and increases your self-confidence and lowers the symptoms associated with mild depression and anxiety.”</p> <p>“The workload should be divided up evenly amongst the sonographers to prevent any injury, argument between coworkers, and from becoming burnt out.”</p> <p>“One thing I have a big problem with is.... “Some things I do while scanning are adjusting my chair...”</p>
C-3	<p>“Foods that are high in antioxidants provide a natural way to combat inflammation.”</p> <p>“I believe if everyone in a department is educated in this matter, they could correct each other on a daily basis.”</p>
C-4	<p>“In order to help with ergonomics I designed a daily diary to help me keep track of my daily routine in order...to improve my ergonomics on a daily basis. I also did an Internet WebMD food & fitness planner in order to help me get on the right track.”</p> <p>“I find that I could use some help in this area. I know many days where I may not eat until supper due to just not wanting to take the time out of my day. I looked up on the WebMD some great ideas on snacks I can pack and eat on the run....”</p> <p>“I will also include a range of motion exercises for my neck, shoulders and wrists.”</p>

(Table continues)

Table M.23 Examples from Transformational Learners to Denote Corrective Action Statements (continued)

C-5	<p>“I also have been taking the time to prop my arm at the appropriate level to reduce strain to my shoulder area...”</p> <p>“I have noticed I hyperextend my neck often, so since it has been brought to my attention, I have been adjusting the monitor to the correct height...”</p>
C-6	<p>“I intend to keep my body in prime shape for decades to come. This will be accomplished by eating healthy, exercising, stretching, and recognizing the difference between a slight injury...versus a serious problem... The obvious advantage...”</p> <p>“I intend to keep my mind in its prime by recognizing the signs of stress, prioritizing goals and keeping them realistic. By applying simplistic measures to help alleviate stress...and by doing things like taking mini-breaks...”</p> <p>“I intend to keep my work environment ergonomic friendly. I will do this by keeping notice of unsafe equipment, and practices...”</p>
C-7	<p>“Something as simple as rotating studies in order to keep one sonographer from being overworked would greatly help.”</p> <p>“The back exercises will be used to work on correct posture and even weight distribution during the day....Shoulder exercises will be used to strengthen the muscles...to prevent rotator cuff injuries from stresses.”</p> <p>“Stretching will help keep muscles flexible and will also be used during the day to help relax as well as target muscles that are tightening or feeling stressed....”</p> <p>“Microbreaks during a study is something I have already implemented into my scanning techniques.”</p>
C-8	<p>“I have been practicing yoga for several years, and I confident that it will help me prevent musculoskeletal injuries, as long as the practice is regular.”</p> <p>“This will help also in order to perform a quality examination. If I don’t take breaks, I could end up with chronic pain, fatigue, and inflammation.”</p>
C-9	<p>“After viewing scan lab videos, I have pinpointed errors that need to be changed to prevent poor scanning habits from being established as a learned scan technique. I am now aware of...”</p>

PPP Theme 7 Findings

Appendices M.24 to M.26 contain subjects' specific statements denoting lack of synthesis, categorized by group classification, with the individual number designating nothing more than the order in which the assignment was recorded from any particular group (A, B, or C). Table M.24 provides pertinent examples for transmissional learners, while Table M.25 contains the examples of the transactional learners, and Table M.26 of the transformational learners.

Table M.24 Examples from Transmissional Learners to Denote Lack of Synthesis

Individual Numerical Designation	Pertinent Comment Examples
A-1	<p>“The equipment at my clinical site is very ergonomic.” <i>(RN: How?)</i></p> <p>“I will usually have water with my meals.” <i>(RN: no explanation of why.)</i></p>
A-2	<p>“If nothing is reported to administration, nothing is going to be done about the problem.” <i>(RN: no explanation of what to report or how to go about reporting the problem.)</i></p>
A-3	<p>“A personalized workout plan is very important for sonographers as they conduct their jobs day to day.”</p>
A-4	<p>“I feel that my clinical site is very ergonomically minded.” <i>(RN: no support to this argument included.)</i></p>
A-5	<p>“A good exercise program will benefit a [sonographer] like you wouldn't believe.”</p> <p>“You need to see what kind of day you are in for and you want to make sure that you are properly staffed.”</p> <p>“Talk to the head of your department about investing in a few high quality chairs.” <i>(RN: no specific type of chair is identified.)</i></p> <p>“When you are working and you notice anything that you feel you need to make your job easier for you and [your] fellow sonographers, tell your boss.”</p> <p>“Don't take your work home with you.”</p> <p>“Just do something that makes you happy.”</p>
A-6	<p>“Make sure that the workload for the day is spaced out adequately.”</p>
A-7	<p>“Since patients are scheduled in 30 minute intervals, we may have a chance to sit and rest for a few minutes and sometimes we don't.”</p> <p>“...I have to be careful at what I eat and how much I eat.”</p>

(Table continues)

Table M.24 Examples from Transmissional Learners to Denote Lack of Synthesis (continued)

A-8	“I’ll take a look at my surroundings and make sure everything is in a good position to keep me from over straining myself.” (RN: <i>no explanation of how this decision is made.</i>)
A-9	“Workload should be adequately balanced, giving the sonographer time to scan the patient and complete paperwork, as well as giving the sonographer time to use the restroom, stretch, and relax.” (RN: <i>no explanation of how to balance schedule.</i>) “If the prevention plan is not followed, then one of several work related injuries can occur.”
A-10	“There are many ways to improve scanning techniques.” “There are many ways to help with scanning ergonomics, [whether] it be something you or the employer or the [manufacturers] can do to help improve the ergonomics of the sonographer.”
A-11	“Being injured could really affect your work.”
A-12	“...it is best to warm up the muscles.” (RN: <i>no indication whether this is actually done.</i>)
A-13	“If I scan too much, it could cause injuries, which could eventually be irreversible.” “It is important to have good scanning habits, so I do not get any unnecessary scanning injuries.”

RN = Researcher’s Note

Table M.25 Examples from Transactional Learners to Denote Lack of Synthesis

Individual Numerical Designation	Pertinent Comment Examples
B-1	“Hopefully every sonographer will take into consideration other techniques to help them at work while scanning.”
B-2	“Exercise and a personalized workout plan are important for anyone.” “Departments need to have flowing workloads and scheduling policies. Encouraging rotation in the workplace as much as possible is important.”
B-3	“Sonographers are extremely vulnerable to injury if certain precautions are not taken.” “Rest breaks mean recovery for the body.”
B-4	“There are plenty of relaxation techniques that can be practiced all throughout the day and are very important to a work day.”
B-5	“Workload should be considered and distributed evenly among the techs in the department.” “Finally, my prevention plan consists of several different factors which all work together to benefit me many years from now.”
B-6	“To better accommodate every sonographer in the ultrasound department, I believe that the patients should be evenly dispersed.” “The sonographer may want to ask their employer if they can rearrange the ultrasound rooms if they are creating problems while scanning.”
B-7	“Sonography is a very physical profession, so all sonographers should come up with a prevention plan to prevent injuries.” “Breaks can either help the sonographer or not if they are not taken.”

Table M.26 Examples from Transformational Learners to Denote Lack of Synthesis

Individual Numerical Designation	Pertinent Comment Examples
C-1	“Diet and nutrition are some of the most important things a person could do to stay healthy.” “Staying physically fit and active is very important to your health.” “Stretching is something that everyone should do daily many times.” “Relaxing is something everyone does differently, but it has very positive effects.” “If they think there is a way to prevent future MSI in the workplace, then they should carry it out.”
C-2	“Ergonomics is the most important thing to understand as a sonographer.” “I know all the technologists appreciate and respect their equipment. They definitely use it to their advantage as they should.”
C-3	“When dealing with ergonomics, it is important to be educated on prevention of injuries related to certain working conditions.”
C-4	“Breaks are very important, due to the time it takes to complete exams.”
C-5	“I think it is important to work with coworkers on an interdepartmental prevention plan.”
C-6	“Gaining information and doing training in prevention can change the future conditions of many sonographers.”
C-7	“Diet and nutrition play an important role in maintaining a healthy lifestyle.” “With the risk of musculoskeletal injuries at such a high percentage, personal fitness is extremely important.” “A sonographer’s workload should vary throughout the day.”
C-8	“It is very important to have breaks while on the job to assure you have concentration to perform properly.” “A sonographer should pay close attention to their body and know how to use it properly.”

PPP Theme 8 Findings

Appendices M.27 to M.29 contain subjects’ specific statements that were alarming in regards to ergonomic practices, categorized by group classification, with the individual number designating nothing more than the order in which the assignment was recorded from any particular group (A, B, or C). Table M.27 provides pertinent examples for transmissional

learners, while Table M.28 contains the examples of the transactional learners, and Table M.29 of the transformational learners.

Table M.27 Examples from Transmissional Learners to Denote Alarming Statements

Individual Numerical Designation	Pertinent Comment Examples
A-1	“Throughout the day, if anyone experiences any pain or problems from scanning, we know we can go to Employee Health and have a physician take a look at our problem.” <i>(RN: How often does this occur? Are any prevention measures being taken, or are recurrent pain and treatment standard expectations at this work environment?)</i>
A-2	“Having the appropriate workload will ensure not burning out the muscles in the arms. However this will depend on departmental demands.”
A-3	“Some sonographers are beginning diets due to being borderline diabetic and high blood pressure.” <i>(RN: Is this a department-wide problem?)</i>
A-4	“The sonographers I work with are always telling me to raise the patient’s bed up to a good level for my arm.” <i>(RN: Is the learner not following this suggestion, if it continues to be repeated?)</i> “If I have to get into an awkward position...that’s what I’ll do.”
A-5	“Musculoskeletal injuries are the most common injury affecting 80% of sonographers. I am sure that most of these have not been reported to the administration.” “I heard a conversation last week at my clinical site about getting a new machine, but the ones that are ordering the machine aren’t the sonographers. If you don’t report the incidence of injury, then the higher-ups won’t realize anything is wrong, so they won’t look for is machine that is more ergonomic friendly.” <i>(RN: Sonographers seem to be accepting the lack of input into equipment that directly affects personal performances and health considerations.)</i>
A-6	“For example, if the department doesn’t have ergonomic friendly machines, then you might want to suggest getting a better machine. Likely that is not possible due to [the] budget.”

RN = Researcher’s Note

Table M.28 Examples from Transactional Learners to Denote Alarming Statements

Individual Numerical Designation	Pertinent Comment Examples
B-1	<p>“I often scan unconsciously in awkward positions more worried about my images than my comfort. But after prolonged pain in my scanning wrist or back, I remember why it is important to use good body mechanics.” <i>(TN: It may be too late by then.)</i></p>
B-2	<p>“...[I] feel that I have a very good understanding of the [ergonomics] concept. I continue to shift all my weight onto my right side when scanning the patient’s left side and to not fully adjust the patient correctly until I feel myself in a strained position.” <i>(RN: The researcher is not convinced, then, that the learner has a firm grasp of ergonomics concepts, based upon this description.)</i></p>
B-3	<p>“If my arm begins to get sore while scanning, I think about the way I am scanning and try to correct my positioning.” <i>(RN: It may be too late by then.)</i></p>
B-4	<p>“I am very guilty of positioning myself in unusual positions when I have a difficult patient.” <i>(RN: no resolution explained.)</i></p> <p>“This requires the sonographer to awkwardly reach across the patient and scan through his or her side and at times through the back. When doing this, I experience pain in my wrist and shoulder. The best possible solution would be to take regular mini-breaks.” <i>(RN: The best possible solution would be for the sonographer to reposition oneself and the patient to prevent this reaching and pain.)</i></p> <p>“As a student, I break this rule.”</p> <p>“By being aware of myself and my surroundings, I have a better chance of preventing work related injuries....If that means I have to stand, bend, and twist my back, I’m probably going to do it and not even be aware of the dangers I’m putting my joints/body in for the future.” <i>(RN: Self-professed evidence that awareness, alone, is not sufficient.)</i></p>
B-5	<p>“...because I see what stress it is when someone is picking up the slack of 3 other people and it does not make for a pleasant working environment.”</p>

RN = Researcher’s Note

Table M.29 Example from One Transformational Learner to Denote Alarming Statement

Individual Numerical Designation	Pertinent Comment Examples
C-1	“I even had some tell me of their aches and pains and then told me how to get them fixed with chiropractors and massages. I did find this amusing.”

PPP Theme 9 Findings

Appendices M.30 to M.32 contain subjects’ specific statements denoting strong clinical transactions, categorized by group classification, with the individual number designating nothing more than the order in which the assignment was recorded from any particular group (A, B, or C). Table M.30 provides pertinent examples for transmissional learners, while Table M.31 contains the examples of the transactional learners, and Table M.32 of the transformational learners.

Table M.30 Examples from Transmissional Learners to Denote Strong Clinical Transactions

Individual Numerical Designation	Pertinent Comment Examples
A-1	“When I evaluated one of my peers, I was actually impressed at how much she focused on good ergonomics. She never pulls on patients; she turns her body into the patient to eliminate strain on her scanning arm; and she always makes sure her chair is at the proper height for the exam.”
A-2	“The checklist used was very beneficial for the sonographers at my facility because...”
A-3	<p>“As a student, getting the right imaging on the screen has been the most important item, but going over this lesson on ergonomics has helped me in understanding how imperative proper positioning of me and the patient is. My clinical instructor has done a good job reminding me how to position, moving the bed, and showing me how to properly hold a transducer.”</p> <p>“I have talked to sonographers from both of my clinical sites and most of them have some kind of soreness or pain from scanning. When starting this program, I didn’t realize how important ergonomics were going to be. After scanning for a couple of months, I understand how diet, relaxing in between [patients], positioning, and exercises will definitely help.”</p>
A-4	“I am very lucky to learn from and work with the [sonographers] I do. They are very conscious of ergonomics and therefore make it easy for me to not only establish good ergonomic skills, but also to help discover better ways to scan.”

Table M.31 Examples from Transactional Learners to Denote Strong Clinical Transactions

Individual Numerical Designation	Pertinent Comment Examples
B-1	“I was able to talk to 3 sonographers about the importance of ergonomics. The first sonographer...”
B-2	“I observed 3 sonographers’ ergonomic workings. The 1 st sonographer...”
B-3	<p>“I see some of the other [sonographers] doing some of these same things and now that I am aware of them, I have been pointing it out to others. They are surprised by some of the things I have noticed, and are practicing to change their habits as well.”</p> <p>“The group of [sonographers] that I work with do a very good job of being conscientious about what they eat. They try to be healthy and give each other ideas about how to do better and encourage each other.”</p>
B-4	“Instead of standing equally on both feet while scanning, she tends to put more weight on one foot than the other foot. She will also lean up against the stretcher on her right side. If this is done repetitively for many years, it could easily result in hip and sacroiliac problems.”
B-5	<p>“After observing and speaking with other sonographers about this, I have found that adjusting my chair and the patient so that my scanning arm and they are all in the same scan plane often helps.”</p> <p>“I have observed each of the sonographers at my clinical site for ergonomic workstation findings while they were scanning. Each sonographer...”</p>
B-6	<p>“I will also continue to take advice from other sonographers on tips they have learned or found out by their own mistakes. It has been so very helpful to ask them questions on why they perform the way they do...”</p> <p>“When asking different sonographers about what WRMSD they have experienced, only a few have had any serious problems – the most serious being a torn rotator cuff for a sonographer that has been in the field for close to thirty years now.”</p>
B-7	“I discussed this issue with our department manager and explained the benefits a scanning table with arm rests and head extensions could provide us.”
B-8	<p>“I observed two sonographers while they were scanning different patients. The first sonographer....The second sonographer....These two sonographers were more aware about their ergonomics when I was observing them and weren’t too surprised by the results.”</p> <p>“When these sonographers watched me scan, they noticed...”</p>

(Table continues)

Table M.31 Examples from Transactional Learners to Denote Strong Clinical Transactions
(continued)

<p>B-9</p>	<p>“The work station at my clinical site is well equipped with ergonomically-correct equipment. The chairs used to scan....The table....The ultrasound units....”</p> <p>“One of the sonographers had issues with plantar fasciitis. The foot rest area...”</p> <p>“My personal evaluation showed often times I tend to over-extend my shoulder in abduction....”</p>
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Table M.32 Examples from Transformational Learners to Denote Strong Clinical Transactions

Individual Numerical Designation	Pertinent Comment Examples
C-1	<p>“In echo there are usually 4 technologists for the day. In a 10 hour day, they are supposed to accomplish 8 patients/studies. This is enough time to do their part of the work load without anyone becoming stressed.”</p> <p>“At my hospital we have ergonomic chairs that are easily adjustable....The ultrasound unit...the transducer cords....Many technologists I have observed have a problem....”</p>
C-2	<p>“The department I’m in at clinic is in the process of planning a big move and the administration is doing a great job with asking the technologists their input and if there is anything they would like to change...”</p>
C-3	<p>“I did see personnel having the patients roll...or move themselves if possible....I observed sonographers leaning, twisting, stretching, bending, and every other ergonomic disaster available to them. Some sonographers realize their shortcomings and don’t care to fix them....I notice I am doing the same thing.”</p>
C-4	<p>“In evaluating the work environment at the hospital, I have found that the facility is ergonomic friendly....My echo site, however, is not ergonomic friendly in many ways....The [sonographers] at the hospital that I have evaluated...don’t think they always have their backs against the seat....The [sonographer] at the echo clinic...has to lean over and reach in order [to help] me adjust the transducer.” <i>(RN: This student has even considered the additional injury risk facing clinical instructors attempting to work around learners’ bodies.)</i></p>
C-5	<p>“An example would be the echocardiographers informing me that hospital policy is that they are to do no more than ten examinations per day, and they try not to do more than eight. This is due to my work environment recognizing and responding to the possibility of musculoskeletal injuries.”</p>
C-6	<p>“One coworker is adamant about wearing compression stockings to help circulation in her legs throughout the day.”</p> <p>“...to the point where a coworker took over scanning and she asked me to annotate for her since her back hurt as well.”</p>
C-7	<p>“The [sonographer] I chose to evaluate had similar opinions to mine. We agreed that...most of the ultrasound equipment is user friendly, such as...”</p> <p>“The sonographer I evaluated had very good ergonomics. She had good posture...kept her upper arm and elbow close to her body...kept her wrist relaxed and not in awkward angles....”</p>
C-8	<p>“Actually viewing myself and another peer allowed me to realize the mistakes that we both make as beginners and the corrections that we need to make. As I have made those changes, I have noticed...”</p>

RN = Researcher's Note

Table M.33 VMA Corrective Action Plan Reflections

Participant and Peer Reviews	Lab 1	Lab 2	Lab 3
SR1	Take more time to make adjustments	“It’s helpful to watch other students scan and critique, so I can be aware of poor ergonomics. I have lots of things to work on!”	Bending and twisting ⁺
PR	Use chair back Do not lean	Don’t twist body Keep wrist straight Keep both feet evenly on the ground Keep scan table at comfortable height	Distribute weight evenly on both feet (when standing to scan) ⁺ Use chair back (when sitting to scan) ⁺
SR2	Stay close to equipment /reaching with non-scanning arm* Make checks on position for comfort (esp. arms and scan hand)*	Rest elbow during apical views Adjust table to better my position	Had good posture and used chair back* (positive behavior) Rested forearm for support (positive behavior)
PR	Stay close to equipment /reaching with non-scanning arm* Need to better position fingers around transducer*	Relax scan arm and wrist ⁺	Technique looked good (and comfortable)* (positive behaviors)

SR = Self Review

PR = Partner’s (Peer’s) Review

* = behavior both self- and partner-identified

⁺ = repeated risk behaviors identified in the individual

(Table Continues)

Table M.33 VMA Corrective Action Plan Reflections (continued)

Participant and Peer Reviews	Lab 1	Lab 2	Lab 3
SR3	Use chair back Keep monitor at eye level	Use chair back ⁺ Take mini-breaks “I am more aware of my scanning behavior. I am more conscious about my positioning when I am scanning. Also, by observing somebody, I am more aware of my own scanning habits. The pictures are useful.”	Use chair back ⁺ Straighten wrist
PR	No suggestions provided	No suggestions provided	[Partner did not complete VMA survey]
SR4	Good scan behaviors – keep them up* (positive behavior)	No errors logged “I am conscious of what mistakes I have made early on and have made an effort to make adjustments to improve on my scanning habits. There were no errors found in this scan lab, but I made an effort not to make mistakes. I’m sure when I have difficult patients I’m not as conscious, but I am trying to pay more attention.”	[Did not complete VMA survey]
PR	Great example of good ergonomic technique*(positive behavior)	No suggestions provided	Keep wrist straight

SR = Self Review

PR = Partner’s (Peer’s) Review

* = behavior both self- and partner-identified

⁺ = repeated risk behaviors identified in the individual

(Table Continues)

Table M.33 VMA Corrective Action Plan Reflections (continued)

Participant and Peer Reviews	Lab 1	Lab 2	Lab 3
SR5	Don't tilt head * Keep body straight*	Adjust scan table height* Take more microbreaks for arm	Need to rest forearm on support* ⁺ Reaching across patient to scan*
PR	Twisting body and leaning toward patient* Tilting head*	Adjust scan table between views* Use support for forearm Shoulders and back are misaligned due to leaning (toward the patient)	Move patient closer to avoid reaching* Rest forearm on support* ⁺
SR6	Stay against chair back*	Adjust scan table height* Don't over-abduct arm (reaching across patient)	External flexion of wrist Tilting neck*
PR	Stay against chair back*	Adjust scan table height*	Head tilt* Shoulder over-abduction ⁺
SR7	Keep hips straight when standing*	[Did not participate in this group lab]	Keep wrist straight
PR	Keep stance squared when scanning*		Great posture and technique (positive behavior)

SR = Self Review

PR = Partner's (Peer's) Review

* = behavior both self- and partner-identified

⁺ = repeated risk behaviors identified in the individual

(Table Continues)

Table M.33 VMA Corrective Action Plan Reflections (continued)

Participant and Peer Reviews	Lab 1	Lab 2	Lab 3
SR8 PR	Keep straight posture Take microbreaks Rest scan forearm on support* Raise the bed to rest forearm*	[Did not participate in this group lab]	[Did not complete VMA survey] Good stance (positive behavior) Rested scan arm (positive behavior) Kept equipment and patient close to avoid reaching (positive behavior)
SR9 PR	Rest forearm for support* Be aware of strange elbow angle Uncross legs (while standing to scan) Rest forearm on support* Straighten wrist	Use back rest of chair* Use back rest of chair* Reaching across patient ⁺ Need to support and rest forearm ⁺ Uncross feet when standing to scan ⁺	Adjust scan table height Use chair back rest ⁺ [Partner did not complete VMA survey]

SR = Self Review

PR = Partner's (Peer's) Review

* = behavior both self- and partner-identified

⁺ = repeated risk behaviors identified in the individual

(Table Continues)

Table M.33 VMA Corrective Action Plan Reflections (continued)

Participant and Peer Reviews	Lab 1	Lab 2	Lab 3
SR10	Nothing specific “Seeing myself helped me realize what I was doing wrong.”	“Depending on the scan, I make different errors, so I need to be aware of the mistakes I make depending on the exam.”	Straight posture (positive behavior) Need to support forearm*
PR	Twisting back Keep equipment close/avoid reaching	No suggestions provided	Keep scan arm supported to rest* Keep arm close to body (reaching) ⁺
SR11	Reaching across patient	Adjust table height	Rest forearm on support
PR	[Partner did not complete VMA survey]	Keep shoulder close to body (reaching over patient) ⁺	Overall, did a good job (positive behaviors)
SR12	[Did not complete VMA survey]	Maintain equal distribution of weight on feet ⁺ Keep shoulder close to body (instead of reaching across the patient)*	Keep arm close to body (stop over-abducting shoulder)* ⁺
PR	Keep feet planted and weight evenly distributed (while standing to scan)	Adjust scan table height Reposition self closer to patient (to avoid reaching and leaning)*	Shoulder/arm is over-abducted (reaching across patient)*

SR = Self Review

PR = Partner’s (Peer’s) Review

* = behavior both self- and partner-identified

⁺ = repeated risk behaviors identified in the individual

APPENDIX N
SCAN BEHAVIOR DEPICTIONS

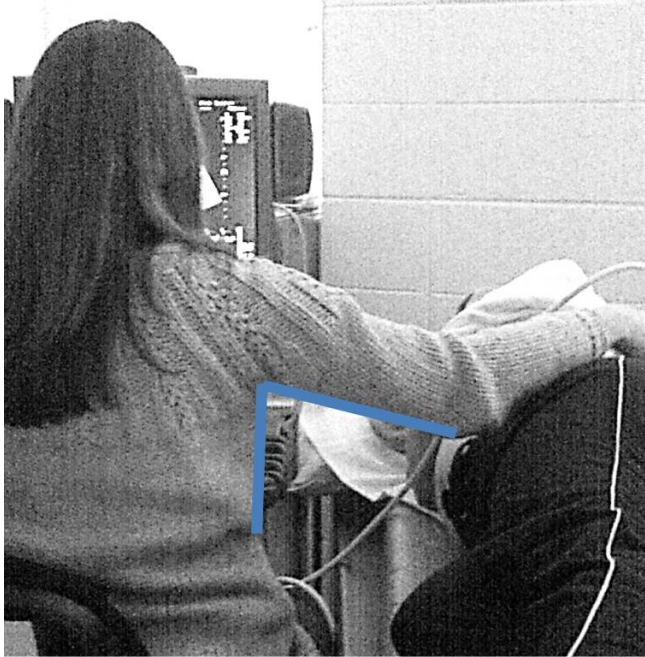


Figure N.1 Hyperabduction of the Scan Shoulder

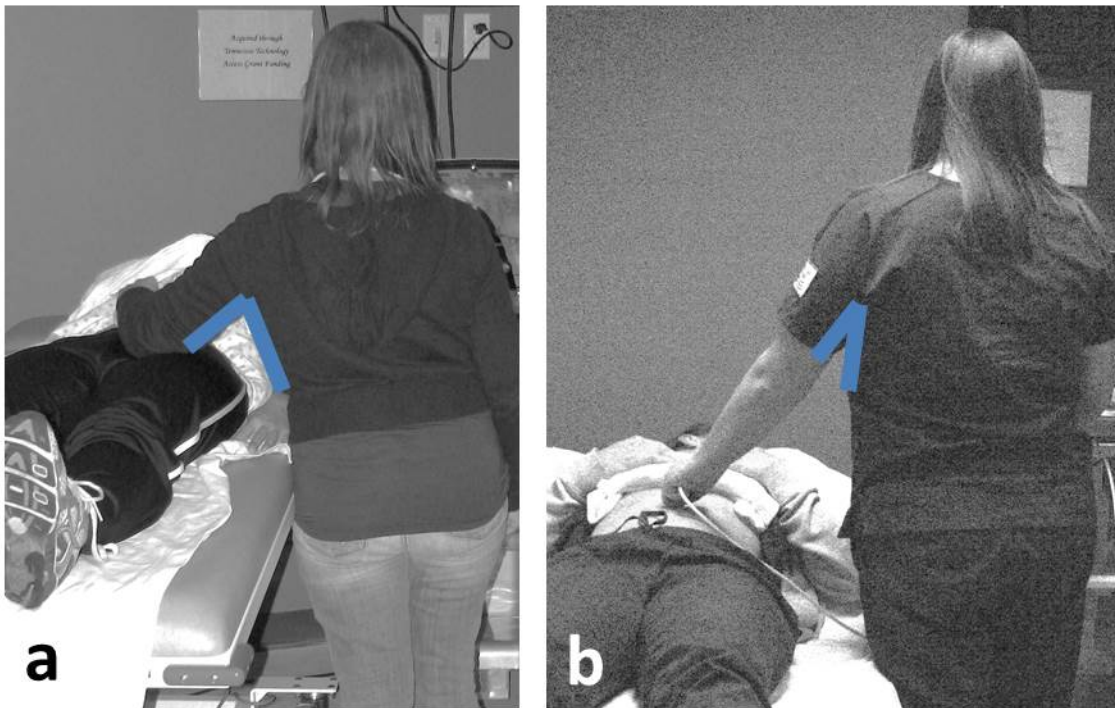


Figure N.2 (a) Hyperabducted Shoulder when scan table is raised, compared to (b) Proper Shoulder Angle Alignment when scan table is lowered in Cardiac Subcostal View



Figure N.3 Sonography Faculty Member who is being Ergonomically Challenged during Practical Scan Instruction

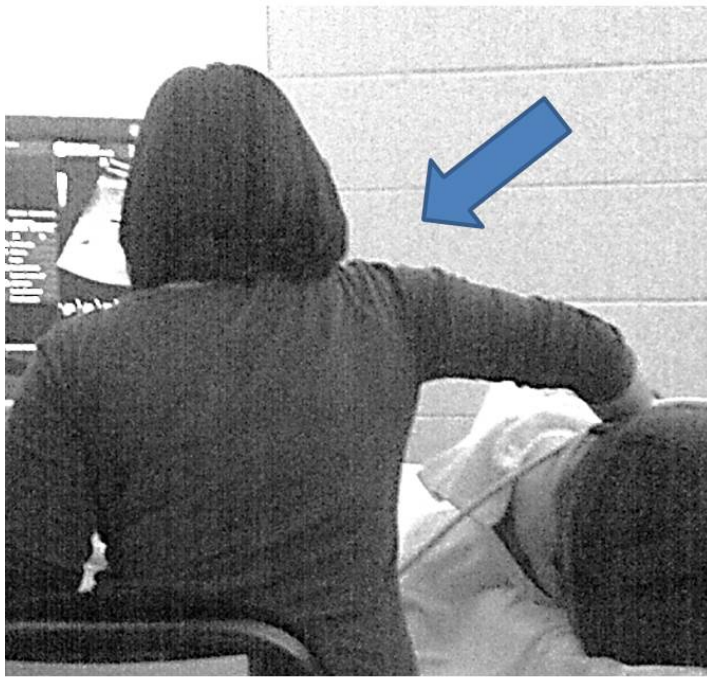


Figure N.4 Two Examples of Anterior Roll of the Scan Shoulder with Hyperabduction, creating cervical spine, shoulder, and scapular strain



Figure N.5 Posterior Shoulder Displacement Creating Joint Strain

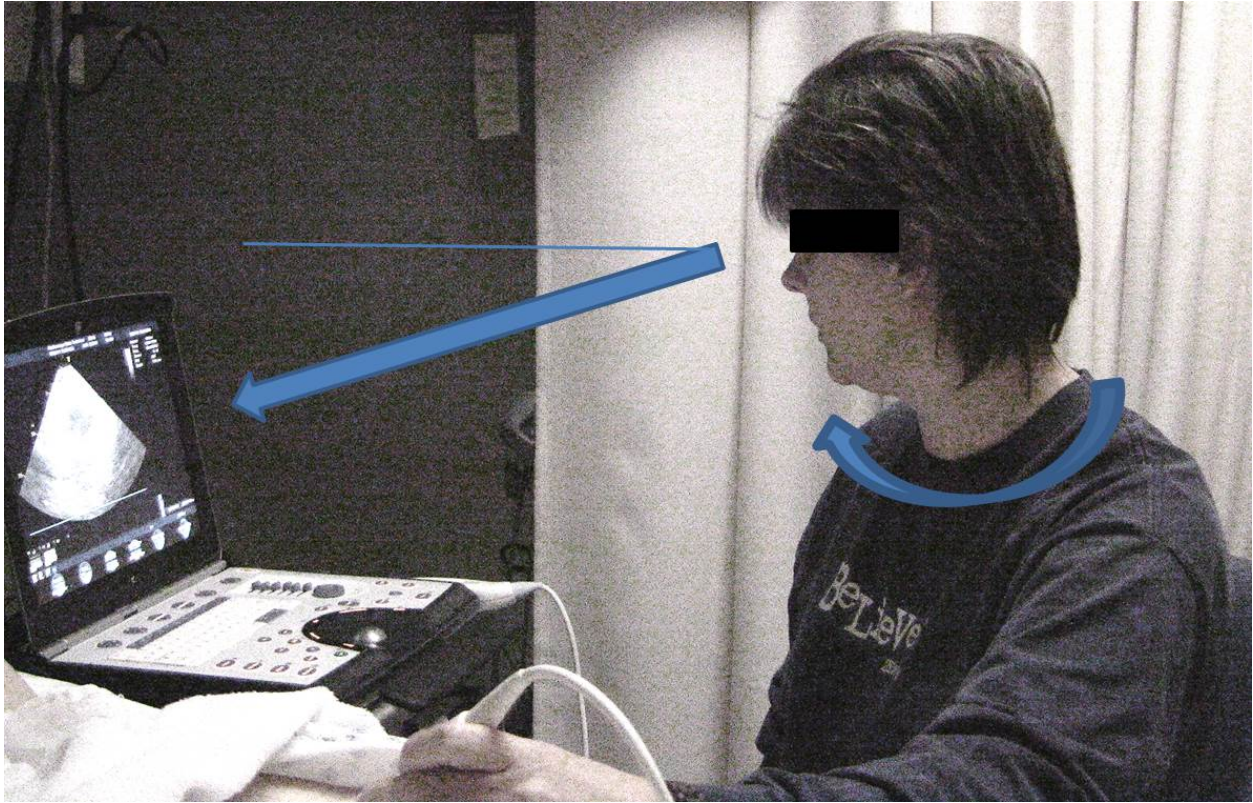


Figure N.6 Slight Cervical Hyperflexion and Lateral Neck Rotation due to Misalignment of the Display Monitor to the Sonographer's Neutral Line of Sight (horizontal line)



Figure N.7 Appropriate Cervical Alignment to Display Monitor due to use of Vertical Tilt and Swing Arm (circled)



Figure N.8 Monitor in (a) Neutral Arm Position and (b) Extended on the Swing Arm of the Ultrasound System for Alignment with Sonographer's Neutral Line of Sight



Figure N.9 Lateral Cervical Extension (Neck Tilt) Risk Behavior



Figure N.10 Slumping of the Shoulders with Jutting of the Chin toward the Display Monitor during Active Laboratory Instruction

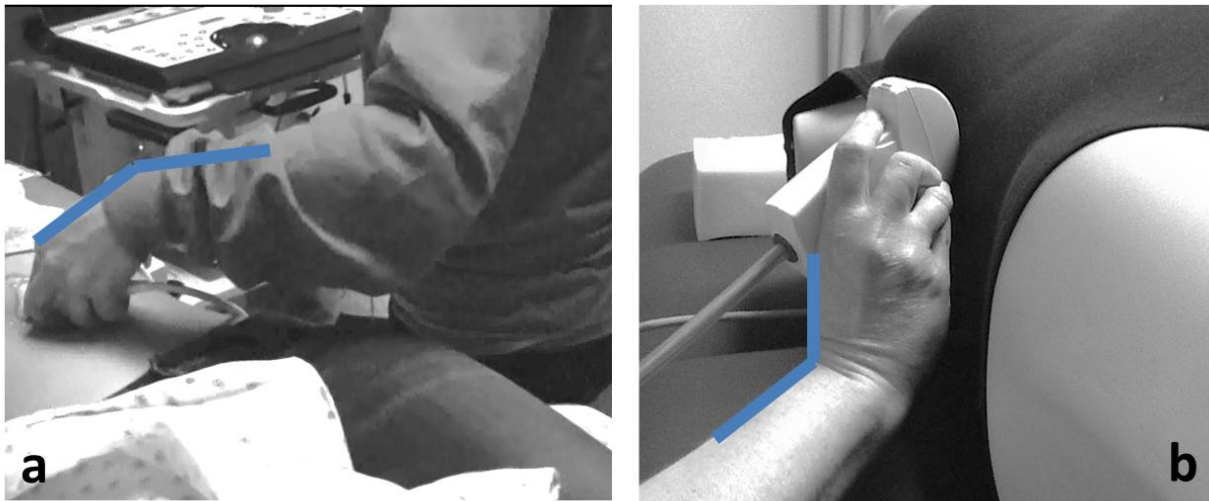


Figure N.11 Negative Scan Risk Behaviors of (a) Wrist Hyperflexion and (b) Dorsiflexion

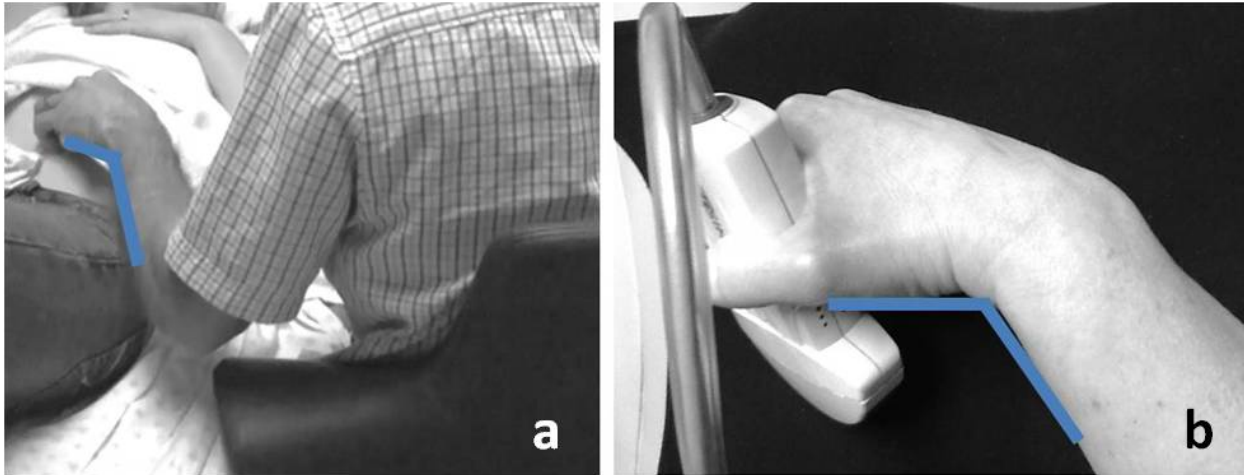


Figure N.12 Negative Scan Risk Behaviors of (a) Outward and (b) Inward Wrist Flexions

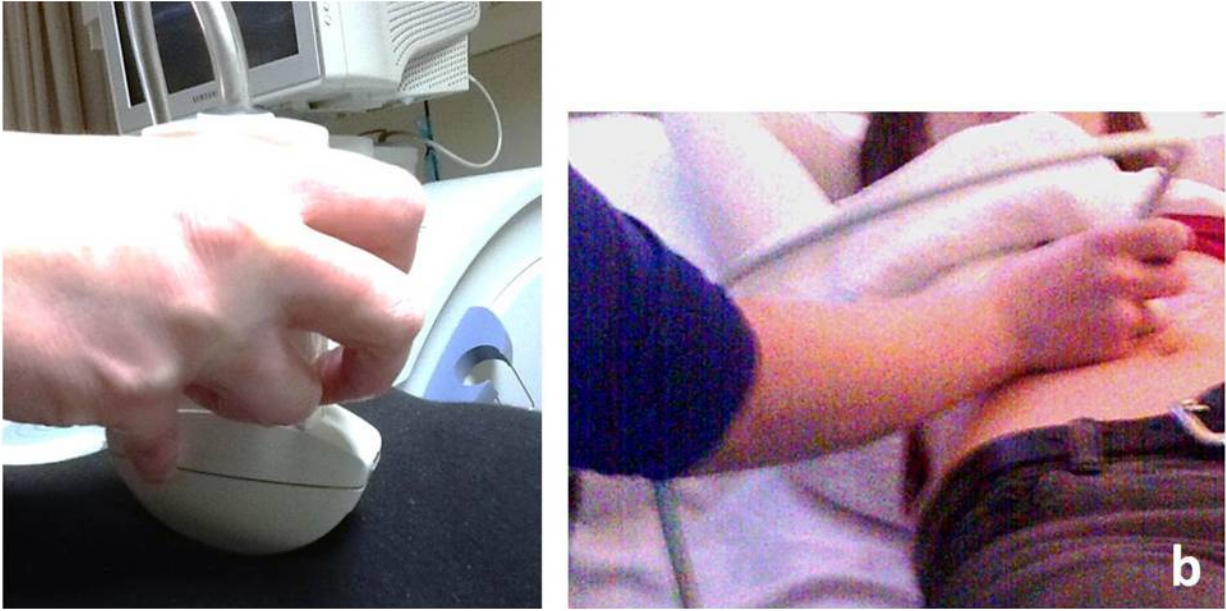


Figure N.13 Negative Transducer Grip Behaviors: (a) Talon Grip and (b) Knuckle Ball Grip

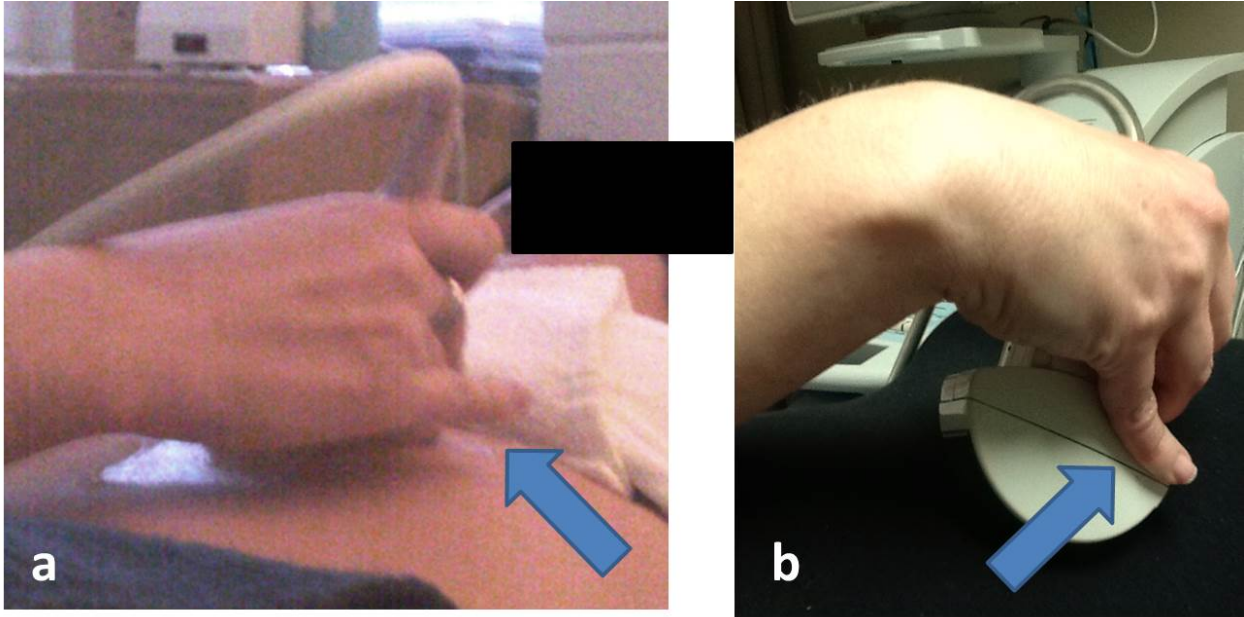


Figure N.14 Negative Fifth Digit Grip Behaviors: (a) Tea Cup Grip and (b) Pinky Press Grip

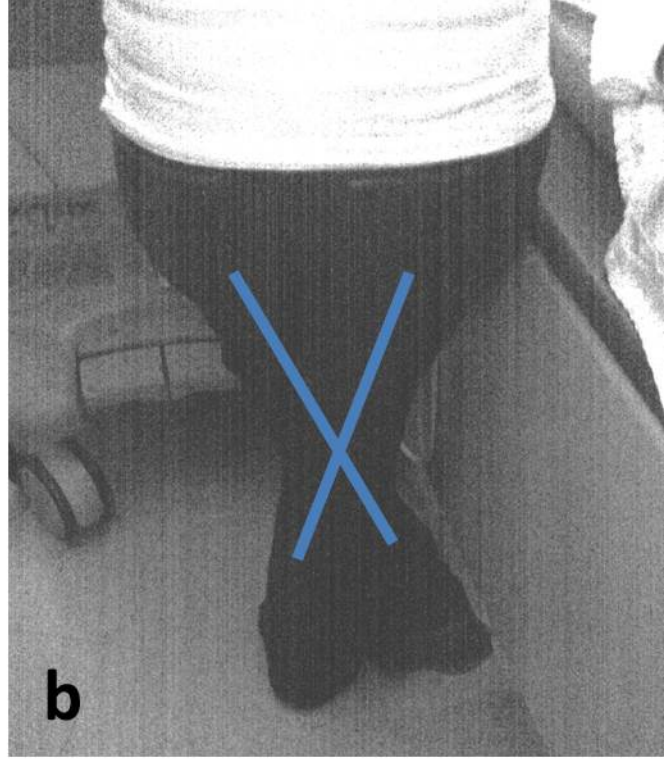


Figure N.15 OBP Misalignment Maneuvers during Standing: (a) Jutting of the Hip, creating hazardous angles of the spine and pressure to hip and knee joints, and (b) Crossing the Legs, removing core balance



Figure N.16 Typical Sonographer Workstation Configuration, with Office (Faux) Ergonomic Chair



Figure N.17 OBP Misalignment Maneuvers during Sitting: (a) Sliding off the Side of a Wide Office Chair, and (b) Sliding off the Side of a Rounded Stool

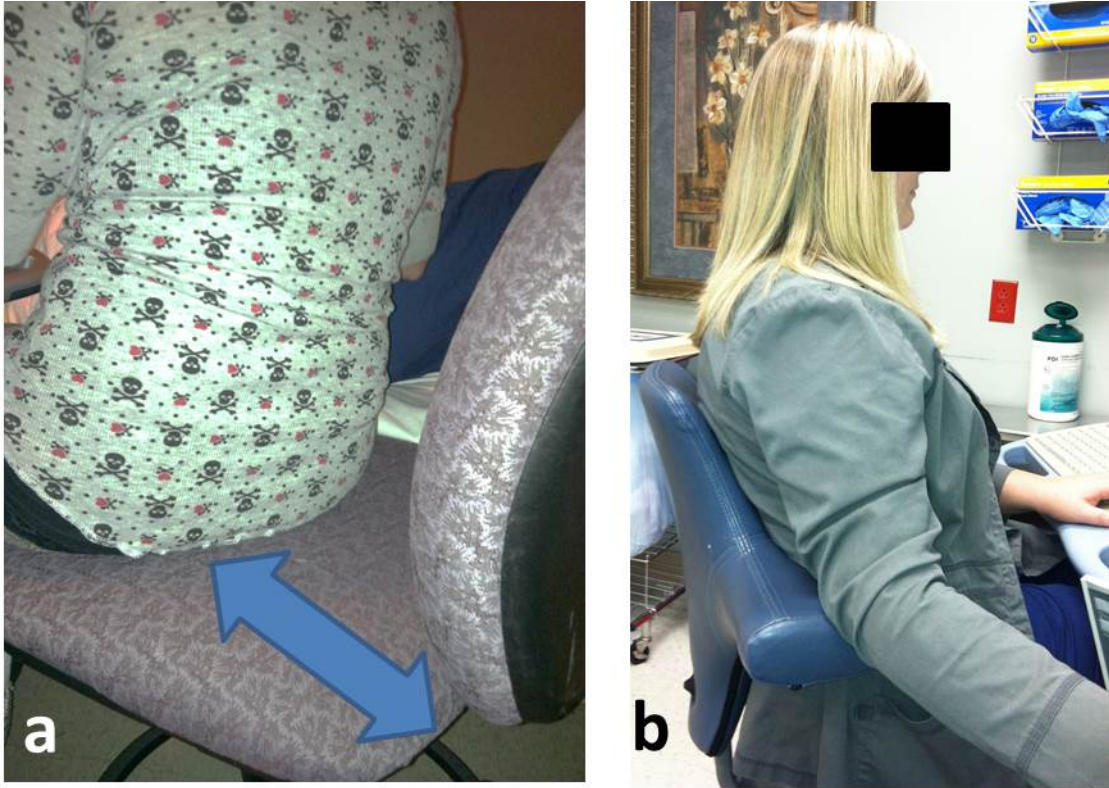


Figure N.18 (a) Faux Ergonomic Chair with excessive seat depth, versus (b) Saddle-seat Ergonomic Chair with shorter seat depth



Figure N.19 Modification of Footrest from Ergonomic Chair to Ergonomic Design of the Ultrasound System



Figure N.20 Sonography Student Failing to Use Back Rest, Leaning Forward, and Hyperabducting Shoulder while Sitting in a Properly Designed Ergonomic Chair

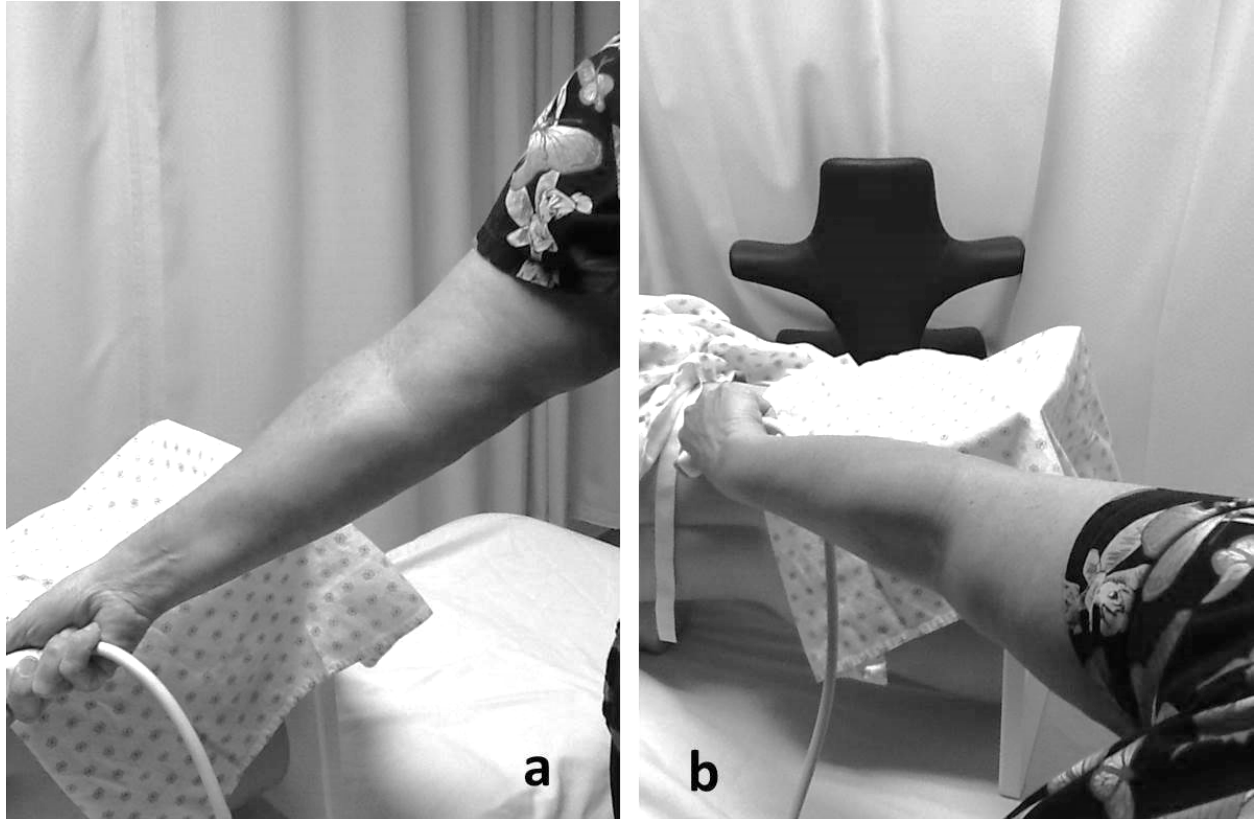


Figure N.21 (a) Extended Supination and (b) Extended Pronation of the Elbow/Forearm



Figure N.22 Makeshift Forearm Rest using Stacked Linen

VITA

Jody Love Hancock was born in Chattanooga, Tennessee, fourth daughter to Joseph and Virginia Love, and has remained a native Tennessean her entire life. She graduated from Hixson High School, thereafter receiving her associate degree in radiography from Chattanooga State Community College; her bachelor's degree in business management from Tennessee Wesleyan College in Athens, Tennessee; and her master's degree in adult education, with a focus in distance learning, from the University of Phoenix in Arizona.

Jody is a certified radiographer, a diagnostic medical sonographer, and a vascular technologist. She has served as the director of the Diagnostic Medical Sonography Program at Chattanooga State for the past 20 years, where she is currently conducting ergonomics research toward her EdD in Leadership and Learning through the University of Tennessee at Chattanooga. Jody is active in her profession, being the recipient of the 2007 Society of Diagnostic Medical Sonography (SDMS) Distinguished Educator Award and recipient of First Place Awards in both the 2011 and 2012 SDMS Scientific Presentation Competitions, in association with pilot studies toward her dissertation, as well as student partnered research that focused on a new sonography scan protocol. Jody has conducted seminars, has been interviewed and consulted upon professional issues, and has been published on ergonomic concerns and other topics in the field of sonography. Jody views the education of her students and colleagues toward reduction of scan risk behaviors as an important professional contribution (maybe even a calling).

Jody is married to the Reverend Thomas Hancock, who is currently working on his doctoral dissertation in the application of Family Systems Theory within the church community. Jody and Tom have three sons, Brian, David and Hunter; and three grandchildren. Jody is active in her church as a certified lay servant, has completed the writing of her first novel, is looking forward to finishing her second, and is a published poet. But on her favorite days, you'll find her outside with those closest to her heart - hiking a mountain with camera in hand, sliding into bases on a softball diamond, peddling like crazy to keep up with the more proficient cyclists in her family, or digging her paddle deeply down a whitewater river.