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RELIABILITY OF SHOULDER GONIOMETRIC MEASUREMENTS IN PERSONS WHO ARE ELDERLY

by

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This Scholarly Project, submitted by Karina Koch, Lauri Paulsen, Heather White and Richard Williamson in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

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Signature(s) Karina Koch
[illegible]
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I wish to dedicate this monograph to my mother who always believed, even before the dream was a reality. – Karina Koch

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ABSTRACT

The population of the United States is rapidly aging; this is exemplified by the cohort of "Baby-Boomers" who make up a large part of the population. This becomes relevant to physical therapists, as our clients will reflect this "graying" of America. There is a lack of research regarding normative values for shoulder range of motion (ROM) in the elderly population. Due to many different factors in the aging process, there may be a decline in ROM in elderly persons. Current normative values may not be applicable to this population.

Two pilot studies were conducted measuring active and passive shoulder ROM in persons 60 years of age and older. Shoulder measurements included the following: flexion, extension, abduction, and internal and external rotation. Fifteen individuals participated in the first pilot study, twelve in the second, with a subset of nine individuals who participated in both studies.

Upon completion of both pilot studies, the researchers were unable to establish intrarater reliability. The researchers then focused their attention to the factors that may affect reliability of goniometric measurements.

There are many factors that can play a part in the reliability of the motion available at a particular joint and the subsequent measurement of that joint. Some of those factors include physiological effects of aging, participant effort, cognitive effects of

aging, the use of substitution patterns of movement, and inconsistent and inaccurate measurements taken by physical therapy students.

CHAPTER 1

INTRODUCTION

According to the United States census report for the year 2000, there were nearly 35 million people aged 65 years and older living in the United States.[1] This part of the U.S. population accounts for more than 12 percent of the total population. In the state of North Dakota, the elderly accounted for 14.7 percent or 94,478 people out of a total of 642,200 residents.

The U.S. census bureau describes the "Baby Boomers" as the cohort of people born in the United States between the years of 1946 through 1964. In the U.S. Census for the year 2000, the baby boomers constituted 28 percent of the total United States population and were between 36 to 54 years old.[2] Over the last decade, the two fastest growing age groups as reported by the census were the 50-54 year-olds at a 55 percent increase and the 45-49 year-olds at 45 percent. The third fastest growing age group in the past decade was the 90-94 year-olds, with a 45 percent increase. This increase in longevity is believed to be due to the better quality of life and the great medical gains that have allowed people to continue to live longer and healthier lives.

As one may readily observe, the population of the United States is becoming progressively older. This becomes important to physical therapists because patients will reflect this change in demographics. Physical therapists will be treating more elderly individuals and must be prepared to meet their needs.

Problem statement

Goniometric measurements are used by physical therapists everyday, often without consideration of the reliability or validity of the goniometer or of the person taking the measurement. There are several reasons that can cause decreased reliability and validity; those factors will be discussed in detail in later chapters.

Most of the literature that reports normal values for joint range of motion (ROM) either does not describe the age range of the population sampled or the research was based on a sample of younger healthy adults.[3-9] There have been several research studies that did examine the average ROM for the elderly; however, the results of those studies are not widely known or used in clinical settings.[10-14] Physical therapists often use the normal values of joint motion as a guideline in establishing goals for patient treatment. The normal values established for younger healthy individuals may or may not be an achievable goal for a patient who is seventy or eighty years old.[4,5,10-13]

Purpose of study

The purpose of this research study originally was to establish normative values for shoulder range of motion in an elderly population. The researchers were not able to establish intrarater reliability after pilot studies were completed; therefore, the focus of the research turned to an examination of the factors involved in the reliability of goniometric measurements of the shoulder in elderly individuals.

Significance of study

This study is significant because there is a lack of research with normal values of shoulder range of motion in elderly individuals. This research also illustrates the factors contributing to changes in the anatomy and physiology that may lead to decreased range of motion and possible decreased reliability of movements in elderly individuals. These factors will further delineate whether or not there is a difference between the norms for elderly individuals as compared to younger healthy people.

This research also sheds light on the problems with goniometric measurements and problems with reliability of measurements taken by physical therapy students or novice physical therapists.

Research questions:

1. Is there a difference in normal range of motion of the shoulder in younger and older individuals?
2. Do other factors associated with aging contribute to the reliability of measurements (such as cognitive status, compensatory movements, etc.)?
3. Are novice / student physical therapists able to establish intrarater reliability with goniometric measurements?
4. Do the physiological effects of aging contribute to the reliability of goniometric measurements?

Hypotheses

Null: There is no difference between range of motion (ROM) of the elderly and the current normative data on shoulder ROM.

Alternate: There is a significant difference between the ROM of the elderly and the current normative data for shoulder ROM.

Null: Elderly individuals give consistent effort during measurements of active ROM.

Alternate: Elderly individuals give inconsistent effort during measurements of active ROM.

Null: Elderly individuals do consistently comprehend directions for various movements given to them by the testers.

Alternate: Elderly individuals do not consistently comprehend directions for various movements given to them by the testers.

CHAPTER 2

LITERATURE REVIEW

Range of motion

Range of motion (ROM) is a technique of determining the arc of motion that an individual has available at a specific joint. Physical therapists may use range of motion to assist in quantifying the amount of limitation imposed on the individual by disease, trauma, or disruption of the natural order of the tissues comprising the joint. The composition of tissues depends largely on the purpose and activity of that tissue. Contractile tissue composition and inert tissue composition vary in relation to the needs of the tissue in performing its function. During movement of the joint, both contractile and non-contractile tissues are utilized. Contractile tissues are the muscles with their tendons and attachments, while non-contractile or inert tissues include other structures such as bone, joint capsules, ligaments, bursae, fasciae, dura mater, and neural structures.[15]

Active range of motion consists of the individual moving the limb distal to the joint through contraction of the muscles which cross the joint, thus testing the contractile tissues of the joint itself. Passive range of motion differs as the joint is moved through its available arc of movement by another person while the individual is relaxed. As the individual does not have to exert effort to move the limb or joint, passive range of motion tests the inert, or non-contractile, tissues of the joint. Passive joint ROM is a direct measure of articular function and impaired ROM reflects underlying pathology of the joint or of organ systems.[16] Determination of the extent of passive range of motion available is determined through use of the end feel, or a feeling of a barrier or blockage to further motion at the end of passive range of motion. The ability to distinguish end feel consistently is necessary for the safe and reliable performance of range of motion analysis and goniometry. Active pathologies may affect either or both of these tissue types and the physical therapist must be able to determine the extent and source of injury before initiating appropriate treatment.

The method most often used in clinical settings for measurement of available range of motion is goniometry. Goniometry is used as an objective measure of shoulder range of motion.[17] Physical therapists refer to normative values from research to determine if an individual has an appropriate arc of motion available for a specific joint. Many researchers have used normative values for which there exists no recorded methodology.[3,6,7] One such widely used study by the American Academy of Orthopedic Surgeons (AAOS) has been cited by multiple subsequent research authors.[5,18,19] In addition to the need for research with reproducible methodology, researchers need to address the changes in range of motion that come with advanced age and to determine if such changes are due to contractile tissues, inert tissues, or some combination thereof.

The majority of literature addressing range of motion was drawn from subjects who were younger than sixty years of age and generally healthy.[5,8,19,20] Although values drawn from this literature are often inferred to other age groups, they are invalid for other age groups due to the nature of tissue alterations inherent with aging. For true validity of range of motion values, they must be applied only to the population directly represented by the sample used in deriving the normal joint ranges, unless a subsequent study has determined those values to be valid for other populations. For a more detailed and complete discussion of the methodology, reliability, and validity of goniometric measurement, please refer to Chapter 3.

Planes of movement

There are three planes of motion at the shoulder. The movements of the shoulder are described for their orientation to the median plane of the body. The median plane is an imaginary vertical plane passing longitudinally through the body from front to back which divides it into right and left halves.[21] Parallel to this plane is the sagittal plane, which also divides the body into right and left portions, but not equal halves. This is the plane of movement where shoulder flexion and extension occur. Shoulder abduction occurs in the coronal or frontal plane which divides the body in to anterior and posterior halves. Rotation is turning or moving a body part around its long axis in a revolving manner; shoulder internal and external rotation occur around the horizontal plane which lies parallel to the horizon, since the shoulder is abducted to 90 degrees.

The shoulder

The shoulder is a complex joint comprised of the conjunction of multiple structures. The joint is composed of the articulations of different bone structures, a multitude of musculature, ligaments, tendons, and the joint capsule. All of the above serve to provide mobility and stability for what would otherwise be a fragile complex. The interactions between the various anatomical components serve to illustrate why the shoulder is often referred to as the shoulder girdle rather than as one joint. For normal full motion of the shoulder, all of the joint complexes comprising the shoulder joint must be free from pathology and permit full excursion.

When discussing the movement of the shoulder it is necessary to delineate which aspect of the shoulder is to be considered. The shoulder is, in actuality, five separate joints: the glenohumeral joint, the suprahumeral joint, the acromioclavicular joint, the sternoclavicular joint, and the scapulothoracic joint.[7,17,22] Each joint will be discussed in its entirety below.

The glenohumeral joint is described as a ball and socket joint wherein the ball is the head of the humerus and the socket is the shallow concavity of the glenoid fossa of the scapula.[16,22,23] The humeral head is partially enveloped within the fibrocartilagenous glenoid labrum and is reinforced by the four tendons of the rotator cuff muscles (supraspinatus, infraspinatus, teres minor, and subscapularis) along with the coracohumeral ligaments. The joint capsule is additionally reinforced by the glenohumeral ligaments.[23] This joint allows for motions in three planes. The glenohumeral joint permits flexion, extension, abduction, adduction, internal rotation and external rotation. Flexion, extension, abduction, and adduction require the head of the humerus to roll and glide along the surface of the glenoid fossa while internal and external rotation necessitate a spinning motion.[22,24]

The suprahumeral joint is a false joint that protects the superior aspect of the head of the humerus.[22] The coracoacromial ligament stretches from the coracoid process and acromion of the scapula and is the suprahumeral joint's sole component.

The acromioclavicular joint is a synovial joint containing a fibrocartilagenous disc between the articulation of the lateral end of the clavicle and the acromion of the scapula.[16] Reinforcement is provided by the superior and inferior acromioclavicular ligaments along with the coracoclavicular ligament.[16,22,23] This joint permits movement of the scapula on the clavicle and allows motion in all three planes.

The sternoclavicular joint joins the medial end of the clavicle to the sternum and cartilage of the first rib. This is a tri-axial joint with an articular disc which permits motion in all three planes.[22,23] Reinforcement to the joint is provided by the anterior and posterior sternoclavicular ligaments, the costoclavicular ligament and the interclavicular ligament.[16,22,23]

The scapulothoracic joint is the attachment of the scapula to the thorax through musculature.[22,23,25] The scapula's interaction with the thorax plays an important and integral part in the mechanics of the shoulder. The muscles that attach to the scapula and are directly involved in movement of the shoulder are the deltoid, biceps brachii, latissimus dorsi, teres major, teres minor, supraspinatus, infraspinatus, subscapularis, pectoralis minor, and coracobrachialis.[22,25]

With an understanding of the articulations comprising the shoulder complex, the motions of the shoulder can then be explored. Movement of the humerus upon the scapula has been briefly described above as rolling, gliding, or spinning. Forward flexion of the shoulder requires slight medial (internal) rotation of the humerus as the arm goes beyond the horizontal due to ligamentous tension.[26-28] In abduction, lateral (external) rotation of the humerus is necessary.[26] Specifically, the glenohumeral joint permits 120° of passive range of motion in abduction.[22] Concurrent with this arc of abduction is a necessary 90° of external rotation which permits the greater tuberosity of the humerus to clear the suprahumeral arch. Fixation of the scapula upon the thorax limits the humerus to 90° of active abduction; however, passive movement from that point will attain the full 120° of motion.

These rotary components demonstrate the necessity of freedom of movement of the scapula as does scapulohumeral rhythm. Scapulohumeral rhythm is a phrase used to describe a two to one ratio of movement wherein the glenohumeral motion is twice that of the scapular motion. Although there is controversy surrounding when each portion performs its movement, the end ratio is accepted by many authors.[7,22,29] Shoulder elevation at full range of 180° arises from 120° from the glenohumeral joint and 60° from the scapulothoracic joint. This 60° of motion at the scapulothoracic joint is accomplished through movement of the clavicle (30°) and of the scapula itself (30°).[26,30,31]

With discussion of the movement of the osseous structures of the joint complete, focus is turned to the muscular component of motion. For each movement of the shoulder, certain muscles act as the primary force while others aid in attaining that movement. Those muscles aiding movement may do so by stabilizing the joint, contracting to offset a line of pull, or lending force to that produced by the primary mover. Table 1 demonstrates which muscles are involved, either as primary or accessory muscles, for various shoulder motions.[22,23,32]

Aging effects

From a holistic perspective, the human body is a remarkable creation of biologic mastery. The growth and development from a small zygote, through the gestational period, parturition, infancy, childhood, adolescence, adulthood, and elderly stages, mark various components of cellular activity, experienced maturity, and personal accomplishments. The advances in medical care, particularly with the use of antibiotics, vaccinations, and public health measures, have gradually increased the average life expectancy in the United States over the last century, and researchers continue to challenge the "age-old question" as to why we age.[33,34] Of course there is no simple answer concerning general theories on aging or its exact effects.

Many questions have been answered regarding genetic causal factors in relation to disease and aging with the advent of the Human Genome Project.[35] This project is mapping the human deoxyribonucleic-acid (DNA) sequence, compiling a literal molecular-blueprint of our species. Locating the specific genes and finding cures for these predispositions to disease may one day lead to the ultimate achievement in medical science. For the purpose of simplicity, however, these genetic factors are merely presented in this paper as playing a significant role in the scheme of aging, along with environmental factors as another major proponent.[34,35]

Inherent to aging are certain physiological changes occurring throughout the body; however, the focus of this study is more on the effects of aging upon the muscles, bones, and connective tissue as related to the shoulder.[34,36] Before discussing aging effects and related changes of these components, one first needs to have a basic comprehension of how these structures are arranged and function under optimal conditions.

Connective Tissue

Connective tissue is responsible for providing and maintaining the form of the body. It is composed of cells embedded in an extensive extracellular matrix composed of water, collagen fibers, glycoproteins, and proteoglycans.[37] Bone, ligaments, tendons, cartilage, joint capsules, fascia, skin, fat, blood, and lymph are all examples of connective tissue.[37-39] Connective tissue (CT) is also involved in mediating an immune response. The primary cell type within connective tissue is the fibroblast which will undergo mitosis (i.e. cell division) in order to aid in repair after connective tissue is damaged. Fibroblasts are responsible for production of collagen, reticular and elastic fibers, glycoproteins, proteoglycans, and glycosaminoglycans.[37]

Extracellular matrix (ECM) is a complex mixture of glycoproteins, glycosaminoglycans and proteoglycans that binds the cells and fibers of CT providing a protective barrier against foreign particles and also acts as a lubricant.[37] The ECM is produced by the fibroblasts and functions to allow passage of cells and nutrients. The macromolecules within the matrix limit collagen fiber size, provide cohesion to the fibers, and participate in maintenance of cell shape and development. The glycoproteins in the ECM serve to 1) bind cells, fibers, and proteoglycans, and 2) attach cells to the basal lamina. Glycosaminoglycans (GAGs) are polysaccharides that often bind to a protein core to form a proteoglycan. The exception is hyaluronic acid which does not form a proteoglycan but may bind with the other proteoglycans to form aggregate molecules called aggrecan .[37,40] Aggrecan occupies space and imparts compressive strength to the tissue, thus providing the ability to withstand high compressive loads to articular cartilage.[38,40]

Collagen fiber structure is determined at the most basic of cell levels, by the DNA of the cells. DNA codes are transcribed and translated by the messenger ribonucleic acid (mRNA) amino acid sequences which direct the assembly of procollagen alpha (α) chains.[37] These polypeptide chains are then synthesized by the ribosomes in the rough endoplasmic reticulum. Three α chains are assembled into a triple helix procollagen molecule which once outside the cell is modified into tropocollagen. Assemblage of the tropocollagen molecules into a quarter staggered array provides a striation pattern and strength to the resultant collagen fibrils. The tropocollagen molecules are joined by cross-links formed through intermolecular bonding between the separate tropocollagens. Cross-links are formed between the collagen fibers and between the collagen and the ECM, and are essential to the tensile strength of the collagen. The collagen fibers further aggregate into bundles to form tendons, ligaments or other necessary tissues depending upon the individual arrangement.

Collagen fibers are highly inelastic yet strong with a tensile strength greater than steel, permitting resistance and transmission of stresses.[37] Hence, collagen fibers possess a unique combination of flexibility and strength which is conferred to the tissue as a whole. There are over nineteen different types of collagen; however, the most common are Types I, II, III, IV, and V (see Table 2).[37,41] The proportion of ECM and collagen fibers will determine the type of connective tissue formed.

Connective tissue types to be discussed include CT proper and supporting CT. Connective tissue proper can be further divided into loose CT, dense regular CT, and dense irregular CT. Loose CT is found in the spaces surrounding muscles, in skin, and ensheathing lymph and blood vessels.[37] It is flexible and stretches easily which does not provide much resistance to stresses placed on the tissue. Dense regular CT, with its arrangement of fibroblasts in a linear orientation in organized bundles, provides resistance to forces of traction and is found in tendons, ligaments, and aponeuroses. Dense irregular CT has a less organized arrangement of its fibers providing resistance for force in all directions. This property makes it a valuable component of skin, articular capsules, the periosteum, the perichondrium, and capsules of organs.

Supporting CT is found in cartilage and bone. The most common type of cartilage is hyaline cartilage, named for the large amounts of hyaluronic acid found therein and composed largely of Type II collagen.[37, 38] The collagen is arranged in layers called zones which transition from softer hyaline cartilage on the outer edge to more dense calcified cartilage that merges with the subchondral bone to anchor the cartilage to the bone.[37] This arrangement is thought to provide a smooth transfer of stress from the superficial to the deep layers, reducing mechanical stress on the cartilage-bone interface.

Numerous changes occur within the connective tissue structure with age. Although there is not sufficient time to discuss all of the alterations that may occur, an effort has been made to provide an adequate depth of information. With increasing age, some of the most basic components of connective tissue morphology undergo modifications or deletions in their ribonucleic acid molecules.[40] Such changes will alter how subsequent proteins are produced, their usefulness to the body, and their properties.[41] Among the particles directly affected by minute alterations on the genetic level are the link proteins and aggrecan core proteins, both of which experience a decrease in synthesis. [40,42] Modification of the size and structure of hyaluronic acid, link proteins, and aggrecan core proteins, hence the aggregates, may occur. Additionally, aggrecan core sulphation is decreased as are the concentrations of hyaluronic acid and glycosaminoglycans (GAGs). [36,40,43] The rate of collagen fiber replacement becomes diminished as does the tissue water content. [36,42,43] Hyaline articular cartilage may show increasingly large deposits of insoluble calcium salts.[42] The effects of these changes, in addition to the increased number of cross-linkages seen, are to increase the rigidity of the connective tissue.[36,40,43] The decrease in link protein synthesis could reduce the capacity to form new stable aggregates in adult or mature cartilage.[40] Increased rigidity is detrimental to the ability of the tissues to disperse stress and compressive forces.[42]

Kefalides and Alper[41] describe connective tissue changes associated with the aging process as being inclusive of "aspects of cellular senescence, inflammatory and growth factors, photoaging of the skin, diabetes mellitus, non-enzymatic glycosylation, the etiology of osteoporosis, collagen cross-linking, and the arthritides." Whether or not these changes are genetically controlled, environmentally induced, or a combination of both, these alterations in connective tissue are difficult to distinguish as being the cause or the effect of aging.

Muscle

There are three types of muscle in the body: cardiac, smooth, and striated. Of primary concern in addressing functional movement is the striated muscle. The basic unit of a muscle is a sarcomere which is composed of various microfilaments arranged into layers. Sarcomeres combine to form myofibrils which group into muscle fibers.[39] Muscle fibers may be arranged either end to end or adjacent to one another. The greatest concentration of muscle fibers comprises the muscle belly.

Muscle contraction begins at the most basic level with a shift in position amongst the bands and zones of the sarcomere. As seen under the microscope, the sarcomere is divided into certain bands to show the position between the actin and myosin filaments.[39] During contraction, however, their overlapping positions draw together each end of the sarcomere and shorten the length, hence contraction of the muscle is achieved.

Myofibrils consist of two protein filaments called actin and myosin. According to the sliding filament theory, these myofibrils have interconnections that specifically utilize energy-carrying molecules and calcium ions for causing muscle shortening. The first component of muscle contraction is the message sent from the brain to the muscle itself via nerve impulses and neurotransmitter conduction which triggers a release of calcium ions from storage sites within the muscle. The calcium rapidly moves into the muscle fibers and binds to troponin C which is found on the actin myofibrils; this binding changes the configuration of the actin, and uncovers the myosin binding sites.[39] At this point, the myosin filament heads contact the actin filaments and split the energy-carrying molecules called adenosine triphosphate (ATP), releasing the necessary energy to produce a sliding movement between the two filaments.

To illustrate the magnitude of the importance of actin-myosin interaction, consider that there are over 500 myosin heads on each myosin filament. As each of these cross-linkages between the myosin heads and actin filaments occurs at an estimated five times per second during muscle contraction, then multiplication by the thousands of myofibrils within a muscle belly demonstrates how this microscopic interaction can have such a great amplitude of movement. As calcium was released into the muscle, it is also actively pumped back to its original storage place, subsequently allowing for immediate muscle relaxation. This returns the cycle back to the resting phase.

Inability or difficulty in muscle contraction may be secondary to a number of causes. Electrolyte imbalance may prevent sufficient amounts of calcium, sodium, or potassium from providing an adequate concentration gradient to spur contraction.[39,44] This may be exacerbated in elders due to decreased hydration and dietary deficiencies.[44,45] Physical trauma or damage to the muscle at any level may produce scar tissue, which is considered to be a specialized connective tissue with altered stress/strain curves.[46] The scar tissue has visoelastic properties different from the original tissue and altered functional ability or inhibited motion. Alteration of the proportion of contractile proteins necessary for muscle contraction, as well as a reduction in the size and number of muscle fibers may also occur. Type I (slow-twitch) fibers remain fairly stable in their concentration and size throughout life while the Type II (fast-twitch) fibers seem to undergo selective atrophy.[36,43] This change may be more attributable to lack of use rather than a truly age-inherent characteristic.[36] Whatever the cause for the atrophy, fragmentation of the Type II fibers exacerbates the loss of Z band materials within, again decreasing contractility. Collagen fiber content may increase within the aging muscle, decreasing its compliance and increasing the risk of injury. Morphological changes in skeletal muscle from aging include a decrease of muscle cell cytoplasm and an increase of fat cells and connective tissue within the muscle.[34]

Nervous system involvement may account for diminished or absent muscle contraction. This involvement may be at any one or a combination of the following areas: the brain, the spinal cord, peripheral nerves, neuromuscular junctions, neurotransmitter receptors, and concentration or efficacy of neurotransmitters.[47] Goldstein[34] and other authors[6,18] have reported a reduction in nerve conduction velocity by 0.4% per year after approximately 20 years of age. For example, reaction time slows in response to a reduction in the conduction rate of sensory nerves in conjunction with a decrease in the rate of perceptual processing. Additionally, a slowing in the propagation rate of nerve impulses, an increased time for the central processing of sensory stimuli, and a reduced speed of muscle contraction also contribute to decreased response time.[36] Physiological changes inherent to aging which affect muscular function include decreased conduction velocity due to diminished axonal impulse transmission from loss of myelin sheath and large myelinated fibers.[43]

Skeletal System

When discussing osteology it must be recognized that the bones of the body may be separated into two categories: axial and skeletal. Axial bones are those comprising the core of the body (i.e. spine, ribs, pelvis), while the skeletal bones are those bones in the periphery making up the extremities.[21] This text will focus mainly on the characteristics and organization of this second category.

Throughout development, a person's bones are constantly undergoing a process of growth and remodeling. The general structure of bone is that of a strong outer layer of cortical bone surrounding either spongy (trabecular or cancellous) bone or a marrow cavity.[21,39] Osseous remodeling is a process wherein old bone is constantly reabsorbed while new bone is being formed, allowing for response to the stresses and strains to which it is subjected.[39] Hence, bone is not a stagnant, unchanging form within the body but is a viable, living tissue.

The predominant protein of the bone matrix is Type I collagen with its triple helix as discussed previously in connective tissue physiology. Large quantities of Type I collagen and other bone matrix proteins are secreted by the osteoblasts.[39] These cells are responsible for the formation of new bone tissue. Conversely, osteoclasts are cells responsible for erosion and reabsorption of previously formed bone. Thus remodeling of bone occurs through the life-span with turnover of calcium on a magnitude of 100%

yearly in infants and 18% per year in adults. This process begins with osteoclastic reabsorption of bone followed by osteoblastic activity resulting in laying down of new bone, a cycle which lasts approximately one hundred days. The remodeling process occurs in partial response to gravity and the stresses and strains imposed upon the bone and is regulated by circulating or humoral hormones.

With aging, several different processes undergo changes that may affect bone strength and performance. Bone strength is diminished through increased osteoclast activity concurrent with a decrease in osteoblast activity or an increase in the number of resorption cycles occurring within the bones.[33,36,41,43] Perry[33] describes the process as beginning around age 40, with each resorptive cycle initiated being associated with an unequal or incomplete osteoblastic response which results in the loss of a small unit of bone. This disparity in production and destruction of bone cells creates a weaker matrix and an overall decrease in strength.[36] In extreme cases, this process may lead to osteoporosis and pathological fractures, which may be associated with impaired healing.[36,41] Wolff's Law states that the greatest concentration of bone is laid down in the areas of highest stress.[48] Thus when bones are regularly stressed, they respond by becoming mechanically stronger and if they are under-utilized, the bone will weaken.[36] In osteoporosis, the quality as well as the quantity of bone laid down may be affected.[41] Weakening of the bone is of great concern as the strength of the bone is proportional to its mass.

Research into the degree of bone loss that is inherent in aging has shown interesting results. McCalden, McGeough, and Brown[49] found a significant decrease in bone compressive strength and density associated with aging. Their research showed an

8.5 percent decrease in cancellous bone compressive strength per decade from the second to the tenth decade. Perry[33] found that perimenopausal women lose between five and fifteen percent of their bone mass with eighty percent of that loss occurring in trabecular bone. Such staggering losses in bone mass reveal themselves through predisposition to fracture especially compression and femoral fractures.

While osteoporosis is more prevalent in women, men may also experience declines in bone strength. Perry[33] correlates loss of bone mass to diminished estrogen levels in females and a decrease in gonadal function in males. An increase in osteoclast activity may begin in the 30's for women and in the 50's for men, with sequelae seen 20-30 years later causing Type 1 and 2 osteoporosis.[36] Type 1 osteoporosis is seen only in women and is thought to be due to decreased estrogen production and blood levels occurring in menopause and thereafter. With this process, bone loss occurs at a rate of approximately 0.6% yearly.[36] Type 2 osteoporosis may occur in either gender and is more likely to be a direct effect of age-related osteoblast activity. The rate of bone resorption accounts for a loss of bone mass on the magnitude of about 0.3% yearly.[36] As the bones weaken, they become increasingly brittle and the risk for fracture increases, especially with a fall or sudden exposure to excessive muscle traction forces (i.e. avulsion fracture).[36,43]

Notelovitz and Ware [23] explain that "age-related bone loss is not inevitable, but instead related to a decline in physical activity. To the extent that decreased activity with aging is inevitable, then bone loss is also inevitable." Weight-bearing exercises along with a proper diet and appropriate medications have been recommended for counteracting the effects of osteoporosis.[23,34]

With increasing age, the incidence of mechanical dysfunction and alteration in the osseous structures often increases. Among the various alterations, many of which are secondary to postural faults earlier in life, are rounded shoulders, forward head, asymmetrical shoulder heights, accentuated lumbar lordosis and thoracic kyphosis.[8] Griegel-Morris et al.[8] conducted a study of healthy persons aged 20-50 years old and found the incidence of postural abnormalities in the thoracic-cervical spine to be as follows: forward head 66%, kyphosis 38%, right rounded shoulder 73%, and left rounded shoulder 66%. Proposed mechanisms leading to postural alteration and exacerbation of abnormalities included sedentary habits, poorly equipped work sites, lack of postural awareness, and habits of falling into gravity.[8,50] Kyphosis results from deformities of the disc and vertebrae, usually in the anterior compartment of the thoracic spine. Diminished anterior vertebral height or anterior disc abnormality produces the kyphotic posture. Additionally, muscle imbalances can produce faulty length-tension forces which induce kyphotic postures.[32,51] For example, paraspinal muscle lengthening in the thoracic spine along with abdominal muscle shortening will depress the chest and cause thoracic flexion. The magnitude of kyphosis may reach 20-30 degrees in the second to fifth decades and 50-90 degrees in the elderly.[36] Depending upon an individual's pain threshold, these postural abnormalities may or may not be associated with detectable levels of pain.[8]

The presence of postural abnormalities may preclude "normal" range of motion by impeding the ability to fully utilize the upper extremities. Range of motion decreases have been associated with disuse, arthritis, trauma from mechanical stresses, altered scapular position, and increased dorsal kyphosis.[36] For example, increased thoracic kyphosis and arthritis can limit the excursion of the humerus in flexion, rotation, and abduction.[22,36] Such loss in range of motion may be accompanied by crepitus or grinding on shoulder elevation.[36]

Decreased joint flexibility is a common complaint in the elderly population, as stiffness and loss of normal range of motion is one of the age-related changes caused by the improperly synthesized collagen proteins.[41,52] Raab[53] notes that the decline in flexibility with age may be due to multiple causes, including "age itself, trauma from mechanical stresses, disuse, and diseases ... In the absence of disease or injury, hypokinesis or disuse leading to muscle shortening and changes in connective tissue may be the major factor in reduced ROM." Although range of motion deficiencies may not initially cause inconvenience or pain, continued use of compensatory mechanisms or substitutions in movement patterns may affect joint integrity over the long term.

With the presence of altered or painful joint mechanics and changed physiology, aged persons may compensate through any of a number of motions that are altered from those typically seen. Such alterations in the performance of motions are referred to as compensations or substitutions. Alterations in movement patterns may be secondary to subjective pain, strength deficits, instability or any combination thereof.[54] People may also change their movement patterns because of faulty recruitment of a stronger or dominant muscle, insufficient power in muscles responsible for normal movement, tightening or shortening of tissue that precludes movement in a particular direction, and/or learned action through work or recreational use.[51,55] While these compensations or substitutions are abnormal from a clinical viewpoint, generally people do not find a lack of range of motion to be worrisome so long as they can perform those activities they wish to in the course of their day.[54] When function is diminished, it correlates closely to the chief complaint that propels a person to seek medical care.

When discussing substitutions specific to the shoulder, the movements have been discussed individually to ease comprehension. If activities require more motion than is available, trunk movement such as extension and lateral flexion may be used for task accomplishment.[11] For example, shoulder flexion limitation resulting from lack of humeral excursion secondary to kyphosis or from tightened structures may be compensated for through increased back extension.[51] Weakness in the anterior deltoid or coracobrachialis muscles in active shoulder flexion may cause a person to use the long head of the biceps brachii causing lateral rotation of the humerus.[56] During active abduction of the shoulder, more than one substitution is possible. The long head of the biceps brachii may be used for lateral rotation of the humerus in order to compensate for diminished strength in the medial deltoid and supraspinatus. If only the supraspinatus is weakened, the trunk may lean to the same side as the arm to be moved. This is done in an effort to initiate abduction passively. Another means of compensating for abduction is ipsilateral shoulder elevation using the upper trapezius.[56,57]

Due to the effects of aging on the different bodily systems, the physical changes and symptoms noted may be due to a combination of normal aging, accumulated disease processes, and disuse along with unspecified environmental factors. Hypokinetics (i.e. decreased activity) is certain to exacerbate the changes of aging, and disease infallibly complicates the health of the individual.[34,43] These changes and alterations in other systems affected by aging will gradually decrease the functional capacity and vitality of the elderly population. Shoulder function may be altered by multiple causes including age, genetics, recreational pursuits, vocational use, pathology, disuse, and mechanical stress.[5,36,53] Even healthy older individuals without active pathology may show decreased range of motion at certain joints as compared to younger individuals.[11,45] This age-related decrease does not necessarily preclude the performance of activities of daily living (ADLs).[11,45] Aging effects vary from individual to individual as one person may be physically active and running marathons, while another of the same age is institutionalized because of disability.[36,43]

Table 1. Muscular Actions in Shoulder Movement[22,23,32]

Movement Full ROM	Shoulder: Primary Muscles	Shoulder: Accessory Muscle	Scapular Muscles
Flexion	Anterior Deltoid Coracobrachialis	Pectoralis Major (clavicular head) Biceps Brachii Infraspinatus Teres Minor Posterior Deltoid	Serratus Anterior Trapezius
Extension	Posterior Deltoid Teres Major Latissimus Dorsi	Triceps (long head) Teres Minor Pectoralis Major (sternal head)	Rhomboids Levator Scapulae Pectoralis Minor
Abduction	Deltoid Supraspinatous	Biceps (long head) Infraspinatus Teres Minor	Trapezius Serratus Anterior
Adduction	Pectoralis Major Latissimus Dorsi Teres Major	Triceps (long head) Coracobrachialis Biceps Brachii	Rhomboids Trapezius
Internal Rotation	Pectoralis Major Latissimus Dorsi Teres Major Subscapularis	Deltoid (anterior fibers)	
External Rotation	Infraspinatus Teres Minor	Deltoid (posterior fibers)	

Table 2. Collagen Type and Location[37,38]

Collagen Type	This collagen type is commonly found in the following structures:
Type I	Skin, tendon, bone, ligaments, joint capsules, annulus fibrosus
Type II	Hyaline cartilage (articular cartilage), nucleus pulposus
Type III	Fetal skin, blood vessels, organs, skin with reticular fibers, initial wound healing and scar formation
Type IV	Basement membranes of epithelial and endothelial cells
Type V	Paracellular collagen, basal lamina of muscle cells and blood vessels

CHAPTER 3

METHODOLOGY

Subjects

Two pilot studies were conducted, completing active range of motion (AROM) and passive range of motion (PROM) of both shoulders on persons 60 years of age and older. The first study included fifteen participants and the second included twelve. There was a subset of nine individuals (hereafter referred to as "subset") who were participants in both the first and the second pilot studies (See Table 3). The pilot studies were conducted at the Physical Therapy Department at the University of North Dakota in Grand Forks, ND. The research study was approved by the Institutional Review Board at the University of North Dakota prior to initiation of the study (See Appendix).

Table 3. Descriptive Statistics of Participants

Age in years	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**
First study	62	83	70	6
Second Study	61	75	67	4
Subset	62	75	67	4

Hand Dominance	**Right**	**Left**	**Ambidextrous**
First study	13	1	1
Second study	12	0	0
Subset	9	0	0

Gender	**Female**	**Male**
First study	11	4
Second study	9	3
Subset	7	2

Inclusion / Exclusion Criteria

Subjects were eligible for participation if they met the inclusion criteria of being over the age of sixty years old and did not meet any of the exclusion criteria. Exclusion criteria consisted of active shoulder pathology of any kind in the last two years, past rotator cuff surgical repair, surgery within the last five years of the shoulder, back, neck, or chest, mental incompetency or the inability to follow directions, severe osteoporosis (as diagnosed by a physician), and an inability to assume the testing positions. Participants were selectively recruited from the Grand Forks community and included current and retired university faculty members and acquaintances of those conducting the research. All participants read and understood the informed consent agreement (See Appendix) and any questions that they had were answered by the researchers.

Instrumentation

Goniometry

Range of motion (ROM) measurements were obtained with a 12-inch plastic universal goniometer. The universal goniometer is the instrument most commonly used to measure joint range of motion.[16] Goniometric measurements are used frequently in the clinic to determine changes in a client's ROM, to aid in establishing diagnoses, to obtain baseline measurements in initial assessments and to set goals for patients. ROM measurements can also be used to help motivate a patient by being able to show the progress they have made.

Validity

Validity is described as "the degree to which an instrument measures what it is purported to measure; the extent to which it fulfills its purpose."[58]

Content validity is described as the judgment of whether the instrument is adequately measuring what it is meant to measure. Content validity was addressed by Gajdosik and Bohannon;[59] "Physical therapists judge the validity of most ROM measurements based on their anatomical knowledge and their applied skills of visual inspection, palpation of bony landmarks, and accurate alignment of the goniometer. Generally, the accurate application of knowledge and skills, combined with interpreting the results as measurements of ROM only, provide sufficient evidence to ensure content validity." They also reported that the reliability and validity might be decreased due to factors of patient differences that cannot be controlled, including obesity and anatomical variations in bony structures.

Criterion validity examines the validity of the measurement as compared to a well established standard. In the case of goniometry, the comparison is to radiography.[60] Criterion validity can also be established in the fact that the angles of the goniometer can be compared with the angle of a protractor or any other known angle. Norkin and White[16] stated that usually the construction of a goniometer is adequate, and the issue of validity is then focused on whether the goniometer accurately measures the angle of joint position and ROM in a subject.

Reliability

Reliability refers to the degree of consistency between several repeated measurements of the same variable, with the same subject, and in the same conditions.[16,61] "The measurement of joint position and ROM of the extremities with a universal goniometer has generally been found to have good-to-excellent reliability...[t]he reliability of goniometric ROM measurements varies somewhat depending on the joint and motion."[61] Several research studies have indicated that the reliability of measurements of joint motion can vary greatly depending on the complexity of the joint being measured.[59,62] It is accepted that intrarater agreement should be within 2-5 degrees during successive measurements of the same motion.[20,22,61]

Protocol / procedure

The same researcher performed all of the active and passive range of motion measurements throughout the study in order to increase reliability of measurements.[19,61,62] Measurements of shoulder range of motion were taken as described in Norkin & White's[16] *Measurement of Joint Range of Motion, a Guide to Goniometry* textbook and American Academy of Orthopaedic Surgeon's[3] *The Clinical Measurement of Joint Motion* with a few modifications. All measurements were taken with the participant in a supine position, with the exception of extension, which was measured in a sitting position. Shoulder extension was measured in a seated position as described by Wiechec and Krusen[63] and AAOS[3], as this is a more functional position in which to measure this motion than the traditional prone lying position which is described in some of the literature.[16,8] The seated position is also a more comfortable position because elderly individuals may feel uncomfortable or may be unable to lay in a prone position.

Flexion and extension occurred in the saggital plane, abduction in the frontal plane, and internal and external rotation in the horizontal plane with the shoulder in 90° of abduction.[16] The scapula was not stabilized during the measurements because scapular motion is a natural part of normal shoulder movement and is described as scapulohumeral rhythm (as described in detail in Chapter 2). Clinicians are unable to consistently differentiate between the two (glenohumeral and scapular movements).[64] To ensure that the participants did not use substitution patterns of movement, participants were instructed, both verbally and visually in the correct way to move. Observation with verbal corrections and cues for proper movement were provided when necessary.

Before the range of motion measurements were taken, each participant went through a brief warm-up consisting of five active repetitions of each of the motions that were to be measured in the study. Warm-up motions were performed in the following order: shoulder flexion, extension, abduction, and internal rotation and external rotation, which were performed concurrently as one smooth motion with the elbows flexed to 90 degrees and positioned at the sides of the body.

During the AROM movements, the examiner passively moved the participant's arm through the required motion as a demonstration, then asked the participant to actively complete the movement, as far as they were able to, without causing any pain or discomfort. For the passive movements, a second researcher moved the participant's relaxed arm in the required movement until resistance was felt at the end of the available range of motion or the participant reported discomfort with continued movement. Measurements were obtained when no further movement was observed, at the end of the available range of motion. The order of the measurements was randomized during the two pilot studies in order to prevent observer bias and participant learning effects. All active range of motion measurements preceded passive range of motion.

In the first pilot study, only one measurement was taken for each motion analyzed. In the second pilot study, two measurements of each motion were obtained; however for statistical purposes, only the first of the two measurements was used for the data analysis.

Data analysis

Plan for analysis

Descriptive statistics such as mean, standard deviation and range were used to describe the motions measured and also to describe the sample of individuals who participated in the study.

The Single Measure Intraclass Correlation Coefficient (ICC) was used to describe the intratester reliability of the goniometric measurements obtained.

Descriptive Statistics

Descriptive statistics for the sample participants are listed in Table 3. The descriptive statistics and intraclass correlation coefficients for measurements in the two pilot studies and subset are listed in Chapter 4.

Alpha level

The alpha level used throughout this research was α=.05.

CHAPTER 4

RESULTS

The results of the pilot studies are listed in Tables 4 through 17. Statistical analysis shows that there was not consistent reliability of measurements taken by the researchers. In the first pilot study, out of 28 possible measurements, nine had an ICC result of .8000 or greater; however, in the second pilot study only six had an ICC of .8000 or greater. Only four of the six measurements were consistent across the two pilot studies. The ICC results for the subset of nine individuals who participated during both of the pilot studies showed even less consistency, as only one out of 28 measurements was above .8000.

Due to the inability to achieve intrarater reliability of measurements, the research questions must be left unanswered. Possible interpretation of the results and answers to the research questions will be addressed in Chapter 5.

Table 4. Flexion

		First Pilot Study*				Second Pilot Study†		
	Time‡	Mean	SD	ICC§		Mean	SD	ICC§
Right Active Flexion	1	167°	13°			162°	7°	
	2	165°	17°	.4494		164°	5°	.6160
Right Passive Flexion	1	172°	12°			167°	7°	
	2	172°	15°	.6801		168°	7°	.6115
Left Active Flexion	1	169°	9°			164°	5°	
	2	169°	11°	.1656		164°	4°	.4764
Left Passive Flexion	1	175°	7°			168°	6°	
	2	175°	10°	.3177		169°	5°	.7570

*: Single measurement of each motion.
†: Listed value reflects the first of two measurements obtained.
‡: First or second measurement in each pilot study
§: Single Measure Intraclass Correlation Coefficient

Table 5. Subset of nine,* Flexion.

	Time†	Mean	SD	ICC‡
Right Active Flexion	1	169°	14°	
	2	167°	9°	
	3	164°	5°	
	4	164°	5°	.1785
Right Passive Flexion	1	174°	13°	
	2	175°	7°	
	3	168°	5°	
	4	170°	6°	.5107
Left Active Flexion	1	171°	11°	
	2	170°	8°	
	3	165°	4°	
	4	164°	4°	.2040
Left Passive Flexion	1	176°	8°	
	2	177°	7°	
	3	169°	5°	
	4	170°	5°	.4047

*: Subset of nine individuals who each participated in both pilot studies.
†: Time measurements were taken in each of the two pilot studies:
1 = First pilot study, first measurement
2 = First pilot study, second measurement
3 = Second pilot study, first measurement
4 = Second pilot study, second measurement
‡: Single Measure Intraclass Correlation Coefficient.

Table 6. Extension

		First Pilot Study*				Second Pilot Study†		
	Time‡	Mean	SD	ICC§		Mean	SD	ICC§
Right Active	1	56°	8°			48°	6°	
Extension	2	54°	6°	.3577		47°	7°	.5515
Right Passive	1	64°	9°			54°	5°	
Extension	2	61°	7°	.4840		54°	6°	.5775
Left Active	1	55°	6°			48°	7°	
Extension	2	53°	6°	.4550		47°	6°	.4632
Left Passive	1	61°	6°			53°	7°	
Extension	2	59°	6°	.5266		52°	5°	.7133

*: Single measurement of each motion.
†: Listed value reflects the first of two measurements obtained.
‡: First or second measurement in each pilot study
§: Single Measure Intraclass Correlation Coefficient

Table 7. Subset of nine,* Extension.

	Time†	Mean	SD	ICC‡
Right Active Extension	1	56°	6°	
	2	55°	7°	
	3	48°	7°	
	4	47°	8°	.4379
Right Passive Extension	1	65°	5°	
	2	61°	8°	
	3	53°	5°	
	4	53°	7°	.5828
Left Active Extension	1	56°	8°	
	2	54°	7°	
	3	48°	7°	
	4	47°	6°	.6003
Left Passive Extension	1	61°	7°	
	2	59°	7°	
	3	52°	7°	
	4	52°	5°	.6500

*: Subset of nine individuals who each participated in both pilot studies.

†: Time measurements were taken in each of the two pilot studies:

1 = First pilot study, first measurement
2 = First pilot study, second measurement
3 = Second pilot study, first measurement
4 = Second pilot study, second measurement

‡: Single Measure Intraclass Correlation Coefficient.

Table 8. Total Flexion plus Extension

		First Pilot Study*				Second Pilot Study†		
	Time‡	Mean	SD	ICC§		Mean	SD	ICC§
Right Active	1	222°	17°			210°	8°	
Flex + Ext‖	2	219°	20°	.7421		211°	6°	.4720
Right Passive	1	236°	18°			221°	7°	
Flex + Ext‖	2	233°	19°	.9069		221°	10°	.7712
Left Active	1	224°	8°			212°	8°	
Flex + Ext‖	2	222°	12°	.4161		211°	7°	.4375
Left Passive	1	236°	8°			221°	7°	
Flex + Ext‖	2	234°	13°	.6065		221°	6°	.8097

*: Single measurement of each motion.
†: Listed value reflects the first of two measurements obtained.
‡: First or second measurement in each pilot study
§: Single Measure Intraclass Correlation Coefficient
‖: Flex + Ext = Calculation of Flexion plus Extension measurements.

Table 9. Subset of nine,[*] Flexion plus Extension.

	Time[†]	Mean	SD	ICC[‡]
Right Active Flex + Ext[§]	1	226°	13°	
	2	222°	12°	
	3	212°	8°	
	4	211°	6°	.2375
Right Passive Flex + Ext[§]	1	239°	13°	
	2	236°	11°	
	3	221°	7°	
	4	223°	8°	.5844
Left Active Flex + Ext[§]	1	227°	8°	
	2	223°	7°	
	3	213°	8°	
	4	211°	7°	.4284
Left Passive Flex + Ext[§]	1	237°	7°	
	2	236°	7°	
	3	221°	8°	
	4	221°	6°	.6352

*: Subset of nine individuals who each participated in both pilot studies.
†: Time measurements were taken in each of the two pilot studies:
1 = First pilot study, first measurement
2 = First pilot study, second measurement
3 = Second pilot study, first measurement
4 = Second pilot study, second measurement
‡: Single Measure Intraclass Correlation Coefficient.
§: Flex + Ext = Calculation of Flexion plus Extension measurements.

Table 10. Abduction

		First Pilot Study*				Second Pilot Study†		
	Time‡	Mean	SD	ICC§		Mean	SD	ICC§
Right Active	1	159°	25°			164°	10°	
Abduction	2	162°	28°	.9214		164°	9°	.3302
Right Passive	1	169°	25°			168°	8°	
Abduction	2	170°	27°	.9672		169°	11°	.3623
Left Active	1	169°	14°			163°	8°	
Abduction	2	172°	12°	.7469		166°	9°	.2581
Left Passive	1	175°	12°			169°	7°	
Abduction	2	179°	12°	.7799		170°	9°	.3504

*: Single measurement of each motion.
†: Listed value reflects the first of two measurements obtained.
‡: First or second measurement in each pilot study
§: Single Measure Intraclass Correlation Coefficient

Table 11. Subset of nine,* Abduction.

	Time†	Mean	SD	ICC‡
Right Active Abduction	1	164°	27°	
	2	167°	29°	
	3	162°	10°	
	4	166°	8°	.5495
Right Passive Abduction	1	171°	26°	
	2	173°	27°	
	3	166°	9°	
	4	170°	10°	.5459
Left Active Abduction	1	172°	8°	
	2	176°	10°	
	3	165°	8°	
	4	167°	8°	.5343
Left Passive Abduction	1	179°	6°	
	2	183°	7°	
	3	171°	7°	
	4	170°	9°	.4151

*: Subset of nine individuals who each participated in both pilot studies.
†: Time measurements were taken in each of the two pilot studies:
1 = First pilot study, first measurement
2 = First pilot study, second measurement
3 = Second pilot study, first measurement
4 = Second pilot study, second measurement
‡: Single Measure Intraclass Correlation Coefficient.

Table 12. Internal Rotation

	First Pilot Study*					Second Pilot Study†		
	Time	Mean	SD	ICC§		Mean	SD	ICC§
Right Active IR‖	1	63°	11°			54°	13°	
	2	62°	9°	.8172		54°	7°	.8108
Right Passive IR‖	1	67°	10°			55°	13°	
	2	68°	9°	.8613		58°	8°	.8366
Left Active IR‖	1	65°	12°			58°	8°	
	2	66°	8°	.5542		58°	7°	.7178
Left Passive IR‖	1	73°	10°			62°	8°	
	2	73°	8°	.6029		63°	7°	.5527

*: Single measurement of each motion.
†: Listed value reflects the first of two measurements obtained.
‡: First or second measurement in each pilot study
§: Single Measure Intraclass Correlation Coefficient
‖: IR = Internal Rotation

Table 13. Subset of nine,* Internal Rotation.

	Time†	Mean	SD	ICC‡
Right Active Internal Rotation	1	64°	9°	
	2	61°	6°	
	3	52°	13°	
	4	54°	7°	.7947
Right Passive Internal Rotation	1	67°	9°	
	2	68°	8°	
	3	53°	12°	
	4	57°	8°	.8303
Left Active Internal Rotation	1	66°	9°	
	2	65°	7°	
	3	58°	7°	
	4	58°	8°	.5223
Left Passive Internal Rotation	1	72°	8°	
	2	74°	8°	
	3	61°	7°	
	4	64°	7°	.4854

*: Subset of nine individuals who each participated in both pilot studies.
†: Time measurements were taken in each of the two pilot studies:
- 1 = First pilot study, first measurement
- 2 = First pilot study, second measurement
- 3 = Second pilot study, first measurement
- 4 = Second pilot study, second measurement

‡: Single Measure Intraclass Correlation Coefficient.

Table 14. External Rotation

		First Pilot Study*				Second Pilot Study†		
	Time‡	Mean	SD	ICC§		Mean	SD	ICC§
Right Active	1	84°	14°			74°	8°	
ER‖	2	86°	14°	.8681		78°	9°	.6961
Right Passive	1	90°	15°			78°	8°	
ER‖	2	92°	11°	.8270		81°	7°	.7190
Left Active	1	83°	9°			73°	6°	
ER‖	2	85°	7°	.7982		76°	7°	.2692
Left Passive	1	89°	10°			76°	6°	
ER‖	2	92°	7°	.7743		81°	7°	.4919

*: Single measurement of each motion.
†: Listed value reflects the first of two measurements obtained.
‡: First or second measurement in each pilot study
§: Single Measure Intraclass Correlation Coefficient
‖: ER = External Rotation

Table 15. Subset of nine,* External Rotation.

	Time†	Mean	SD	ICC‡
Right Active External Rotation	1	85°	10°	
	2	88°	9°	
	3	73°	7°	
	4	79°	7°	.3805
Right Passive External Rotation	1	91°	10°	
	2	95°	5°	
	3	77°	7°	
	4	81°	5°	.3153
Left Active External Rotation	1	84°	11°	
	2	87°	8°	
	3	73°	5°	
	4	78°	7°	.4476
Left Passive External Rotation	1	90°	11°	
	2	93°	6°	
	3	77°	5°	
	4	82°	7°	.5802

*: Subset of nine individuals who each participated in both pilot studies.
†: Time measurements were taken in each of the two pilot studies:
1 = First pilot study, first measurement
2 = First pilot study, second measurement
3 = Second pilot study, first measurement
4 = Second pilot study, second measurement
‡: Single Measure Intraclass Correlation Coefficient.

Table 16. Total Internal Rotation plus External Rotation

	First Pilot Study*				Second Pilot Study†		
	Time‡	Mean	SD	ICC§	Mean	SD	ICC§
Right Active	1	147°	21°		128°	18°	
IR + ER‖	2	148°	18°	.9058	132°	13°	.8170
Right Passive	1	157°	20°		132°	18°	
IR + ER‖	2	160°	17°	.9076	138°	12°	.8354
Left Active	1	148°	14°		132°	11°	
IR + ER‖	2	151°	13°	.7614	134°	9°	.6960
Left Passive	1	162°	15°		138°	10°	
IR + ER‖	2	165°	14°	.7487	143°	10°	.8170

*: Single measurement of each motion.
†: Listed value reflects the first of two measurements obtained.
‡: First or second measurement in each pilot study
§: Single Measure Intraclass Correlation Coefficient
‖: IR + ER = Calculation of Internal Rotation plus External Rotation measurements

Table 17. Subset of nine,* Internal Rotation plus External Rotation.

	Time†	Mean	SD	ICC‡
Right Active IR + ER§	1	149°	14°	
	2	150°	13°	
	3	125°	16°	
	4	133°	10°	.6655
Right Passive IR + ER§	1	159°	15°	
	2	163°	12°	
	3	129°	17°	
	4	138°	10°	.7220
Left Active IR + ER§	1	150°	9°	
	2	152°	13°	
	3	132°	9°	
	4	136°	8°	.4909
Left Passive IR + ER§	1	163°	13°	
	2	167°	12°	
	3	138°	9°	
	4	146°	8°	.5677

*: Subset of nine individuals who each participated in both pilot studies.

†: Time measurements were taken in each of the two pilot studies:

1 = First pilot study, first measurement
2 = First pilot study, second measurement
3 = Second pilot study, first measurement
4 = Second pilot study, second measurement

‡: Single Measure Intraclass Correlation Coefficient.

§: IR + ER = Calculation of Internal Rotation plus External Rotation.

CHAPTER 5

DISCUSSION & CONCLUSION

The researchers were unable to achieve reliability of measurements; therefore it cannot be conclusively determined from this sample whether or not there are any differences in the range of motion of the shoulder for the elderly in comparison to previously established normal values. Thus, the researchers feel that a comparison of these results to the norms is not feasible at this time.

The results of this research could be due to one or a combination of several factors, including physiological effects of aging, participant effort and other cognitive effects of aging, use of substitution patterns of movement, and inconsistency of student or novice measurements. In the case of the subset comparisons, the lack of consistent results could be due to the fact that the second pilot study was conducted three months after the first with all of the usual summer activities that people are involved in possibly contributing to the change in the participant's available range of motion.

Physiological effects of aging may contribute to the reliability of measurement testing. Changes in musculature, osteology, and connective tissue physiology may potentially alter joint kinematics and kinetics such that goniometric measurements are no longer reliable or valid.[4,62] Muscle weakness as a result of poor recruitment of the appropriate muscles,[47] sedentary lifestyles, declines in muscle strength and connective tissue alterations may also contribute to diminished range of motion and decreased reliability. The presence of osteoporosis or thoracic kyphosis also may contribute to faulty movement patterns. Determination of the effects of aging on cellular or systemic levels would require a more in depth analysis, which is beyond the scope of this research study.

Other factors may also contribute to the reliability of measurements. These factors can include decreased cognitive abilities, use of substitution patterns of movement, and over-exuberance of participants in the completion of the required movements. Some of the participants did not clearly comprehend verbal and visual instructions given by the researchers and required repeated cues to complete the motion in the proper plane. Several of the participants repeatedly tried to use substitution patterns in the completion of the required movements. Over-exuberance also proved to be a factor with the many of the participants. Individuals tried to do their very best, taking the movement to its ultimate limit regardless of substitution patterns used or the advice of the researchers. Such attempts required redirection by the researchers through physical and verbal means. Participants were also anxious to do better than their previous measurement and better than their friends or spouses who also participated, despite the unavailability of their previous measurements.

Measurements taken by students and novice clinicians may also influence the reliability of goniometry. With novice measurement, incorrect placement and alignment of the goniometer or possible misreading of values may occur.[9] Stratford et al[61] discussed research with goniometric measurements taken by physical therapy students; they found that there were two primary areas of error. First, students were prone to error when the measurements were between 70 to 110 degrees. Second, students read the wrong side of the measurement scale, although this error occurred less often than the first type.

Stratford et al[61] outlined several strategies for avoidance of measurement errors in goniometry, these strategies included: 1) adoption of a standardized procedure for ROM measurements; 2) the use of bony landmarks or imagining a line along the axis of the bones on either side of the joint and exposing the joint and limbs to be measured; and 3) minimization of improper reading of the goniometer scale.

This research cannot be compared to other research studies because of the lack of reliability of the measurements. Other research studies have achieved reliability (both intrarater and interrater); however, the researchers were unable to locate any previous research that describes reliability of student or novice therapist measurements.

Most research to date has been conducted predominantly with younger, male, and/or healthy individuals, with experienced clinicians taking the measurements.[3-8] Other studies have outlined research with very strict protocols for taking goniometric measurements that are not clinically applicable in the opinion of the researchers of this scholarly project.[9,20,28,65,66]

Limitations

The pilot studies were conducted using small groups of participants, n1=15 and n2=12. In retrospect, it would have been better to use a larger sample, however a sample size of 15 for a pilot study to establish reliability is usually sufficient.

Attempts to avoid extraneous factors on the part of the participants would be beneficial. For example, participants reported that they spent the time between measurements playing golf or working in their garden. These factors could have influenced the participant's available shoulder range of motion, by either an increase or a decrease. The reliability of the subset measurements could have been affected by the fact that the pilot studies were conducted three months apart. The change could be attributed to a more active lifestyle during the summer months, causing an increase in flexibility due to more participation in various activities such as sports or yard work. These activities could also have a detrimental effect by causing joint stiffness and muscle soreness.

In retrospect, the researchers feel that participants should have been given clearer instructions on the avoidance of certain activities (golf, gardening) between the first and second measurements for each pilot study. Ideally, the two pilot studies should have occurred within a shorter time frame. Previous research studies have also addressed these factors; Mayerson & Milanno[20] outlined sources of variance including placement of the goniometer, judgment of the therapist in regard to defining the limit of motion and physical fluctuations throughout the day.

Suggestions for future research

The authors see a need for further research into the following areas:

1. The establishment of normal range of motion values for the older population.
2. Further research examining the reliability of novice measurements as compared to experienced clinicians.
3. Examination of the cause of variability in the ROM of elderly, whether it is caused by age, cognitive, anatomical, physiological causes, or the presence of systemic diseases or illnesses (diabetes, rheumatoid arthritis, etc).

Clinical implications / conclusion

The findings of this scholarly project call into question the use of goniometric measurements in clinical settings. Oftentimes clinicians use goniometric measurements without ever considering their own reliability. Without knowledge of one's own reliability, no conclusions should be drawn from any obtained measurements. This becomes relevant in documentation of objective measurements and the establishment of outcomes for clients. If the original measurements were not accurate or reliable, then the comparison of subsequent measurements are also unreliable. Thus, the demonstration of improvement and attainment of goals cannot be accurately demonstrated.

APPENDIX

REPORT OF ACTION: EXEMPT/EXPEDITED REVIEW

University of North Dakota Institutional Review Board

Date: April 26, 2001 **Project Number:** IRB-200104-222

Name: Michelle LaBrecque, Karina Koch, Lauri Paulsen, Heather White; Richard Williamson **Department/College:** Physical Therapy

Project Title: Normative Values for Shoulder Range of Motion in the Elderly Population

The above referenced project was reviewed by a designated member for the University's Institutional Review Board on April 26, 2001 and the following action was taken:

[X] Project approved. **EXPEDITED REVIEW** Category No. 4
Next scheduled review is on: April 2002

[x] The attached consent form dated April 26, 2001 is the **only consent form which may be used for this study.**

[ ] Project approved. **EXEMPT REVIEW** Category No. ______
This approval is valid until ______ as long as approved procedures are followed. No periodic review scheduled unless so stated in the Remarks Section.

[ ] The attached consent form dated ______ is the **only consent form which may be used for this study.**

[ ] Project approved **PENDING** receipt of corrections/additions. These corrections/additions should be submitted to ORPD for review and approval. **This study may NOT be started UNTIL final IRB approval has been received.** (See Remarks Section for further information.)

[ ] Project approval **deferred. This study may not be started until final IRB approval has been received.** (See Remarks Section for further information.)

[ ] Project **denied.** (See Remarks Section for further information.)

REMARKS: Any changes in protocol or adverse occurrences in the course of the research project must be reported immediately to the IRB Chairperson or ORPD.

PLEASE NOTE: Requested revisions for student proposals MUST include adviser's signature.

Cindy D. Dan 4/26/01

Signature of Designated IRB Member
UND's Institutional Review Board

Date

cc: Michelle LaBrecque

If the proposed project (clinical medical) is to be part of a research activity funded by a Federal Agency, a special assurance statement or a completed 310 Form may be required. Contact ORPD to obtain the required documents.

X EXPEDITED REVIEW REQUESTED UNDER ITEM 4 (NUMBER[S]) OF HHS REGULATIONS
___ EXEMPT REVIEW REQUESTED UNDER ITEM ___ (NUMBER[S]) OF HHS REGULATIONS

UNIVERSITY OF NORTH DAKOTA HUMAN SUBJECTS REVIEW FORM FOR NEW PROJECTS OR PROCEDURAL REVISIONS TO APPROVED PROJECTS INVOLVING HUMAN SUBJECTS

Please include ALL information and check ALL blanks that apply.

PRINCIPAL INVESTIGATOR: Michelle LaBrecque, Karina Koch, Lauri Paulsen, Heather White, and Richard Williamson **TELEPHONE:** 777-2831 **DATE:** 14 April 2001

ADDRESS TO WHICH NOTICE OF APPROVAL SHOULD BE SENT: Michelle LaBrecque, Physical Therapy Department, UND, Box 9037

SCHOOL/COLLEGE: UND School of Medicine **DEPARTMENT:** Physical Therapy **PROPOSED PROJECT DATES:** 5/1/01 through 12/1/01
(E.g., A&S, Medicine, EHD, etc.) (Month/Day/Year)

PROJECT TITLE: Normative Values for Shoulder Range of Motion in the Elderly Population.

FUNDING AGENCIES (IF APPLICABLE): ___

TYPE OF PROJECT (Check ALL that apply):

X NEW PROJECT ___ CONTINUATION ___ RENEWAL ___ DISSERTATION OR THESIS RESEARCH X STUDENT RESEARCH PROJECT

___ CHANGE IN PROCEDURE FOR A PREVIOUSLY APPROVED PROJECT

DISSERTATION/THESIS ADVISER, OR STUDENT ADVISER: Michelle LaBrecque

PROPOSED PROJECT: ___ INVOLVES NEW DRUGS (IND) ___ INVOLVES NON-APPROVED USE OF DRUG ___ INVOVLES A COOPERATING INSTITUTION

IF ANY OF YOUR SUBJECTS FALL IN ANY OF THE FOLLOWING CLASSIFICATION, PLEASE INDICATE THE CLASSIFICATION(S):

☐ MINORS (<18 YEARS) ☐ PREGNANT WOMEN ☐ MENTALLY DISABLED ☐ FETUSES ☐ PERSONS WITH MENTAL RETARDATION

☐ PRISONERS ☐ ABORTUSES ☐ UND STUDENTS (>18 YEARS)

IF YOUR PROJECT INVOLVES ANY HUMAN TISSUE, BODY FLUIDS, PATHOLOGICAL SPECIMENS, DONATED ORGANS, FETAL MATERIAL, OR PLACENTAL MATERIALS, CHECK HERE ___

IF YOUR PROJECT HAS BEEN\WILL BE SUBMITTED TO ANOTHER INSTITUTIONAL REVIEW BOARD(S), PLEASE LIST NAME OF BOARD(S): ___

Status: ___ Submitted; Date ___ ___ Approved; Date ___ ___ Pending

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1. ABSTRACT: (LIMIT TO 200 WORDS OR LESS AND INCLUDE JUSTIFICATION OR NECESSITY FOR USING HUMAN SUBJECTS.)

Normative Values of Shoulder ROM in an Elderly Population

Active and passive range of motion are used by physical therapists to assess whether contractile or inert tissues cause restricted movement. Knowledge of the causal tissue and the severity of loss in comparison to "normal" values may then direct the treatment initiated for the individual.

Research has been performed to assess what "normal" range of motion is, but the majority of literature published on the topic fails to fully assess the issue. Much of the research utilized a sample consisting of young individuals or concentrated on just one aspect of motion (active or passive). While the values obtained from these bodies of research are valid when applied to the corresponding population, they are often inferred to other periods of life.

Generalization of these normal ranges of motion to geriatric populations is invalid due to physiological changes inherent to aging. The extensibility of tissue is lessened as the components are altered. Thus, it is logical to assume that range of motion would also be diminished in the elderly

The objectives of this project are to determine if individuals of increased age do possess decreased range of motion (both active and passive) compared to younger populations and the extent of diminishment present to determine valid shoulder ranges of motion for an elderly population.

PLEASE NOTE: Only information pertinent to your request to utilize human subjects in your project or activity should be included on this form. Where appropriate attach sections from your proposal (if seeking outside funding).

2. PROTOCOL: (Describe procedures to which humans will be subjected. Use additional pages if necessary. Attach any surveys, tests, questionnaires, interview questions, examples of interview questions (if qualitative research), etc., the subjects will be asked to complete.)

Selection of participants:

Participants will be aged sixty and older. We plan to group the participants into age groups of 60-69, 70-79, 80-89, and 90 and older; however if there are an insufficient number of participants in the two oldest groups, they could be combined to form an 80 and older group. We plan to have at least 30 males and 30 females in each age group; that number could be greater than 30 if there are more individuals interested in participating. We also plan to do a pilot study with 15 to 20 participants, all within the age range of 60 and older.

Participants will be eligible for the study if they meet the age requirements and do not meet any of the exclusion criteria. Exclusion criteria for participation in this research will include:

- Presence of active shoulder pathology (within the past two years).
- Past rotator cuff repair.
- Surgery within the past five years of the shoulder, back, neck, chest.
- Mental incompetency or inability to follow directions.
- Inability to assume the test position of supine for all motions except extension which will be measured in a sitting position.
- Severe osteoporosis (as diagnosed previously by a physician).

Participants will be recruited from the community of Grand Forks and surrounding areas. We plan to contact the area Senior Citizens Centers and church organizations for recruitment. We also hope to have some recruitment through word-of-mouth from the participants themselves. We do not plan to recruit any patients from hospitals, clinics, or residential / assisted living facilities. We are not recruiting from nursing homes and other residential facilities because studies in the past have shown that those individuals have decreased range of motion.

We plan to contact the various organizations listed in the previous paragraph, and explain the purpose of the research and ask if they are interested in participating. Researchers will invite all who meet eligibility criteria to participate in the study.

Recruitment will occur until all age groups have the minimum number of participants as listed previously. If there are still individuals who are interested in participating after all groups have been filled, they will be added as time constraints allow.

Participation in this research is voluntary. During the interview and informed consent procedure, the researchers will ensure that all participants understand that their participation is voluntary and that they are free to participate or not participate as they wish. Participants are free to request to be withdrawn from the study up until the time that data collection is complete and analysis begins.

Participants will receive no monetary incentive for participation in this research study nor will they receive any services without charge or course credits. They will receive a small card on which the researcher will list the participant's range of motion values obtained for the various shoulder movements performed. Participants may also receive a brochure detailing the benefits of healthy living and an active lifestyle; brochures may be obtained from the AARP or the APTA, and these brochures will also be available for those who choose not to participate.

Procedure for informed consent

Prospective participants in this research study will read and sign an informed consent statement which will outline the reason for the study, the procedures to be used, and information about contacting the researchers if necessary. Participants will also be given a copy of the consent form to keep for future reference. The researcher will also verbally explain the purpose of the study and answer any questions that the participant might ask.

Procedures

The research will be conducted in the physical therapy department at the University of North Dakota or at an alternate site that might be convenient for the participants. If conducted elsewhere, the researchers plan to use a portable treatment table with the same amount of padding, and the same type of goniometer. The research will be conducted by Karina Koch, Lauri Paulsen, Heather White, Richard Williamson and Michelle LaBrecque. Ms. LaBrecque is an instructor in the UND PT Department, and Mss. Koch, Paulsen, White and Mr. Williamson are all physical therapy students at UND.

During the process of data collection, Ms. Paulsen will perform the informed consent portion, interview and participant warm-up, Ms. White will demonstrate the movements and assist the passive motions of the participants, Mr. Williamson will measure the range of motion with a 12" universal goniometer, and Ms. Koch will record the measurement values obtained.

Participants will be asked to wear a comfortable, non-binding, short-sleeved shirt; however gowns will be available for those who are wearing the incorrect clothing.

We anticipate that participation in this study will require approximately 15 to 20 minutes of the participant's time. The pilot study may require an additional 5 to 10 minutes per session as multiple measurements may be taken.

After the informed consent and interview are finished, each participant will be taken through a brief warm-up period. Warm-up activities will include various active shoulder movements. This warm-up should help to decrease muscle stiffness and decrease any risk of participant injury. The warm-up will consist of 5 active range of motion repetitions of each of the motions to be tested: shoulder flexion, extension, abduction, internal and external rotation. This will be done in a sitting position.

This research study will measure active (AROM) and passive (PROM) range of motion of the shoulders. We plan to measure both shoulders for each participant. Movements to be tested include: shoulder flexion, extension, abduction, internal rotation and external rotation. Participants will be required to lie in a supine position for measurement of all motions except extension, which will be measured in a sitting position. For each of the motions to be tested the procedure will be as follows: one researcher (Ms. White) will passively move the participant's arm through the movement to demonstrate the movement, then the participant will be asked to actively move the arm as far as possible into the position, the other researcher (Mr. Williamson) will then take the AROM measurement with the goniometer, Ms White will then passively move the participant into the same motion until resistance is felt and then the PROM measurement will be taken; a third researcher (Ms. Koch) will be recording the values obtained. Care will be taken to ensure that researchers do not apply any stretching force during the PROM portion of the measurements.

Each participant will be measured only one time in the AROM and once time in the PROM, unless the researcher deems it necessary to take a second measurement. In the pilot study each participant will be measured two times during a one-day period. Each of the shoulder motions will be measured once on each shoulder. Individuals who participate in the pilot study will be eligible to participate again during the formal study.

Procedures will not be randomized during formal data collection for the research study, as each participant will be measured only once and there will be no learning effects. During the pilot study, the order of the measurements will be randomized, both from patient to patient as well as from the first to the second measurements.

There will be no use of confidential personal data (medical records, etc) during this study. Data collected from participants will be identified by a participant number known only by the researchers. Data to be obtained through the participant questionnaire includes general health and lifestyle questions, and questions to determine participant eligibility.

Still photographs will be taken of at least one individual to document the standard positions used for all participants. If possible, all identifying features of the participant will be excluded from the pictures. Consent will be obtained from individuals whose photographs are taken.

We do not anticipate any hazards or adverse effects as a result of the research procedures. If any injuries do occur as a result of this study, participants may seek medical attention as necessary, with the participant and their third party payer assuming responsibility for payment.

Criteria for outcomes

Measurement of variables:

The independent variables are the age of the participant, the gender, activity level / occupation, and hand dominance. The dependent variable is the shoulder range of motion that is measured.

Criteria for completion of research:

Data collection for this study will be complete when each age group has the minimum number of participants (as listed previously).

Strategies of data analysis:

Descriptive statistics: means and standard deviations.

Inferential statistics: T-tests and ANOVA.

Records

Participant records obtained from this study will be kept in a locked filing cabined in the office of Michelle LaBrecque in the Physical Therapy department at UND. Only the researchers and faculty advisor will have access to the participant records that might identify the participant. The records will be kept for a period of three years, after which they will be destroyed. Data obtained from participants will be assembled in aggregate form and analyzed.

3. **BENEFITS:** (Describe the benefits to the individual or society.)

Benefits for this research study include:

- To establish normative values for range of motion in the elderly population.
- Participation in this research study will be of benefit to the participant, giving each participant his or her range of motion values.
- There is minimal data examining normal range of motion values for the elderly; therefore, we hope to establish new data for use by clinicians in physical therapy.

4. **RISKS:** (Describe the risks to the subject and precautions that will be taken to minimize them. The concept of risk goes beyond physical risk and includes risks to the subject's dignity and self-respect, as well as psychological, emotional or behavioral risk. If data are collected which could prove harmful or embarrassing to the subject if associated with him or her, then describe the methods to be used to protect the confidentiality of data obtained, debriefing procedures, storage of data, how long date will be stored (must be a minimum of three years), final disposition of data, etc.)

Risks for this study include:

- There is a chance that the participant may experience slight muscle soreness secondary to the range of motion activities they will be performing. As researchers, we will attempt to minimize and/or prevent this by including a brief warm-up prior to collecting our data.
- There may be a slight risk of injury secondary to the motions they will perform. As researchers we will attempt to prevent this with careful and thorough explanation of the procedure and proper handling techniques.
- Confidentiality will be ensured by identifying the participants by a subject number known only by the investigators.
- Participant records obtained from this study will be kept in a locked filing cabined in the office of Michelle LaBrecque in the Physical Therapy department at UND. Only the researchers and faculty advisor will have access to the participant records that might identify the participant. The records will be kept for a period of three years, after which they will be destroyed.

5. **CONSENT FORM:** Attach a copy of the **CONSENT FORM** to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no **CONSENT FORM** is to be used, document the procedures to be used to assure that infringement upon the subject's rights will not occur.

Describe where signed consent forms will be kept and for how long (must be a minimum of 3 years), including plans for final disposition or destruction.

The researchers will give the participant time to independently read the informed consent form. The researcher will also verbally explain the purpose of the research and answer any of the questions that the participant might have. Participants will also be given a copy of the consent form to keep.

Please see two attached informed consent forms: one for the Pilot study, the other for the main part of the study.

Consent forms will be kept in a locked filing cabinet in the office of Michelle LaBrecque in the Physical Therapy Department at UND for a period of three years; after which, the records will be destroyed.

6. For **FULL IRB REVIEW** forward a signed original and fifteen (15) copies of this completed form, including fifteen (15) copies of the proposed consent form, questionnaires, examples of interview questions, etc. and any supporting documentation to the address below. An original and 19 copies are required for clinical medical projects. In cases where the proposed work is part of a proposal to a potential funding source, one copy of the completed proposal to the funding agency (agreement/contract if there is no proposal) must be attached to the completed Human Subjects Review Form if the proposal is non-clinical; 7 copies if the proposal is clinical medical. If the proposed work is being conducted for a pharmaceutical company, 7 copies of the company's protocol must be provided.

Office of Research & Program Development
University of North Dakota
Grand Forks, North Dakota 58202-7134

On campus, mail to: Office of Research & Program Development, Box 7134, or drop it off at Room 105 Twamley Hall.

For **EXEMPT** or **EXPEDITED REVIEW** forward a signed original, including a copy of the consent form, questionnaires, examples of interview questions, etc. and any supporting documentation to one of the addresses above. In cases where the proposed work is part of a proposal to a potential funding source, one copy of the completed proposal to the funding agency (agreement/contract if there is no proposal) must be attached to the completed Human Subjects Review Form.

The policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use of Human Subjects performed by personnel conducting such activities under the auspices of the University. No activities are to be initiated without prior review and approval as prescribed by the University's policies and procedures governing the use of human subjects.

SIGNATURES:

Principal Investigator	Date
Project Director or Student Adviser	Date
Training or Center Grant Director	Date

(Revised 2/2000)

INFORMATION AND CONSENT FORM

Normative Values for Shoulder Range of Motion in the Elderly Population ($\geq$ 60 years old).

Principal Investigators: Karina Koch, Lauri Paulsen, Heather White, Richard Williamson, and Michelle LaBrecque from the Department of Physical Therapy at the University of North Dakota

You are being invited to participate in this pilot-study to measure shoulder range of motion. The purpose of this study is to determine intra-rater reliability for measuring the shoulder movements.

We hope that the results of this study will provide information for establishing normative values for shoulder range of motion. We also hope to educate those involved in this study to understand some of the benefits of stretching and exercise.

The criterion for being selected for this pilot study includes the following: 1) the first twenty people willing to participate, 2) your absence of surgery within the last five years on the shoulder, neck, back, or chest, 3) your age, 60 years or older, 4) your ability to lie on your back (supine) and sit in a chair in order to measure your shoulder movements, 5) your absence of any shoulder pathology (within the past two years), 6) your absence of "severe osteoporosis" as diagnosed by your physician, & 7) your mental ability to comprehend and follow directions.

As a subject for this study, you will be asked to make an appointment at your convenience. The appointment will have two different times listed (morning and afternoon). You will be required to attend both times; the first time is for the initial testing, and the second time is for re-testing.

On the scheduled day of your appointment and at the designated testing area, a brief questionnaire will be presented to you for information relative to your age, activity level, and any pertinent medical history. You will be asked to wear a comfortable, non-binding short-sleeved shirt when you arrive for your appointment. For measuring the shoulder movements, you will assist the examiners by lying on a treatment table and helping them by moving your shoulder in specific directions, guided by the examiner. The first measurement will be an active movement, showing how much range of motion you can achieve without help; the position will be held for a few seconds while the examiner aligns and reads the goniometer (a measuring tool) placed appropriately in line with the arm and body positioning. After you rest for a few seconds, another examiner will passively move your shoulder in the same motion to the point of resistance, while the first examiner will again measure your range of motion using the goniometer. There will be a total of five shoulder movements tested on both shoulders, right and left. These movements will include flexion, extension, abduction, internal rotation, and external rotation; the students will help guide you through each of these motions. You will be asked to perform two measurements for each motion. The initial testing should take no longer than ten or fifteen minutes.

On the second scheduled appointment that same day we will re-measure your shoulder range of motion in the same manner as before, with the same person measuring. This time the shoulder to start with and order of movements will be randomized. This second measurement will take approximately ten to fifteen minutes. Re-measuring will allow us to show consistency in our measurements and to establish our intra-rater reliability.

As previously stated, the measurements will be within your range of tolerance. We expect the testing to be comfortable for the patient, however, some may experience minor soreness. To minimize this occurrence, you will be taken through a brief warm-up activity prior to the testing procedure. This warm-up activity will last two minutes and will include repetition of the same movements that will be tested.

As an incentive you will receive a record of your shoulder range of motion measurements achieved.

Your name will not be used in any of the reports or in the results of this study. Any information that is obtained in connection with this study and that can be identified with you will remain confidential, and this data will be disclosed only with your permission. Participant records obtained from this study will remain in a locked filing cabinet for three years, and after the three years the records will be destroyed. The participant's data in the study will be identified by a number known only to the investigators, and only the researchers and faculty advisor will have access to the participant records.

The investigators or participant may stop the experiment at any time if the participant is experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to his/her health. Also, if you decide to participate, you are free to discontinue participation at any time and withdraw from the study, without prejudice; however, once the data is measured, recorded, and completed, you may not withdraw your data from the study. Your decision whether or not to participate will not prejudice your future relationship with the Physical Therapy Department at the University of North Dakota.

This study will be voluntary, and there will be no compensation or cost, given to, or collected from the participant.

The investigators involved are available to answer any questions you have concerning this study. In addition, you are encouraged to ask any questions concerning this study that you may have in the future. Questions may be asked by calling Ms. Michelle LaBrecque at (701) 777-2831, or Ms. Lauri Paulsen at (701) 777-9195. If you have any other questions or concerns, please call the Office of Research and Program Development at (701) 777-4279. At your request, you will be given a copy of this form for future reference.

In the event that this research activity results in a physical injury, medical treatment will be available as it is to a member of the general public in similar circumstances. You and your third party payer must provide payment for any such treatment. In case of accident or injury, there will be no liability to the University of North Dakota, the investigators, nor the Physical Therapy department at UND.

All of my questions have been answered and I am encouraged to ask any questions that I may have concerning this study in the future. I have read all of the above and willingly agree to participate in this study as it as been explained to me by Karina Koch, Lauri Paulsen, Heather White, and Richard Williamson.

____
Signature of Participant   Date

______________________   ______________________
Witness   Date   Principle Investigator   Date

#______

INFORMATION AND CONSENT FORM

Normative Values for Shoulder Range of Motion in the Elderly Population ($\geq$ 60 years old).

Principal Investigators: Karina Koch, Lauri Paulsen, Heather White, Richard Williamson, and Michelle LaBrecque from the Department of Physical Therapy at the University of North Dakota

You are being invited to participate in this study to measure shoulder range of motion.

We hope that the results of this study will establish normative values for shoulder range of motion among the elderly. We also hope to educate those involved in this study to understand some of the benefits of stretching and exercise.

The criterion for being selected for this study includes the following: 1) your mental ability to comprehend and follow directions, 2) your absence of surgery within the last five years on the shoulder, neck, back, or chest, 3) your age, 60 years or older, 4) your ability to lie on your back (supine) and sit in a chair in order to measure your shoulder movements, 5) your absence of any shoulder injuries within the past two years, and absence of rotator cuff surgery, 6) your absence of "severe osteoporosis" as diagnosed by your physician, & 7) pilot study participants may be included.

As a subject for this study, you will be asked to make an appointment at your convenience. On the scheduled day of your appointment and at the designated testing area, a brief questionnaire will be presented to you for information relative to your age, activity level, and any pertinent medical history. You will be asked to wear a comfortable, non-binding short-sleeved shirt when you arrive for your appointment. For measuring the shoulder movements, you will assist the examiners by lying on a treatment table and helping them by moving your shoulder in specific directions, guided by an examiner. The first measurement will be an active movement, showing how much range of motion you can achieve without help; the position will be held for a few seconds while the examiner aligns and reads the goniometer (measuring tool) placed appropriately in line with the arm and body positioning. After a few seconds of rest, one examiner will passively move your arm into the same position to the point of resistance, while the first examiner will again measure your range of motion using the goniometer. There will be a total of five shoulder movements, tested on both shoulders, right and left. These movements will include flexion, extension, abduction, internal rotation, and external rotation; the examiners will help guide you through each of these motions. The initial testing should take no longer than ten or fifteen minutes.

As previously stated, the measurements will be within your range of tolerance. We expect the testing to be comfortable for the patient, however, some may experience minor soreness. To minimize this occurrence, you will be taken through a brief warm-up activity prior to the testing procedure. This warm-up activity will last two minutes and will include repetition of the same movement that will be tested.

Some incentives for you will include a brochure on health education, shoulder exercises, and a record of your shoulder range of motion measurements achieved.

There are no standard treatments or alternative treatments prescribed in this study, as it involves only the measurement of shoulder movement. The measuring will not follow a randomized order.

Your name will not be used in any of the reports or in the results of this study. Any information that is obtained in connection with this study and that can be identified with you will remain confidential, and this data will be disclosed only with your permission. Participant records obtained from this study will remain in a locked filing cabinet for three years, and after three years the records will be destroyed. The participant's data in the study will be identified by a number known only to the investigators, and only the researchers and faculty advisor will have access to the participant records.

The investigators or participant may stop the experiment at any time if the participant is experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to his/her health. Also, if you decide to participate, you are free to discontinue participation at any time and withdraw from the study, without prejudice; however, once the data is measured and recorded, you may not withdraw your data from the study. Your decision whether or not to participate will not prejudice your future relationship with the Physical Therapy department at the University of North Dakota.

This study will be voluntary, and there will be no compensation or cost, given to, or collected from the participant.

The investigators involved are available to answer any questions you have concerning this study. In addition, you are encouraged to ask any questions concerning this study that you may have in the future. Questions may be asked by calling Ms. Michelle LaBrecque at (701) 777-2831, or Ms. Lauri Paulsen at (701) 777-9195. If you have any other questions or concerns, please call the Office of Research and Program Development at (701) 777-4279. At your request, you will be given a copy of this form for future reference.

In the event that this research activity results in a physical injury, medical treatment will be available as it is to a member of the general public in similar circumstances. You and your third party payer must provide payment for any such treatment. In case of accident or injury, there will be no liability to the University of North Dakota, the investigators, nor the Physical Therapy department at UND.

All of my questions have been answered and I am encouraged to ask any questions that I may have concerning this study in the future. I have read all of the above and willingly agree to participate in this study as it as been explained to me by Karina Koch, Lauri Paulsen, Heather White, and Richard Williamson.

____
Signature of Participant Date

____
Signature of Witness Date

____
Signature of Principle Investigator Date

#_______

Participant #____.

Age:______ Gender: ☐ Male / ☐ Female

Hand Dominance: ☐ Left / ☐ Right / ☐ Ambidextrous

Occupation (If retired, list former occupation):______________________________

Year retired:______________

Please answer the following questions by checking YES or NO.

	YES	NO
1. Are your shoulders comfortable with your arms at rest by your side?	☐	☐
2. Do your shoulders allow you to sleep comfortably?	☐	☐
3. Do you have any trouble completing your daily activities due to shoulder pain or discomfort? (work, chores, hobbies)	☐	☐
4. Do you have any problems completing any personal hygiene activities due to shoulder pain or discomfort? (cleaning, wiping, etc)	☐	☐
5. Have you had to alter your activities due to shoulder pain or discomfort?	☐	☐
6. Have you ever had surgery on your back, shoulder, neck, or chest? (Including rotator cuff surgery.) If yes, please describe.	☐	☐
7. Have you ever seriously injured your shoulder (Badly enough that you had to seek medical attention). If yes, please describe.	☐	☐
8. Do you experience pain with any shoulder movements? If yes, please list which movements cause pain.	☐	☐
9. Do you have any illnesses or diseases at this time? (High blood pressure, Diabetes, Osteoporosis, etc) Please list:	☐	☐
10. Have you ever broken your arm or shoulder? If yes, please give details:	☐	☐

Memorandum

To: UND institutional Review Board.

Regarding: Change in Protocol for Project #IRB-200104-222

There has been a change in the protocol in our project.
We have not yet begun our data collection for our study, so this change will not affect the results of our project.

The change is with the duties of the researchers. In the original protocol, we specified that Richard Williamson would do the measuring, Heather White would move the participant's arms, Karina Koch would write down the measurements obtained, and Lauri Paulsen would perform the informed consent, survey and warm-up part.

The changes will be as follows:
- For the Pilot study: Karina Koch will be taking the measurements, Lauri Paulsen will keep her same position, and Heather White will be moving the participant's arms and writing down the measurements obtained. Richard Williamson will not be present for the pilot study due to obligations for his military reserve duty.
- For the main part of the study, the only change (from the Pilot study above) is that Richard Williamson will be present, and he will be writing down the measurements obtained from the participants.

Thank you,

Lauri Paulsen

Memorandum

To: UND Institutional Review Board.

Regarding: Status of Project #IRB-200104-222

There has been a change in our project. After the completion of two pilot studies, we had not been able to achieve intra-rater reliability of our measurements. We have elected to change the focus of our research study to the reliability of goniometric shoulder measurements in subjects over the age of sixty. We do not plan to complete any further human data collection. We will use only the data obtained from the two pilot studies for data analysis and for comparison with other research studies found in our review of the literature. There will also be a change in the title of our research study to "Reliability of shoulder goniometric measurements in persons who are elderly".

Please advise us of any other information you might need from us at this time.

Thank You,

Lauri Anne Paulsen

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