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THE RAPID OFFICE STRAIN ASSESSMENT (ROSA): VALIDITY OF ONLINE
WORKER SELF-ASSESSMENTS AND THE RELATIONSHIP TO WORKER
DISCOMFORT

By

Michael Sonne

A Thesis
Submitted to the Faculty of Graduate Studies
through the Faculty of Human Kinetics
in Partial Fulfillment of the Requirements for
the Degree of Master of Human Kinetics at the
University of Windsor

Windsor, Ontario, Canada
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Abstract

The purpose of this study was to examine if office workers were capable of using an online version of ROSA to accurately assess MSD risk factors in their own offices, and see if online training can reduce discomfort. Fifty-five participants completed a four week program where they assessed their own office simultaneously with a trained observer, and either received or did not receive feedback on their performance. A main effect for Assessment Type was seen for the ROSA final score, and mouse and keyboard section, with workers underestimating these risk factors on average. Worker and observer assessments of the chair, monitor and telephone were not significantly different but were significantly correlated. Worker-reported scores were more strongly correlated with discomfort than observer-reported scores. Feedback appeared to have a detrimental effect on worker-assessment accuracy, and the relationship between discomfort and ROSA scores. Mean discomfort decreased across the four weeks of the study, as did ROSA final scores.

Dedication

This thesis is dedicated to my sister, KC. Your hard work, dedication and creativity is inspiring and will take you to great places. Thank you for your unconditional support and the laughs we have shared.

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Thank you to my committee; Dr. Greg Chung-Yan and Dr. Patti Weir, for their contributions towards the development and refinement of this research. Thank you to the staff and faculty in the Department of Kinesiology for their support, kindness and commitment to students. Thank you to CRE-MSD for funding the initial project on the development of the Rapid Office Strain Assessment. Thank you to Dr. Janessa Drake for your kind words and encouragement. I could not be in the position I am now without the confidence you gave me to succeed.

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Glossary

The Rapid Office Strain Assessment (ROSA): A tool developed to quantify risk factors in the office environment by assigning scores to various equipment configurations and worker postures.

Musculoskeletal Disorders (MSD): An umbrella term for a number of injuries and disorders of the muscles, tendons, nerves, and ligaments. Also known as Repetitive Strain Injuries (RSI), Cumulative Trauma Disorders (CTD), or Work-Related Musculoskeletal Disorders (WRMSD).

Computer Workstation: An office workstation is defined as an individual or group workspace featuring a chair, computer monitor, keyboard, mouse, telephone, and any other computer peripherals required to complete computer-related work.

De Quervain's Tendonitis: An inflammation of the extensor pollicis brevis and the abductor pollicis longus tendons of the thumb.

Lateral Epicondylitis: Also known as "tennis elbow". A disorder caused by highly repetitive activities resulting in an inflammation of the tendons inserting onto the lateral epicondyle in the elbow.

Carpal Tunnel Syndrome: A condition in which the median nerve is compressed in the wrist, leading to numbness and muscle weakness in the forearm and hand.

Frame of Reference Training (FOR): A method of educating individuals to conduct evaluation, in which the criteria for evaluation are grouped into smaller and well defined "frames" (specific postures, behaviours, or achievements).

Web-Based Training: A method of educating workers using the computer, where training information and feedback are provided through the internet.

Canadian Standards Association (CSA) International: A not-for-profit membership-based association that develops standards that enhance public safety and health.

Adobe DreamWeaver CS4: Hyper-text mark-up language (HTML) software designed to assist in the development of dynamic standards-based websites and web-based applications.

Observer: the individual conducting an ergonomic evaluation. This would be the individual recording the participant's working postures and workstation configuration using the Rapid Office Strain Assessment.

Worker: The individual who occupies a computer workstation and completes some or all of their working tasks by using the computer.

Workstation: The computer, monitor and input devices, as well as seating arrangements and communication tools (telephones, etc.) that a worker interacts with in order to accomplish working tasks.

Chapter I

1.0 Introduction

Computer-based tasks have become an increasingly more prevalent part of the workplace in the past two decades. In 1989, 39% of workers reported using the computer as part of their required working tasks, with that number rising to 50% in 1994 (Lowe, 1997). In 2000, 60% of Canadian workers reported that they used the computer as part of their job, with 80% of those workers requiring the computer on a daily basis (Lin & Popovic, 2003; Marshall, 2001).

Though computer work is associated with lower levels of muscular exertion compared with manual material handling, the rate of musculoskeletal disorders (MSDs) has increased at a rate parallel to the increase of computer users in the workplace in the past two decades (Bayeh & Smith, 1999). It has been reported that anywhere between 10% and 62% of computer workers experience the symptoms of MSDs as a result of their work (Wahlström, 2005). Risk factors related to the use of MSD onset in computer workers include the presence of sustained, non-neutral postures of the upper extremities (Keir et al., 1999; Village et al., 2005), as well as prolonged static seated tasks (Gerr et al., 2002).

Postures that are associated with musculoskeletal disorders have been commonly assessed using ergonomic checklists, such as RULA – Rapid Upper Limb Assessment (McAtamney & Corlett, 1993), REBA – Rapid Entire Body Assessment (Hignett & McAtamney, 2000), and OWAS – Ovako Working Posture Assessment System (Karhu et al., 1977). The goal of these checklists is to classify jobs and job tasks into certain risk levels, and to guide the ergonomist's decision on how urgently workstation changes must

be made. These checklists were developed primarily for manual material handling tasks, and while loosely applicable to the office environment (Leuder, 1996), they do not account for all of the variables that can contribute to musculoskeletal disorders in this workplace. The Rapid Office Strain Assessment (Sonne et al., 2010) was developed to address these concerns and provide ergonomists with a quick method of identifying and quantifying risk factors in the office environment using a checklist.

The Rapid Office Strain Assessment (ROSA) (Sonne et al., 2010) was developed to assign risk factors to the various components of an office workstation, as well as to quantify a level of risk associated with the workstation. This tool has been tested by comparing total body discomfort scores from the Cornell University (CU) discomfort questionnaire (Hedge et al., 1999) against ROSA final scores achieved by expert workstation assessments. ROSA final scores were shown to be moderately correlated with whole body discomfort ($r=0.38$) and inter- and intra-observer reliability were excellent (ICC= 0.91 and 0.88, respectively). Although methods like ROSA appear to be useful as screening tools when used by a trained professional in an office environment, performing an individual assessment of each employee in a workplace can still be quite time consuming and costly for an employer.

ROSA may show promise in identifying risk factors within the office environment; however, research has indicated that there are challenges and concerns over how the risk factors can be eliminated. Preventative measures for reducing MSDs related to office work include training workers on the risk factors present and the use of methods to reduce their impact. The most effective method of training has been shown to be a training session followed by a participatory approach, where an ergonomist aids a worker

in setting up their furniture within their workstation (Bohr, 2002). However, this approach is also the most time consuming and one of the most costly, as ergonomic experts must be hired to perform the training and new furniture must be purchased. Furthermore, assigning specific departments within an organization to receive training over another department may not be based on quantified evidence of ergonomic risk factors, and the employees with the greatest needs may not receive the risk factor identification and furniture adjustment training they require. Amick and colleagues (2003) found that office ergonomic training alone was not effective in reducing symptom development throughout the course of a workday. This research indicates that the use of adjustable furniture and direct instruction on how to adjust the furniture is essential in preventing the onset and proliferation of MSD symptoms. To limit MSD symptom development, the furniture in an office must be selected carefully, and the training methods that are used must also consider the characteristics of the worker population being trained.

Training protocols related to ergonomics and video-based online training can be categorized as belonging to one of three main approaches. Behaviour modelling (Bandura, 1982), frame of reference (Bernardin & Buckley, 1981), and tutorial approaches are most commonly used to deliver information to workers (Seidel et al., 1978). These training methods can be tailored to suit the population being trained, and can also be adapted from a hands-on, in person style, to an online computer-based approach. One benefit of an online training approach is that it allows for the tracking of user responses, and can also be designed to allow for a dynamic training environment where the learner's input can shape how the remaining training is carried out.

Incorporating feedback and the ability for workers to self-pace and repeat their training at will serves to increase training effectiveness. The goal of external feedback in the learning process is to provide correction on errors in order to increase performance in the person who is learning (Schmidt & Lee, 2005). Feedback can be provided during training, immediately after training, or on a regularly scheduled timeline at set periods after the training has been completed. Additionally, feedback can be precise (as in, all errors, even marginal ones, are corrected), or given only if errors in performance exceed a specific window (Lee and Carnahan, 1990). While feedback can be used as an effective tool in increasing the effectiveness of learning, it does require additional human resources (in the form of an instructor who is observing training, then giving instructions on how to perform the training next time). For the purposes of this study, it is important to examine whether feedback is essential in learning to use the Rapid Office Strain Assessment effectively.

A workplace assessment tool that incorporates the convenience of online delivery with self-guided video-based training and risk assessment would give workers a means by which they can learn about risk factor identification and MSD prevention, and an outlet for describing their perceptions of the demands of their work in a quantitative way. It also provides employers with a more cost-effective alternative to traditional ergonomics training. With an entire office presenting worker self-selected scores related to their workstation setup over a designated time period, more problematic workstations could be targeted quickly and with less cost, and priorities for equipment purchases and/or additional training could be established.

Therefore, the purposes of this study are to determine:

1. if worker self-assessments of their office workstations using an online version of ROSA are comparable to those made by a trained observer.
2. if workers can improve their self-assessment scores using ROSA online over the course of a one month training period. Directed expert feedback and the effect that it has in improving worker scores will be specifically evaluated.
3. the relationships between the ROSA scores from workers and a trained observer and worker-reported discomfort scores.
4. if training using ROSA online can help to reduce worker-reported discomfort.

1.1 Research Questions

1. Are ROSA subsection and final scores reported by office workers using the online version of the tool comparable to those determined by a trained observer for the same workstations?
2. What is the impact of directed expert feedback and number of assessments on the agreement between trained observer- and worker-reported ROSA scores?
3. What are the relationships between worker-reported and trained observer ROSA scores and worker-reported discomfort scores?
4. Is an office ergonomic training protocol using ROSA online effective in reducing musculoskeletal discomfort in office workers?

1.2 Hypotheses

1. Workers will be able to assess their own office workstation accurately using ROSA online. Specifically, worker-reported ROSA scores will not be significantly different from those obtained from a trained observer at any time during the four week protocol. It is expected that participants will be able to complete ROSA online with a high degree of accuracy because only gross postural assessments are required (Burdorf, 1995).
2. An increase in the agreement between worker-reported and trained observer ROSA final and area scores is expected between weeks 1 and 4 of the study. Similar to the work of Frese et al. (1991), it is expected in this study that the group that receive directed expert feedback on their ROSA assessments will experience greater improvement, relative to trained observer assessments, compared to the group that did not receive feedback. This is also supported by Bohr (2000) and Mastronardi (2009), who saw greater training effectiveness when workers received feedback and actively participated in their training sessions.
3. The correlations between worker-reported ROSA scores and worker-reported musculoskeletal discomfort will be higher than those between trained observer ROSA scores and worker-reported discomfort. Based on previous studies on self-reporting, it is expected that workers will over-report risk factors (Heinrich et al., 2004; Wiktorin et al., 1993). Additionally, the presence of pre-existing musculoskeletal discomfort has been shown to factor into over-reporting of ergonomic risk factors (Juul-Kristensen & Jensen, 2005; Mikkelsen et al., 2003). Sonne et al. (2010) found in many cases that high discomfort scores were being reported, although moderate (3-

- 5) ROSA scores were being assessed at the workstation. This may influence the correlation between musculoskeletal discomfort and ROSA scores.
4. Ergonomic assessment alone has not been proven to reduce musculoskeletal discomfort (Amick et al., 2003). However, decreased discomfort has been documented following the addition of adjustable furniture (Amick et al., 2003) and the use of a participatory approach to ergonomic training (Mastronardi, 2009). While no new products will be introduced to the workstations during the course of the proposed study, the knowledge of how to configure the office workstation using the existing furniture, and the ability to quantify the risk level of the office, will provide the workers with the feedback necessary to make and maintain useful changes to their workstation. As a result, it is expected that the repeated worker assessments and the information on making changes to the workstation will lead to decreases in reported discomfort over the span of the 1 month training period.

Chapter II

Review of Literature

2.1 Magnitude of Office Work

The number of computer users in the workforce has been steadily increasing over the past two decades (Bayeh & Smith, 1999) from 33% of workers in 1989 to 60% in 2003 (Lin & Popovic, 2003; Marshall, 2001). Of the 60% of workers that used the computer in 2000 to complete work tasks, 80% of them reported using the computer on a daily basis (Lin & Popovic, 2003). In 2001, 60% of female workers and 50% of male workers reported that they used a computer at work (Marshall, 2001). In 2004, computer workers in Canada reported having 9.9 years of computer experience on average (Wulff-Pabilonia & Zoghi, 2004).

Measures recorded from computer use tracking software have placed the average time of computer use per week at 12.4 hours for computer users in a multi-nation study (Taylor, 2007). These workers on average had a peak daily use of 4.9 hours per day, recording 37,000 mouse clicks and 23,800 keystrokes per week. The most common functions of computers in the workplace have been internet exploration, word processing and email (Lin & Popovic, 2003; Lowe, 1997). The most common characteristics of computer users up until 2003 have been that they were under 55 years of age, had high levels of education or income, worked full time and were in high skill or clerical positions (Lin & Popovic, 2003).

2.2 Musculoskeletal Disorders

Musculoskeletal disorders (MSD) are injuries to the soft tissues of the body (nerves, muscles, tendons, ligaments, blood vessels, and spinal discs) that are a direct result of an individual's interaction with their workplace (OHSCO, 2008).

Musculoskeletal disorders are associated with numerous risk factors. These risk factors include awkward postures, high force exertion, static postures, repetitious activities, and activities of long duration (Carter & Bannister, 1994; NIOSH, 1997). The issues that pertain most prominently to the office environment are those of static and awkward postures, duration and repetition (Village et al., 2005).

MSDs heavily factor into the finances of businesses in Canada, and can mean the difference between profitability and expansion, and non-sustainability. Between 1996 and 2004, MSDs resulted in over \$12 billion in costs to Ontario employers (OHSCO, 2008). The costs of MSDs can be divided into indirect and direct costs (Moore et al., 1993). Direct costs include the resources responsible for labour, equipment, buildings and supplies. The indirect costs include the costs associated with worker rehabilitation, medication and social impact of the disorders (Coyte et al., 1998). Musculoskeletal disorders were also shown to contribute to 42% of all lost time claims and 50% of all lost time days in Ontario in 2007 (OHSCO, 2008).

The symptoms associated with MSDs in the office workplace do not take long to manifest in workers once the risk factors are encountered. In the first month of a three year longitudinal study by Gerr et al. (2002), 46% of neck and shoulder musculoskeletal symptoms were reported by workers. In this same time frame, 32% of hand and arm musculoskeletal symptoms developed. The most common musculoskeletal disorders that

are associated with computer work have been identified as DeQuervain's tendonitis, lateral epicondylitis and carpal tunnel syndrome, all of which increased in prevalence by a factor of 2.2 when office work exceeded 20 hours per week (Blatter & Bongers, 2002; Village et al., 2005). These disorders were more prevalent in the female office worker population when compared to their male counterparts (Carter & Bannister, 1994).

Complaints of musculoskeletal discomfort in the office workplace are common amongst computer users (Village et al., 2005), but the prevalence of discomfort has varied between several studies. Conservative numbers put the percentage of computer users who experience musculoskeletal symptoms between 25-35% (Carter & Banister, 1994), but more recent studies have shown discomfort levels to be as high as 63% (Marcus et al., 2002; Wahlström, 2005). With respect to body region, greater than 35% of workers reported discomfort in the neck, 35% in the shoulder, and 17% and 8% in the wrist/hands and elbow, respectively (Borg & Burr, 1997). Discomfort in the neck was reported by Korhonen et al. (2003) to be present in 34.4% of office workers. Additionally, office workers may experience more musculoskeletal disorders than workers in other lines of employment, such as industrial or manufacturing work (Bendix et al., 1985; Leuder, 1986; Smith et al., 1981).

The slow onset of disability seen with musculoskeletal symptoms associated with office work may lead to a seemingly low prevalence of musculoskeletal disorders in the workplace. This trend is illustrated by Gerr et al. (2002), who analyzed 632 new hires that completed 15 or more hours of computer work per week. In this study, the incidence of the onset of musculoskeletal symptoms in office workers was 58 cases per 100 person-years of work. As rest appears to be the most effective method of alleviating the

symptoms of musculoskeletal disorders (McLean et al., 2001), disorders may never develop unless prolonged computer work occurs on a daily basis (Carter & Bannister, 1994). However, the discomfort experienced by workers still directly influences their productivity in the workplace, and has been mentioned as a contributor to worker disability (Gerr et al., 1991).

Specific characteristics of the workers themselves have also been linked to the risk of musculoskeletal disorders. For example, being female, over the age of 30 years, non-Caucasian, less than the 20th percentile in height, and having a previous history of neck and shoulder discomfort were all seen as risk factors for the onset of musculoskeletal symptoms and disorders (Demure et al., 2000; Gerr et al., 2002).

In conclusion, there is a positive relationship between musculoskeletal disorders and computer work. Risk factors related to posture, work duration, equipment configuration and task demands will all be discussed in section 2.3, alongside specific risk factors related to the use of computer equipment and office chairs.

2.3 Office Ergonomics and Equipment Configuration

2.3.1 The Chair

The chair is the most frequently used component of the office workstation. Regardless of what task the user is performing (be it keying, mousing, reading, or using the telephone), the user will typically be sitting in a chair. Research conducted on computer intensive work has indicated that some users may spend up to 90% of their day sitting in an office chair (Dowell et al., 2001). Sitting in general poses a threat to back health for the computer user. When compared with a standing posture, there are significantly higher compressive forces on the spine when in a seated posture (Callaghan & McGill, 2001). Additionally, research has shown that prolonged sitting is positively associated with disc herniations (Wilder & Pope, 1996).

Comfort while sitting is related to the fit of the chair to the body type of the person, the person's performance or behaviour when seated, and the person's assessment of their comfort while seated (Harrison et al., 1999). The behaviour of the chair user dramatically impacts the ability for the chair to aid in reducing musculoskeletal discomfort. Branton and Grayson (1967) examined sitting patterns in office workers, and found that less than 50% of the time spent sitting was in a posture that received full back support from the backrest. A slouching posture, where the user was only receiving partial support from the seat pan and armrests, was seen 23.4% of the time. An additional 3.3% of the time was spent receiving only minimal support from the seat pan itself, and 23.8% of the time was spent in other postures (such as leaning to one side or the other) (Branton & Grayson, 1967). To ensure that the worker is sitting in a position which encourages

full back support, it is important that the chair is adjusted properly, and that the rest of the workstation is configured correctly as well.

The CSA standards on office ergonomics are a set of guidelines designed to optimize the design of office workstations for its workers. When these guidelines are met, the end result is expected to be healthy, efficient, effective, productive, comfortable and satisfied workers (CSA International, 2000). When examining the features of the chair, the CSA standards state that an office chair should not restrict circulation to the legs, and should allow the user to easily change and maintain postures, support the back and spine and provide a surface that will prevent sliding off the seat. When evaluating the properties of office ergonomic seating, the chair can be broken down into its main components – the seat pan, the backrest and the armrests.

2.3.1.1 Seat Pan

In regards to the seat pan, the height, width and depth, as well as the shape and density of the pan, must all be considered. The ideal height of a chair is considered to be the user's popliteal height plus the thickness of their footwear (CSA International, 2000). If the chair is too high, there will be excessive pressure on the underside of the thigh. This may impinge the blood vessels and nerves flowing to the legs, leading to pain and numbness in the extremities (Tichauer & Gage, 1978). Additionally, if the chair is too high, this may cause the worker to sit forward on the edge of the chair without back support, leading to increased muscle activity in the lower back and possible muscle fatigue (Harisinghani et al., 2004). If the chair is too low, there may be excessive pressure under the buttocks, as well as unnecessary spinal lean and pelvic rotation that compromises the lumbar spine curve (CSA International, 2000; Harrison et al., 1999).

The seat pan height should be adjustable to accommodate a large range of workers. The seat height variations should be adjustable between 380mm and 510mm, which will accommodate a range between the 5th percentile female and a 95th percentile male (CSA International, 2000).

The depth of the seat pan also contributes to the worker's comfort. It is essential that the legs can be positioned so there is no compression or contact at the back of the knee. This will allow the individual to sit back into the backrest, reducing strain on the back muscles (Callaghan & McGill, 2001; CSA International, 2000). If the seat depth is too long, the back rest will not support the lower back, and the resulting rearward curvature of the spine will lead to discomfort (CSA International, 2000; Harrison et al., 1999). Additionally, if the seat pan is too short, pressure will be placed on the back of the thigh, compressing blood vessels and nerves (Tichauer & Gage, 1978). The seat pan depth should be no greater than 432mm, or less than 420mm. If the seat pan is to be adjustable for depth, the adjustability should go from 432mm to 482mm (CSA International, 2000; Keegan, 1953).

Other factors to consider for the seat pan are its width, shape and angle. The seat pan should be wide enough to ensure that people can easily get into and out of the chair, as well as provide them with the ability to adjust their posture. The chair width should be no less than 450mm (CSA International, 2000; Keegan, 1953). The seat pan should be curved behind the back of the knee, creating a "waterfall edge". This curved surface will reduce pressure points that could further contribute to compression of nerves and blood vessels under the thigh (Keegan, 1953; Tichauer & Gage, 1978). The seat pan should also feature a posterior inclination of 5 degrees, which has been shown to reduce lumbar

disc pressures and EMG readings while seated (Harrison et al., 1999). This posterior inclination can make it easier for a user to sit with their back against the backrest. The properties of the seat pan height and depth that are analyzed using the Rapid Office Strain Assessment (Sonne et al., 2010) can be found in Figure 1.

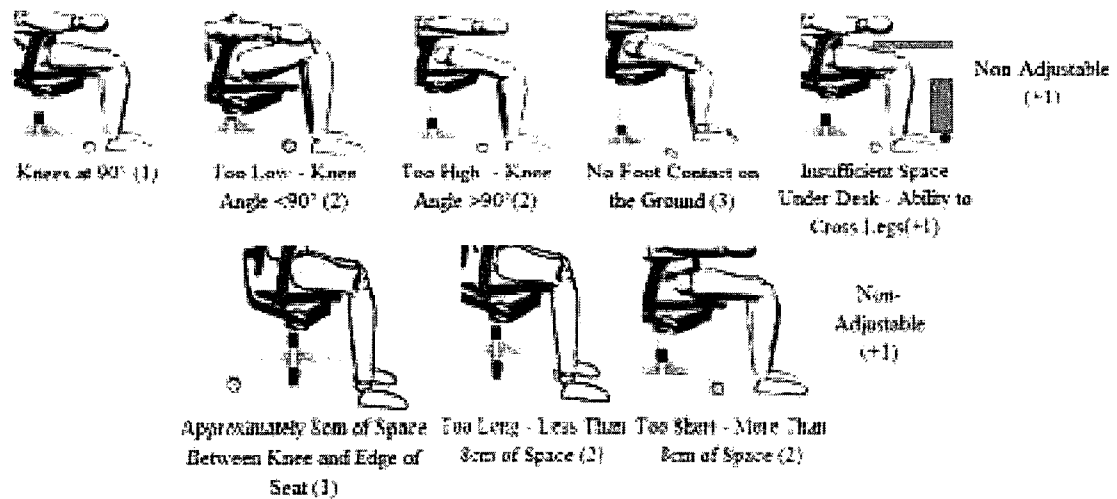


Figure 1: Risk factors pertaining to the seat pan height and depth found in the Rapid Office Strain Assessment, along with the score for each risk factor (Sonne et al., 2010).

2.3.1.2 Backrest

Up to 85% of the population will report back pain at some point during their life (Andersson, 1999). Furthermore, it is estimated that half of all office workers will seek some sort of medical treatment for low back discomfort (Hart et al., 1995). As previously mentioned, there is greater pressure on the intervertebral discs when sitting compared to standing (Nachemson, 1966). The flattening of the lumbar spine and the increased strain on the ligaments, tendons and muscles of the lower back also contributes to the risks associated with working in a seated posture (Harrison et al., 1999). The backrest is essential in preventing kyphotic motion of the lower back and increased muscular

activity, thus creating a more comfortable sitting posture. The backrest properties can be broken down into the inclination of the rest, the shape and position of the lumbar support and the height of the backrest.

The back support should provide support to all regions of the back. However, the most important area of support is in the lumbar region (CSA International, 2000; Keegan, 1953). The addition of a lumbar support has been shown to decrease the amount of muscle activity and disc pressure in the lower back when the user is in a reclined position (Figure 2) (Andersson & Ortengren, 1974). The design of the lumbar support should be vertically convex and horizontally concave, and should feature an adjustability range of at least 50mm, between 150mm and 250mm above the seat pan height (CSA International, 2000). The main source of increased muscular activity and disc pressure in the lower back is the rearward rotation of the pelvis associated with the seated posture (Wu et al., 1998). Wu and colleagues (1998) found that the presence of a pelvic wedge prevented this rotation, thus decreasing the pressure on the lower back. The pelvic wedge was also a source of discomfort for some users. A compromise could be a combination of a lumbar and pelvic support (Dowell et al., 2003) combined with ideal sitting posture, as outlined in the CSA Standards (CSA International, 2000). The importance of limiting the movement of the pelvis during sitting has been a long standing consideration. Keegan's (1953) rules for chair design indicate that there must be a gap between the backrest and the seat pan to allow for the posterior projection of the sacrum. The amount of lower back support present in the backrest is paramount in ensuring low back comfort while sitting. However, the backrest is only as effective as the user's sitting posture and their adherence to contact with the back support during sitting.

Contact with the back support is influenced by the position of the backrest and the task requirements associated with the worker's job. Sitting postures can be broadly categorized as forward, upright or reclined. A reclined posture of approximately 110° relative to the seat pan has been associated with lower levels of activity in the erector spinae muscles (Boudrifa & Davies, 1985). As seen in Figure 2, when backrest angle increases, the amount of back muscle activity decreases (Anderssen & Ortengren, 1974).

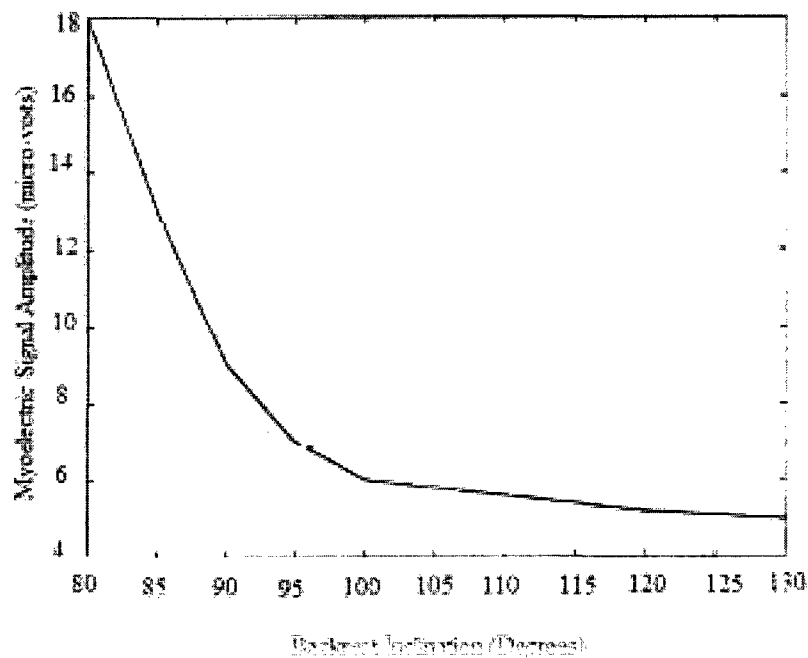


Figure 2: Myoelectric amplitude reduces with increase in seat back inclination (Anderssen & Ortengren, 1974).

As backrest angle increases, the view of the monitor is reduced and forward head postures with respect to the body begin to contribute to neck and upper back discomfort (Haughie et al., 1995). With this in mind, it is important to achieve an optimal level of backrest recline while interacting with the computer. It is recommended that the backrest angle be adjustable between 93-113° with respect to the seat pan (CSA International,

2000), which falls in line with earlier research indicating that the minimum amount of acceptable seat back recline (the degree to which the user leans backwards into the chair) is 105° (Keegan, 1953). With backrest inclination angles of greater than 110°, increased lower back comfort can be expected in workers, up to a certain point. However, with higher amounts of backrest inclination, the amount of reach required to access computer peripherals will also increase, resulting in increased strain on the muscles of the upper back and shoulders. The value of 110° (Harrison et al., 1999) appears to be a level of recline acceptable to achieve worker comfort and minimize the amount of reaching and non-neutral head and neck postures. The properties of the backrest analyzed using the Rapid Office Strain Assessment (Sonne et al., 2010) can be found in Figure 3.

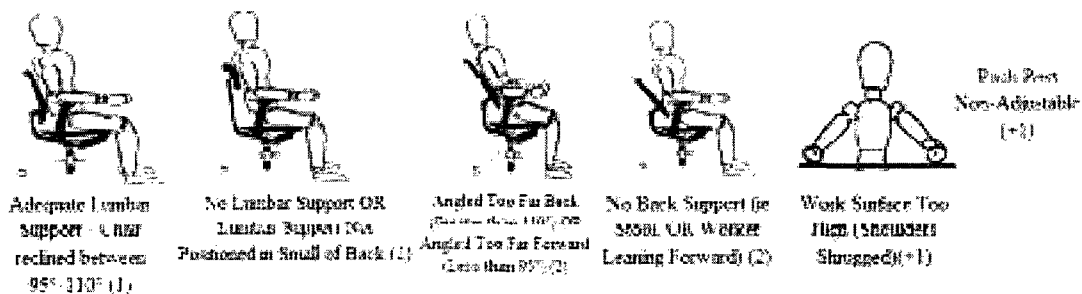


Figure 3: Risk factors pertaining to the backrest found in the Rapid Office Strain Assessment, along with the score for each risk factor (Sonne et al., 2010).

2.3.1.3 Armrests

Armrests reduce intervertebral disc pressure and muscle activity in the upper back and shoulders (Brattgard, 1969; Hasegawa & Kumashiro, 1998). The presence of armrests on a chair has also been reported to increase comfort in users (Hasegawa & Kumashiro, 1998), and reduce the static loading on the shoulder and arm muscles during mousing (CSA International, 2000; Lueder & Allie, 1997). However, the mere presence of armrests does not ensure that the worker will be comfortable. It is important to have the armrests configured to fit the user. The CSA standards state that armrests should be height adjustable within 180mm-280mm, and the armrest should be at least 180mm long. The inside distance between armrests should be 450mm to allow users safe and easy entry and exit from the seat (CSA International, 2000). Additionally, the shape and composition of the armrest must also be considered. It is important that the armrest be free of sharp or hard edges, as this may cause pressure points leading to damage to the soft tissues in the forearms (Szabo & Gelberman, 1987). The risk factors related to the armrests that are analyzed using the Rapid Office Strain Assessment (Sonne et al., 2010) can be found in Figure 4.

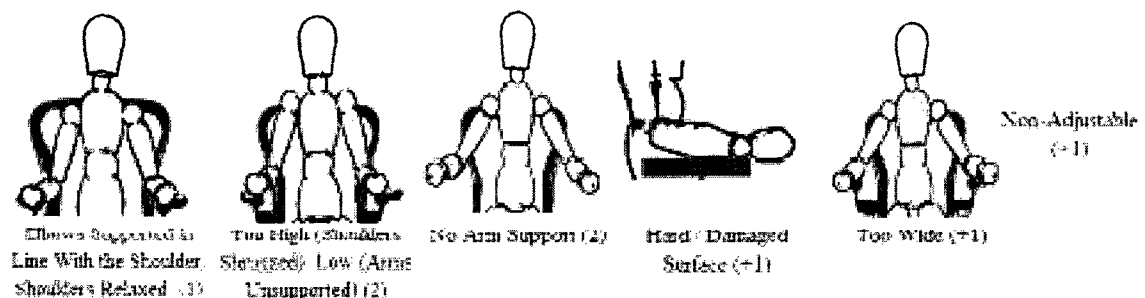


Figure 4: Risk factors pertaining to the armrests found in the Rapid Office Strain Assessment, along with the score for each risk factor (Sonne et al., 2010).

Seated comfort is a multi-factorial challenge. As indicated in this section, chair design and adjustability, as well as the interaction of the user with the chair, all factor into whether or not a worker is comfortable in their workstation. A neutral sitting posture has been shown to be associated with lower levels of musculoskeletal discomfort (Genaidy & Karwowski, 1993). The ideal postures listed within the CSA standards on office ergonomics promote neutral positioning of the body in order to improve comfort.

2.3.2 *The Monitor*

The monitor position greatly affects how a worker interacts with their workstation. Heights and distances away from the worker can influence seated posture, as well as the interaction with other computer peripherals such as the mouse, keyboard and telephone (Burgess-Limerick et al., 1998). The height, angle and distance from the user all play a role in determining the optimal position of the monitor.

The CSA standards indicate that the ideal height of the monitor should be where the top row of text on the screen is level with the worker's sitting eye height (CSA International, 2000). This monitor position is intended to allow the worker to view the screen with the head and neck in a neutral posture. There is research that contradicts the use of either a high and low monitor position. A high monitor position is associated with greater visual strain (Bergvist & Knave, 1994; Jaschinski et al., 1998; Sommerich et al., 2001; Sotoyama et al., 1996), and a low monitor position is associated with musculoskeletal stress of the head, neck and upper back (Figure 5) (de Wall et al., 1992; Grieco et al., 1982; Sommerich et al., 2001).

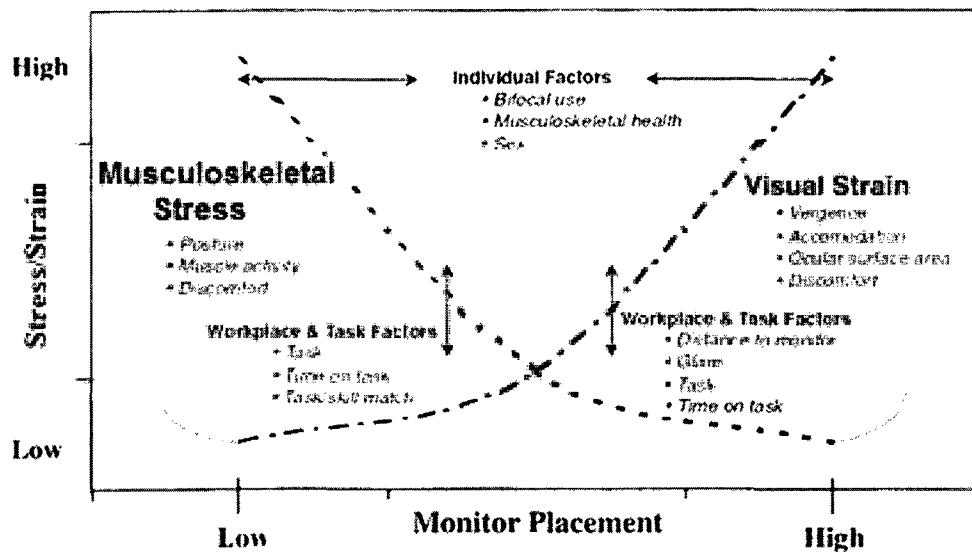


Figure 5: Monitor position and the trade-off between visual strain and musculoskeletal stress (Sommerich et al., 2001).

A conflicting report has found that lower monitor positions have been associated with less muscle activity in the trapezius (Burgess-Limerick et al., 1998), as well as less reported user discomfort (Hill & Kroemer, 1986). However, a very low monitor position (40° below eye level) compared to a moderate monitor position (15° below the sitting eye level) was deemed to be less favourable by users (Turkville et al., 1998). Increased muscular activity in the neck and upper back has also been seen in high monitor positions (Straker et al., 2008). These conflicting reports on high and low monitor position can make it difficult to recommend where the monitor should be positioned for the end user, though lower to moderate monitor positions seem to provide the user with the optimal trade-off between musculoskeletal stress and visual strain (Figure 5). The risk factors pertaining to the monitor that are analyzed using the Rapid Office Strain Assessment (Sonne et al., 2010) can be found in Figure 6.

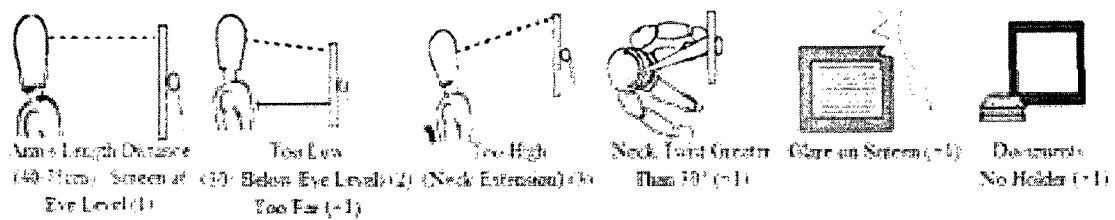


Figure 6: Risk factors pertaining to the monitor found in the Rapid Office Strain Assessment, along with score of each risk factor (Sonne et al., 2010).

2.3.3 *The Keyboard*

Using the keyboard has been compared with repetitive, upper limb intensive industrial work in terms of the amount of sustained non-neutral postures and rapid, repetitive motions that have been known to cause musculoskeletal disorders in the upper extremities (Serina et al., 1999). The CSA standards on office ergonomics (CSA International, 2000) indicate that the keyboard should be positioned with the worker's arms hanging relaxed from the shoulders, and elbows at approximately 90° to allow the wrists to be fairly straight while keying. Deviations from a straight wrist position and relaxed shoulders have been associated with discomfort (Fogelman & Lewis, 2002; Korhonen et al., 2003). To obtain an ideal keyboard height, two strategies can be used. An adjustable keyboard tray can be positioned to the proper height for the worker, or the worker can raise or lower their chair to keep the keyboard at the proper height. If the keyboard platform is too high, the user may have to shrug their shoulders, which may increase the stress on the upper back, neck and shoulder muscles (Lueder & Allie, 1997). If the keyboard is too low, excessive extension of the wrists can contribute to fatigue and possible injury in the extensors of the forearm (Szeto & Ng, 2000), as well as increased carpal tunnel pressure (Hedge et al., 1999).

A horizontal distance of greater than 12cm from the edge of the desk surface to the “J” key on the keyboard has been associated with a lower incidence of hand and arm disorders and discomfort (Marcus et al., 2002). Additionally, a “J” key height of greater than 3.5cm above the desk surface, and radial wrist deviation greater than 5° while mousing was associated with a greater risk of hand and arm disorders and symptoms.

To combat non-neutral postures of the wrist during typing, alternative keyboard designs have been explored. Split keyboard designs attempt to position the wrists in a neutral position by separating the keyboard in half and increasing the opening angle (the degree that the front of the keyboard separates between the G and H keys), as well as the gable angle (the degree to which the middle of the keyboard elevates with respect to the outer edges of the keyboard) (Rempel et al., 2007). Research into the effects of split keyboards on discomfort has been unable to show significant results in terms of increased productivity or comfort (Swanson et al., 1997). However, from a muscle activation perspective, a split keyboard, such as the Microsoft Natural Ergonomic Keyboard (Microsoft Hardware Group, Redmond, Washington, USA), has been shown to reduce EMG activity in the muscles of the forearm when compared to standard keyboards (Szeto & Ng, 2000). Additionally, joint angles are closer to neutral when using a keyboard that has an opening angle of 12°, a gable angle of 14° and a slope (the degree to which the front of the keyboard is elevated with respect to the back of the keyboard) of 0°. This keyboard configuration was also rated to be the most preferred keyboard configuration by users in a study comparing standard keyboards and split keyboards (Rempel et al., 2007). Use of a split keyboard, combined with a proper keyboard height, was also associated with less ulnar deviation and forearm pronation (Rempel et al., 2009). The risk factors

pertaining to the keyboard that are analyzed using the Rapid Office Strain Assessment (Sonne et al., 2010) can be found in Figure 7.

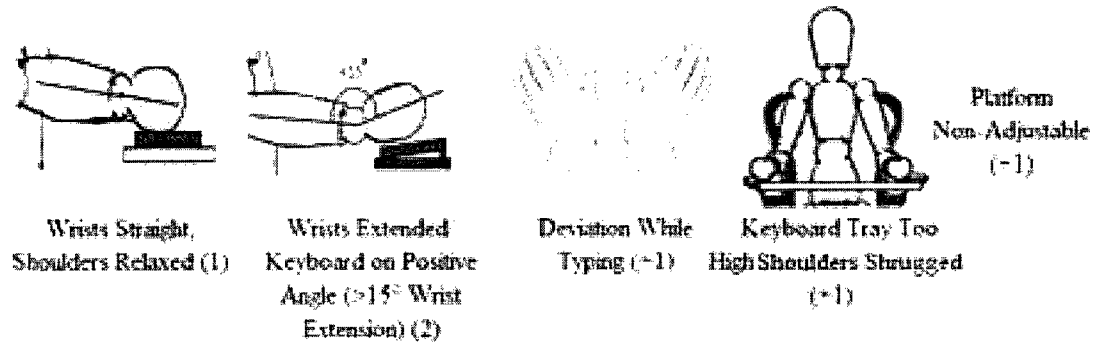


Figure 7: Risk factors pertaining to the keyboard found in the Rapid Office Strain Assessment, along with the score for each risk factor (Sonne et al., 2010).

2.3.4 *The Mouse*

With modern computer graphic user interfaces, a majority of computer work involves the user moving a cursor on the screen by physically manipulating a mouse or trackball. Estimates of total average mouse use during the workday have been reported as approximately 60% of the total computer work (Fagarasanu & Kumar, 2003; Harvey & Peper, 1997). The typical mousing configuration for a right handed worker has them placing their mouse to the right side of the keyboard and using their right arm to control the cursor. In this scenario, the anterior and medial deltoid (Cook & Kothiyal, 1998), the right upper trapezius and rhomboids (Harvey & Peper, 1997) have shown increased muscular activation, as well as increased pressure in the carpal tunnel compared to neutral straight wrist postures (Keir et al., 1999) when compared to a scenario where the mouse is directly in line with the shoulder.

The risk factors associated with the mouse can be categorized based on the mouse type (traditional or otherwise) and the position of the mouse during use. The CSA guidelines on office ergonomics (CSA International, 2000) state that the mouse should be positioned to allow the hand to be at the same level as the elbow, with the wrist as straight as possible (Cook & Kothiyal, 1998; McAtamney & Corlett, 1993). If the mouse is used for a long period of time, the palm or forearm should also be supported to minimize the static contractions of the shoulder muscles (CSA International, 2000; Lueder & Allie, 1997). A challenge associated with a standard configuration of the mouse and keyboard for a right handed user lies in the position of the numerical keypad on a standard keyboard. The numerical pad causes the user to extend the arm further to the right, which causes an increase in shoulder muscle activity (Cook & Kothiyal, 1998). The recommended course of action to eliminate this risk factor is to implement one of the following solutions: Use the mouse with the left hand on the left side of the keyboard, provide a keyboard without a numerical pad, or provide a slide over platform that will position the mouse on top of the numerical keypad (CSA International, 2000).

Alternative mousing devices, such as the trackball, allow for a central position of the cursor control. This central position has been associated with decreased muscle activity when compared to the traditional right side mousing position (Harvey & Peper, 1997). The trackball has been shown to be associated with lower levels of ulnar deviation in users, but has also been shown to increase the amount of wrist extension required to control the cursor (Fagaransanu & Kumar, 2003). Another alternative mousing solution has been shown to encourage neutral postures of the wrist and forearm while mousing. Aaras and colleagues (2002) tested the joystick style of mouse and found

significant decreases in worker discomfort in comparison to a traditional mouse over the course of a 1 year testing period.

The style and position of the mouse depends on the task demands placed on the worker. An alternative input solution, such as a tablet for graphic design, is a prime example of a cursor control device that fits the needs of the task demands. Risk factors pertaining to the mouse that are analyzed using the Rapid Office Strain Assessment (Sonne et al., 2010) can be found in Figure 8.

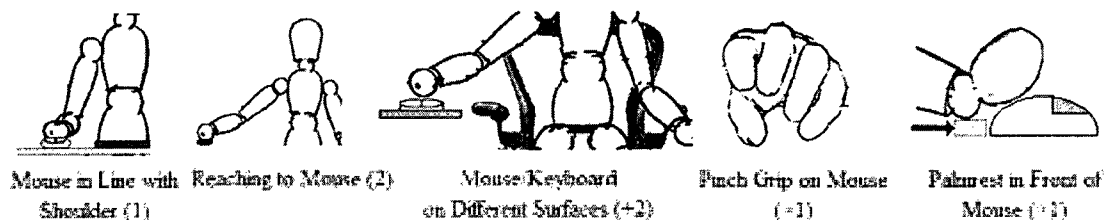


Figure 8: Risk factors pertaining to the mouse found in the Rapid Office Strain Assessment, along with the score of each risk factor (Sonne et al., 2010).

2.3.5 Duration of Exposure

The duration of office work has been shown to increase the amount of discomfort that workers experience, as well as how rapidly the onset of discomfort occurs from the initiation of office work (Blatter & Bongers, 2002; Brandt et al., 2004; Fogelman & Lewis, 2002; Kryger et al., 2003; Marcus et al., 2002). The risk of musculoskeletal discomfort was greater for workers who used the keyboard for greater than 4 hours a day compared to workers who used the keyboard for less than 4 hours a day, as reflected by odds ratios of 1.46 and 1.05, respectively (Blatter & Bongers, 2002). The impact of computer work duration was different in both men and women, with a significant increase in the odds of experiencing musculoskeletal discomfort occurring at 6 hours of

work per day in male computer workers, and at 4 hours of work per day in female computer workers (Blatter & Bongers, 2002). The duration of computer work over the course of a week also influenced the risk of developing musculoskeletal disorders, as the risk of disorders increased significantly with greater than 20 hours of computer work (Village et al., 2005).

Localized discomfort has also been shown to increase in workers who used the computer for long periods of time throughout the work day. Forearm pain risk increased with use of a mouse device for more than 30 hours per week, and with more than 15 hours of keyboard use per week (Kryger et al., 2003). Right forearm pain also increased in a linear fashion with an increase in mouse use between 0-30 hours, and with increasing keyboard usage between 0-15 hours (Kryger et al, 2003; Lassen et al., 2004). Increases in discomfort and disorders of the neck and shoulder have been associated with prolonged computer work. The right shoulder pain prevalence ratio increased from 1.6 to 2.5 in workers who worked greater than 30 hours per week at the computer, when compared to workers who performed less than 30 hours of computer work per week. The pain prevalence ratio increased for tension neck syndrome from 2.5 (for workers who worked between 25-29 hours at the computer) to 4.7 (for workers who spent more than 30 hours a week at the computer) (Brandt et al., 2004). The 2004 study by Brandt and colleagues also saw the relative risk ratio for new neck pain increase from 1.8 for 15 hours of computer work per week to 2.4 for greater than 30 hours per week. New neck and shoulder pain symptoms were also significantly correlated with greater than 20 hours of mouse work per week and keyboard use of greater than 15 hours per week, which was

close in magnitude to the amount of exposure to computer work that was associated with discomfort and disorders of the forearms (Kryger et al., 2003; Lassen et al., 2004).

2.4 The Rapid Office Strain Assessment (ROSA)

Ergonomic checklists have been used for the past 3 decades to quickly assess and prioritize factors related to the onset of musculoskeletal disorders. The Rapid Upper Limb Assessment (RULA) (McAtamney & Corlett, 1993), Rapid Entire Body Assessment (REBA) (Hignett & McAtamney, 2000) and Ovako Working Posture Analysis System (OWAS) (Karhu et al., 1977) use graphical depictions of postures that correspond with a risk score reflective of the overall likelihood of the posture causing a musculoskeletal disorder. These checklists all serve as a method of quickly screening a large pool of jobs to determine where intervention needs to occur, and how urgently that intervention should take place. However, RULA, REBA and OWAS are primarily used to screen jobs related to manual material handling tasks, and some of the information contained within each checklist is not applicable to an office workstation.

Adaptations to RULA (McAtamney & Corlett, 1993) have allowed for general analysis of upper limb posture associated with computer work (Leuder, 1996). This adaptation can analyze computer-related working postures, but the tool does not account for factors related to specific office equipment (such as the chair, mouse and keyboard), and their contribution to musculoskeletal discomfort. Another office ergonomic risk checklist is the Office Ergonomic Assessment (OEA), developed by Robertson and colleagues (2009). The OEA allows for the systematic evaluation of all furniture and accessory positioning within the office. It also provides the user with a score reflecting how effective ergonomic training was, and how adjustable the furniture within a

workstation is. The scores produced from the OEA do not correspond with worker discomfort, however, and as such, it provides no information related to the impact of equipment positioning on worker musculoskeletal comfort.

The Rapid Office Strain Assessment (ROSA) (Sonne et al., 2010) (Appendix F) is a tool that was developed to screen office workstations for risk factors related to the onset of musculoskeletal discomfort. To accomplish this, risk factors are grouped into the following categories: chair, monitor, telephone, mouse and keyboard. Each risk factor group is also influenced by a duration score, reflective of the exposure to each of the components of the workstation. The scores were derived from a review of literature related to risk factors in office and computer work. Ideal working postures were identified using the CSA Standards on Office Ergonomics – CSA Z412 (CSA International, 2000), and were assigned a score of 1. Equipment positions or working postures that deviated from ideal were assigned increasing scores of up to 3. Risk factors for each section of ROSA were identified as fixed factors (only one factor could be selected out of a choice of 2 or more factors) or additive factors (more than one factor could be added on to the fixed factor). Scoring charts were created similar to the grand score chart found in RULA and were used to compare two areas of the workstation against one another and produce a score reflective of the overall risk factors for the chair and the other workstation peripherals (monitor, telephone, mouse and keyboard).

The scoring process begins with the chair subsection, where scores from the chair height and chair depth section are added together to form the vertical axis in the Section A scoring chart (Figure 9A). Scores from the chair back rest and armrests sections are added together to form the horizontal axis for the Section A scoring chart. With these

two scores, the intersecting cell is found, and the Section A score is received. To receive the final chair score, the duration value (-1, 0, or 1) is then added to the Section A score.

The score for Section B (Figure 9B) is achieved by using the score from the monitor section (plus monitor duration factor) as a value on the horizontal axis, and the telephone section score (plus telephone duration factor) as a value on the vertical axis. The intersecting score is the Section B score, which then composes the vertical axis on the monitor and peripherals scoring chart. The Section C (Figure 9C) score is a product of the keyboard (and duration) score on the horizontal axis, and the mouse (and duration) score on the vertical axis. This score is then used as the horizontal axis for the Monitor and Peripherals score (Figure 9D). The score that is achieved from this scoring chart is then used as the horizontal axis in the ROSA final score chart (Figure 9E).

The Section A chair score forms the vertical axis of the ROSA final score chart, and is used to determine the final risk score out of a scale of 1 to 10 (with 10 representing the highest possible risk).

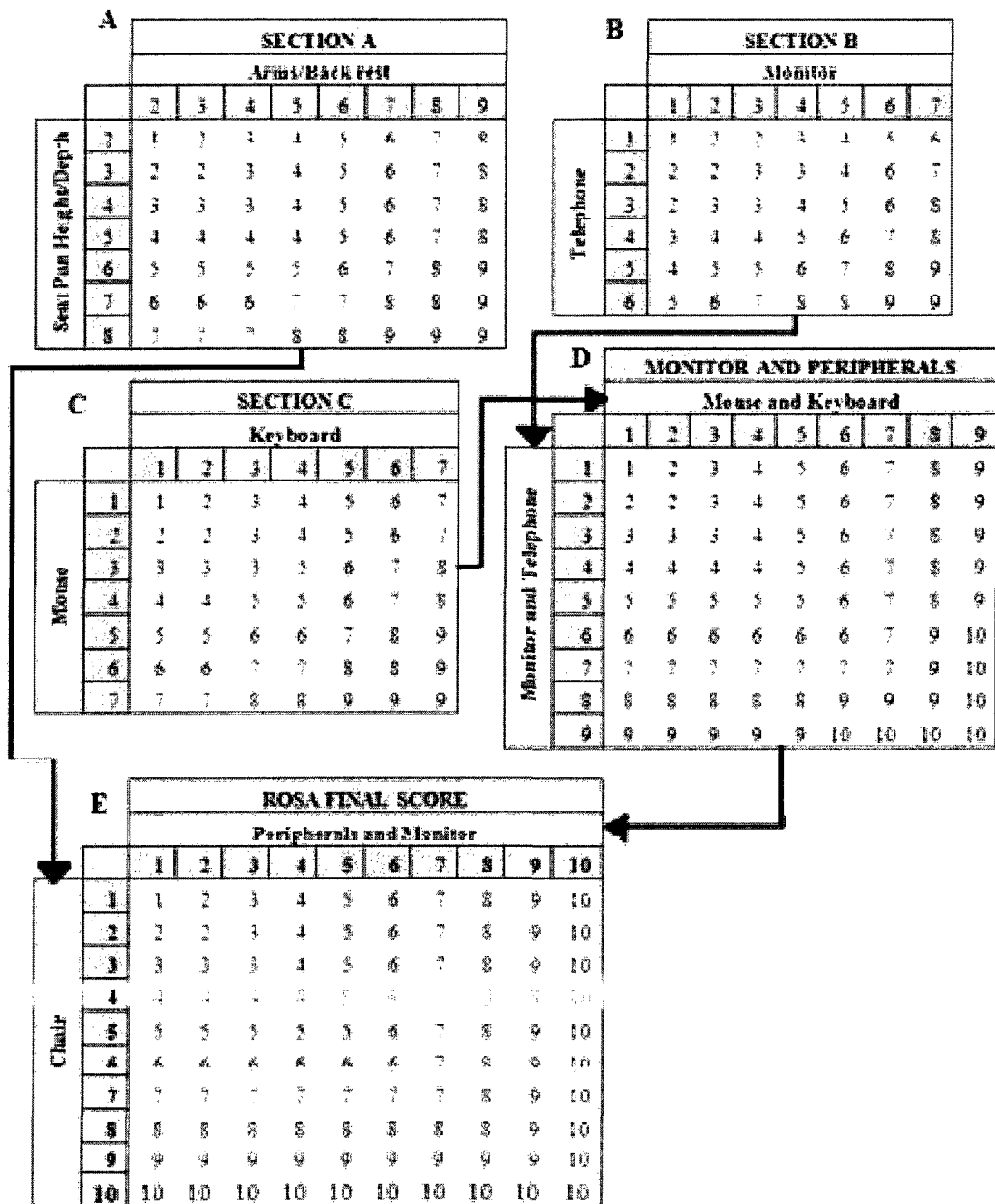


Figure 9: ROSA scoring charts – A – Section A; B – Section B; C – Section C; D – Monitor and Peripherals; E – ROSA final score (Sonne et al., 2010)

From the values achieved from the peripherals and chair score, a ROSA final score on a scale of 1-10 is achieved, with 1 representing the minimum level of risk within the office, and 10 representing the maximum level of risk. Each risk factor in ROSA was represented on a one-page paper checklist in text and graphical depiction of each equipment configuration or posture. The risk factors analyzed within ROSA can be seen in Figures 1, 3, 4, 6, 7 and 8.

ROSA final score and discomfort relationships were examined by Sonne et al. (2010) by comparing ROSA scores from 72 office assessments with discomfort questionnaire data collected from workers who used their workstations for greater than 50% of their work week. A moderate significant correlation of $r=0.38$ was found between ROSA final scores and total body discomfort. An analysis of variance conducted on the mean discomfort levels for each ROSA final score level collected indicated a significant increase in discomfort between scores 3 and 5, as well as an overall increase in mean discomfort as ROSA final scores increased between 2 and 6.

To assess the inter-rater reliability of ROSA scores, three trained observers simultaneously assessed 14 workstations (Sonne et al., 2010). Intra-rater reliability was assessed by having three trained observers assess three mocked up workstations once a week for four weeks. Inter- and intra-rater reliability was excellent, with reported intra-class correlation coefficients of 0.88 and 0.91, respectively.

The Rapid Office Strain Assessment tool can effectively and reliably evaluate workstations for risk factors related to musculoskeletal discomfort. However, assessments must still be completed by individuals trained in ergonomics. In a practical

application, conducting ergonomic workstation evaluations of every office within a facility would be a time consuming task for an ergonomist and expensive for a company. One of the purposes of this study is to examine how effectively workers can perform self-assessments of their workstation using an online version of ROSA. If it is found that workers can accurately assess their own offices, then considerable time and costs savings could be realized.

2.5 Worker Training

Forms of computer training, such as tutorials and web-based courses, allow users to control the pace of learning and the schedule over which they complete their education. An effective computer-based training program must convey the learning material to the user in a method that is as effective, or more effective, than traditional classroom setting (with one instructor and multiple students) in order for the process to be beneficial to the user. This section aims to highlight various training approaches that can be used to deliver ergonomic information relevant to office workstations, as well as the advantages and disadvantages of computer training. The self-guided component of the training conducted centres around a worker viewing videos on their computer, then performing adjustments to their own workstations based on what they deem to be appropriate from the training material. Finally, the determinants of success or failure and the important components of a training program will be discussed.

2.5.1 Training Approaches

Two common approaches to computer-based training are tutorial-based and behaviour modelling (Gist et al., 1989). A third form of training, Frame-of-Reference

(FOR) training (Bernardin & Buckley, 1981), is also applicable to a computer training environment. In the tutorial approach, lessons are presented to the student in text-based examples during computer-based instruction, and students select appropriate responses in structured drills. The training then provides the students with responses and feedback on their performance. Tutorial training tends to be somewhat self-contained, with the students applying their learning directly back into the computer program in the form of answering questions (Seidel et al., 1978). The tutorial approach is advantageous, as it allows the students to control the pace of their lessons, to learn in private, and to gain rapid feedback (Gist et al., 1988).

Behaviour modelling is a training approach where students view a live or video-taped instructor who demonstrates the required behaviours for intended performance. The student then emulates the behaviour required to achieve the desired or correct end result. This method has been shown to increase user self-efficacy in the performance of tasks related to the computer (Gist et al., 1989). A video-taped presentation combined with an interactive computer program has also been shown to increase mastery of software-related tasks when compared against strictly tutorial-based approaches (Gist et al., 1988, 1989). Furthermore, a behaviour modelling approach associated with computer usage has shown to be correlated with positive work styles, less negative affect during training and greater satisfaction with training (Gist et al., 1989).

Finally, Frame-of-Reference (FOR) training serves as a method to effectively increase rater accuracy compared to other types of training (Bernardin & Buckley, 1981; Schleicher et al., 2002). FOR training provides observers with strict guidelines for rating performance by providing definitions of each rating dimension, defining scale anchors,

allowing observers to practice their rating skills, and providing feedback on rating performance (Aguinis et al., 2009). FOR training imposes a categorization system on the observer, and helps in the observer's ability to define and interpret performances (Pulakos, 1984). One of the goals of FOR training is to help keep the rater's bias or personal experiences out of the evaluation of tasks as much as possible (Schleicher & Day, 1998). Research on FOR training has shown effectiveness in improving rater accuracy, reliability and validity because it reduces the information processing demands placed on observers and provides greater clarity to the dimension definitions (Schleicher et al., 2002). FOR training has also been shown to be applicable to a web-based application (Aguinis et al., 2009), leading to decreased biases in personality-based job analyses.

However, one of the primary limitations of FOR training is the forced linearity of the evaluation process. As observers are forced to categorize performance into strict frames or bins (Sulsky & Day, 1992), any behaviours or performances that fall outside of these frames may go unrated. If the frames are not selected properly, the overall rated performance for a task may not be properly evaluated.

2.5.2 Advantages of Computer-Based Training

Computer-based training typically offers learners more control over their learning by increasing their practice time, time on task and their attention levels on tasks (Brown, 2001). Computer-based training has been shown to increase student scores by an average of 0.30 standard deviations when compared to a traditional classroom setting (Kulik & Kulik, 1991). A meta-analysis conducted by Kulik and Kulik (1991) showed that 81% of

studies that examined computer-based instruction had better results than traditional instruction methods (such as lecture or textbook-based instruction). The meta-analysis also reported a general effect size of 0.30 for the improvements from a computer-based instruction class over a traditional instruction class.

Computer-based instruction has also been shown to be a more cost-effective method of instruction compared to tutoring (Niemiec et al., 1986), and is more time-effective than traditional instructional methods (Kulik et al., 1980; Orlansky & String, 1979). Furthermore, students have indicated a preference towards computer-based instruction because of the level of control over the learning process (Katz, 2002) because they are able to access their material independently, and follow the path they choose through the lessons (Picoli et al., 2001).

In summary, the advantages of a computer-based training approach are an increase in learner control over the teaching process, an increase in cost and time-effectiveness, and that students prefer it over other approaches. A combination of the various teaching methods would allow for the best features of each training approach, and could lead to more effective delivery of training material. This study aims to provide a balanced approach by incorporating a Frame-of-Reference analysis of posture, and a comparison of worker posture against what is viewed on video during training.

2.5.3 Disadvantages of Computer-based Training

While there are a number of advantages of computer-based training, the drawbacks of this type of instruction also need to be addressed. In some situations, students that were given complete control over their computer learning experience chose

to terminate their learning experience before they mastered the task they were attempting to learn (Tennyson, 1980). When training is provided through a computer, there is also a tendency to reduce the personal touch that good instructors provide in a teaching and learning setting. There is no opportunity for the instructor to notice a struggling student, and as a result, change their teaching style or alter what information to deliver next (Cook, 2007). The success of the computer training process also relies on the user's ability to navigate the programs properly and make appropriate decisions (Brown, 2001).

A second disadvantage is that structured computer-based training has distinct yes and no answers, with no middle ground or room for error. To allow for immediate feedback, multiple choice type quizzes are typically used to examine students. If the results are then displayed to the learner as a total score, without information on which answers were correct or incorrect, there can be a negative impact on the training process. Recognizing errors and providing feedback on how to correct them can serve an important role in the training process, increasing the satisfaction with the overall learning experience (Frese et al., 1991). When considering the design of a computer training program, the role of errors and error correction in the learning experience should be considered.

Moreover, while computer learning has led to higher self-efficacy in users, participants may be less satisfied with the learning process when compared to the traditional instructional approach (Picoli et al, 2001). This may be due to a lack of mastery in the tasks, as reported in previous studies (Steinberg, 1989; Tennyson, 1980).

In summary, the disadvantages of computer training are a lack of mastery in self-selected training approaches, a lack of feedback from errors in the educational process and less satisfaction in the learning process. To design a more effective computer-based training program, it is important to address these issues.

2.5.4 Role of Feedback in Training

Feedback in training typically occurs upon the completion of a task, and usually consists of information regarding one's performance given from the instructor to the trainee (Hattie & Timperly, 2007). The role of feedback on errors during training serves as a method of correcting mistakes and allowing for improved performance during the next completion of a task (Frese et al., 1991). Providing feedback has also been shown to increase performance in monitoring tasks during self-guided learning (Nietfied et al., 2006). Feedback on performance is very important, as it helps a learner measure their progress, as well as correct their mistakes and improve their skills. There are three main goals to providing feedback. The first is to provide information to the trainee on how their existing performance has gone, and the second is to tell them what in their current performance is wrong. Finally, feedback should contain information on how to improve performance the next time the task is performed (Hattie & Timperly, 2007).

The type of feedback (either negative or positive) can also have a role in the effectiveness of the training. Negative feedback has been shown to decrease participant motivation, and thus decrease the effectiveness of training, while positive feedback has the opposite effect (Van Dijk & Kluger, 2000). Additionally, feedback has to be detailed. In the example of academics, classrooms that only give grades have seen less

performance improvement than classrooms that provided grades alongside short comments on what areas were lacking in performance (Black & William, 1998). For the sake of this study, the values that were achieved in each training session were given to the participant, as well as specific comments on which areas were scored incorrectly and how they could be improved.

There are specific dimensions to feedback given on task performance that are important to understand when guiding learners. These dimensions relate to the timing, scheduling, and type of feedback given to the learner. There are two types of broad feedback – inherent and augmented. Inherent feedback is feedback provided on a task that comes from the execution of a task (such as seeing the knees go to a 90 degree angle after adjusting a chair) (Schmidt & Lee, 2005). Augmented feedback is information provided supplementary to inherent feedback (such as an ergonomist telling a worker that their chair was still high after the adjustment had been made) (Schmidt & Lee, 2005). Augmented feedback is important to enhance the learning experience and ensure that learners are receiving accurate information in order to improve their performance.

Augmented feedback can be provided immediately after an action, during an action, or after a specific period of time following the action. Additionally, feedback can be directed at the results (knowledge of results), or towards the performance (knowledge of performance) (Schmidt & Lee, 2005). Various combinations of these approaches can contribute differently to the overall outcome of the desired activities (such as immediately provided knowledge of results – where a person is told the results of their assessment immediately after their interview, as opposed to 1 week later in a written report). For the sake of the current study, participants will use inherent feedback when

they adjust their furniture in order to achieve a desired posture by looking at the changes in their own body before and after and adjustment, and will receive augmented feedback in the form of immediate knowledge of results.

Finally, feedback is only effective if the training itself is completely understood. In situations where the interpretation of knowledge is not correct, providing feedback has been proven to be effective in correcting performance (Kulhavy, 1977). The online training module features a mock training screen that will help the participants understand the concept of ROSA training online, helping them focus on the actual method required to assess their own office.

2.5.4 Determinants of Success in a Computer Training Program

External and internal factors may determine the effectiveness of a computer training program. The individual differences of the students play an important role in which method of instruction is the most effective in introducing or enhancing concepts. The student's goal orientations, learning self-efficacy, age and education all factor into the effectiveness of the training (Brown, 2001). The student's computer experience also plays a critical role. As indicated by Brown (2001), the level of computer experience may factor into a student's choices and the amount of knowledge gained through computer-based training. Those students who have had more computer experience should be able to focus more of their time on performing the training, instead of on learning how to use the software (Brown, 2001).

The influence of age on training effectiveness was also explored by Gist et al. (1988). Results from this study indicated that older students (greater than 40 years of

age) had lower training performance scores than younger students (less than 40 years of age) when learning computer-related skills. As this study was conducted in an era where only an estimated 30% of users were using computers at work (Lowe, 1997), a lack of experience with computers may have had more of an impact than it would today, due to the increased prevalence of computers in both education and the workplace.

The method in which the computer training program is presented also affects how well students learn. Allowing a high degree of choice throughout the training program has been shown to increase student satisfaction with training (Mathieu et al., 1992). The employee's job involvement and career plans may also impact how effective work training is. Workers with low levels of control and a lack of career interest in the field they are being trained in may result in decreased effectiveness of a training program (Noe & Schmitt, 1986).

Student computer experience, age, education, job involvement and job interest should all be accounted for in the development and targeting of an occupational training program. Targeting the right employees and using the most applicable training methods can lead to a more effective training program. The participants' age and experience at the current office job were balanced between all experimental groups in the present study. All participants in the study also spent at least 50% of their day on the computer, in an attempt to reduce the effect of computer experience amongst participants.

2.5.5 Training in Ergonomics

Introducing ergonomics training in a workplace has been shown to increase general interest in ergonomics, as well as decrease the number of risk factors and

complaints regarding the conditions of the workplace (Menozzi et al., 1999). Three common methods of implementing training on risk factors associated with office work are literature and lecture-based approaches, and a participatory approach (Johnson et al., 1994). Conflicting reports have emerged regarding which of these methods is the most effective in reducing musculoskeletal disorder symptoms. Bohr (2000) found that a participatory approach, whereby workers actively made modifications to their own workstations, was more effective in reducing discomfort and pain, but in a later study found that there was no significant difference in training methods when it came to reducing musculoskeletal discomfort (Bohr, 2002). More recently, a training protocol that combined a participatory approach with literature and lecture was shown to be the most effective in reducing musculoskeletal disorder symptoms and improving the set up of office workstations (Mastronardi, 2009). In the majority of cases, intervention of any kind has been shown to reduce symptoms of musculoskeletal discomfort in office workers (Bayeh & Smith, 1999; Bohr, 2000, 2002).

In summary, ergonomics training that gets workers to actively make modifications to their own workstations has shown improvement in workstation conditions, as well as overall worker comfort compared to lecture-based and literature-based training methods. This study aims to provide active participation for the workers by having them perform their own office ergonomic assessment and make adjustments by watching educational videos and receiving feedback on their office configuration.

2.6 Self-Reporting

Self-reporting is commonly used in ergonomics for quantifying postures (Wiktorin et al., 1993), work durations (Heinrich et al., 2004) and force estimations (Spieholz et al., 2001), and more specifically, office settings (Fogelman & Lewis, 2002; Gerr et al., 2003). Workers today are asked more regularly to report equipment position and the duration of their interaction with their office equipment for the purpose of identifying general hazards in epidemiological studies (Fogelman & Lewis, 2002, Jensen et al., 2002; Korhonen et al., 2003; Kryger et al., 2003, Marcus et al., 2002). Self-reporting has its advantages and disadvantages, and its place in the field of ergonomics. This section aims to discuss how and when self-reports can be used by workers to report ergonomic hazards, as well as discomfort, pain and injury.

2.6.1 Advantages of Self-Reporting

Self-reporting is a fast and inexpensive method of collecting data on work composition, worker discomfort and the physical demands of a workplace (Andrews et al., 1997; Dane et al., 2002; David, 2005; Spieholz et al., 1999). Typically, self-reports are made on a questionnaire or in a diary that workers can complete during or after their tasks are completed. Self-report studies have been shown to allow for the possible identification of predictors for improved worker health (Juul-Kristensen & Jensen, 2005).

Self-reporting does not typically interfere with the worker while they perform their job and generally requires little training in order for the reports to be completed properly. No equipment other than a pen and paper is required in order to gather an estimation of the risk of MSDs inherent to a job. Self-report questionnaires are very

beneficial due to their ease of use, savings in time and money, and their ability to be sent out to large samples of workers with little effort (Spielholz et al., 1999).

2.6.2 Disadvantages of Self-Reports

While self-reporting approaches are very easy and quick to use, research has shown they are only applicable when assessing gross postural activities such as sitting or standing, as well as the duration of work (Burdorf, 1995). Worker perceptions of exposure have been found to be imprecise and unreliable, and the challenges of worker literacy and comprehension of the questions play a role in the ease of implementation for a workforce (David, 2005).

A common challenge associated with self-reporting has been the over-reporting of various measures. A study by Heinrich et al. (2004) showed that workers who used the computer for more than 3 hours a day over-reported the amount of computer work they actually engaged in by an average of 2 hours, compared to direct measurements. Over-reporting also occurred for workers who spent less time on the computer (an average over-reporting of 0.4 hours for workers using the computer less than 3 hours a day). Similar results were also seen by Homan and Armstrong (2003), whereby workers over-reported the amount of computer work they performed by a factor of 1.5. This overestimation increased to a factor of 4 when examining the amount of keying that occurred during the day (Homan & Armstrong, 2003).

Self-reporting of exposure to ergonomic risk factors has been shown to be affected by the presence of musculoskeletal symptoms (Juul-Kristensen & Jensen, 2005; Mikkelsen et al., 2003). The influence of other factors outside of the task or the

workplace, such as psychosocial variables or pre-existing injuries and discomfort, has led to self-reported exposures exhibiting very low validity (Burdorf & Laan, 1991) and reliability (Wiktorin et al., 1993).

2.6.3 Examples of Self-Reporting

Self-reporting approaches can facilitate the collection of large amounts of data consistent with epidemiological studies on the development of musculoskeletal disorders, or measuring ergonomic exposure in intervention trials (Dane et al., 2002). Burdorf (1995) found that self-reports were only effective for examining gross activities, such as sitting and standing. This gross postural assessment is applicable in such epidemiological studies, as it allows for a broad classification of working posture for further analysis.

Studies using self-reporting approaches have also shown that worker discomfort has a negative effect when it comes to interpreting workstation configurations. Coury (1998) found that when workers were given a self-directed training package, their self-reports of discomfort actually increased after the training package was read. The explanation for this phenomenon was that increases in worker awareness lead them to believe that the inadequacies of their workstation were doing greater damage to their bodies than they had previously realized. The study went on to warn that programmes focused only on the subjects, and not their working environments, as well as programmes delivered through only one medium for intervention (i.e. workstation modification), should be closely monitored. This study serves as a cautionary example of how self-reporting can lead to possible over-reporting and falsely positive identification of workstation-related risk factors.

Heinrich et al (2004) compared a questionnaire with observational and direct measurements to examine the differences in ergonomic hazard reporting in computer users. The questionnaire was shown to be an unreliable method to measure postures, as well as duration of computer use, leading the authors to state the research challenges in this field should focus on developing quick and inexpensive techniques for assessing exposure to non-neutral postures and computer use (Heinrich et al., 2004).

Over-reporting of upper extremity risk factors (such as non-neutral postures, high repetition and extended durations) has also been seen in comparison to those determined via video analysis and direct measurement. Of these three methods, self-reports were the least precise assessment method, consistently over-estimating directly recorded measurements of exposure (Spielholz, et al., 2001). Self-reports of extreme posture duration, repetition, hand force and movement velocity were also shown to over-estimate actual values.

While gross movements (such as sitting and standing) may be assessed accurately using questionnaires, it is recommended that more precise measurements be used when examining body positions such as trunk flexion and rotation (Burdorf, 1995). The Rapid Office Strain Assessment assesses gross postural categories without specific requirements for precise measurements, indicating that the limited demands inherent in the tool may lead to usefulness in self-assessment.

2.6.4 Self-Report Studies Conducted in Ergonomics

Burdorf and Laan (1991) looked at the applicability of worker assessments on postures of the back. Workers completed a questionnaire after each task, and a journal

was used to input their daily activities periodically throughout the course of a work day. Worker postures and work durations were compared against the values from the OWAS posture recording system (Karhu et al., 1977), which was completed by an expert in the same time frame as the workers completed their questionnaires. It was found that using exposure information based on self-reports of back postures was unreliable due to the high frequency of over-reported postures and work duration (Burdorf & Laan, 1991).

These results were echoed by Wiktorin et al. (1993), whereby Swedish workers were asked to complete self-reports on their daily manual material handling requirements and their working postures. Compared against actual measurements taken from pedometers, posimeters and inclinometers, the self-reported results showed insufficient agreement for head rotation, postures with the hands above the shoulders, and carrying, pushing or pulling loads of 1kg to 5kg. Additionally, tasks with varied duration and frequency showed poor agreement for all tasks examined. Workers were only shown to have statistically significant similarities between their reporting of loads lifted and actual loads lifted between 1kg and 5kg, as well as their distance walked (Wiktorin et al., 1993). The overall conclusion from the study was that workers may be able to effectively report manual material handling loads in epidemiological studies requiring more gross evaluations of exposure, but not in studies where precise values are required.

Self-reporting appears to be an effective method of retrieving job information in research that is dependent on larger sample sizes and gross postural analysis. Over-reporting a range of variables (such as work duration) should be considered when interpreting data related to worker-reported outcomes.

2.7 Literature Review Summary

Musculoskeletal disorders are the number one source of lost time injuries in Ontario (OHSCO, 2008), and contribute to over \$12 billion in indirect and direct costs to Ontario employers per year. Risk factors related to musculoskeletal disorders in office work include sustained non-neutral postures of the upper limbs (Village et al., 2005), and prolonged static sitting while using the computer (Heinrich et al., 2004). These risk factors have a large effect on the number of musculoskeletal disorders reported every year, as over 60% of Canadian workers require the use of a computer to perform required tasks at their jobs (Marshall, 2001).

Attempts to proactively control these risk factors in the office have primarily come in the form of training and ergonomic assessment (Amick et al., 2003). The most effective methods of office ergonomics training have involved the participant as an active member in the training, thereby allowing them to make their own workstation modifications (Bohr, 2000; Mastronardi, 2009). Training and additional assessment recommendations in ergonomics can be made by using initial risk factor screening tools, such as RULA (McAtamney & Corlett, 1993) and REBA (Hignett & McAtamney); however, these tools are primarily used in manual material handling tasks. The Rapid Office Strain Assessment (Sonne et al., 2010) is a checklist developed to quickly determine if an office workstation requires additional assessment or intervention. A limitation of ROSA is that experts are still required to complete the initial screening assessments, which is reflective of additional costs to the workplace through the hiring of ergonomic consultants.

If workers could be trained to perform their own ROSA assessments in an online training module, then the initial screening process would be much faster and inexpensive. This study aims to develop such an online method for using ROSA by building a worker-reporting and online training protocol, then examine the accuracy of ROSA scores achieved through this method compared to those obtained from a trained observer.

Chapter III

Methods

3.1 Participants

Participants were recruited from the administrative staff at a private construction company, a school board's administrative office, a University of Windsor office, and the regional office of a national not-for-profit organization. To be included in this study, workers had to use a computer workstation for at least 50% of the day, use the same computer workstation during every workday and have had no recent ergonomic training (within 1 year). Fifty-nine participants were recruited and distributed between groups (Table 1). During the course of the experiment, 4 participants dropped out due to vacations, illness or prior commitments. This left the final count of participants who completed all 4 weeks of the study at 55. Participants were asked to report their height, body mass, age, time at company, time at job, and initial level of discomfort. After each of the recruitment sessions were conducted through email, and prior to the start of data collection at each of the participating workplaces, participants were evenly assigned to one of the two groups. Participants were balanced across the two feedback groups (see below) on these four variables in order to control for possible effects these characteristics might have on assessment ability. Once participants were assigned to one of the two groups, the groups were checked for significant differences in biographic and demographic variables. If differences were found, participants were re-assigned until there were no statistical differences between groups. Finally, participants were asked to refrain from buying new office equipment throughout the course of the four weeks of the experiment.

3.2 Procedures

The objectives of this study were to assess the accuracy of worker-reported scores using the ROSA online tool, the impact of feedback and online training on worker assessment accuracy, the relationship between worker-assessed and trained observer ROSA scores and reported discomfort, and the impact of online office ergonomics training program on musculoskeletal discomfort.

Table 1: Summary of participant groups and training schedule. Note that for weeks 1 through 4, all participants performed a worker-assessment using ROSA online, had their workstation assessed by a trained observer, and filled out a discomfort questionnaire online.

	Group 2 (27 Participants)	Group 1 (28 Participants)
Week 0	ROSA Online Application Training	ROSA Online Application Training
Week 1	AS/DQ, FB	AS/DQ, NoFB
Week 2	AS/DQ, FB	AS/DQ, NoFB
Week 3	AS/DQ, FB	AS/DQ, NoFB
Week 4	AS/DQ, FB	AS/DQ, NoFB

FB = Feedback
NoFB = No Feedback
AS = Assessment
DQ = Discomfort Questionnaire

For this study, the training was performed using an online version of the Rapid Office Strain Assessment (outlined in section 3.2.3.1). This training consisted of two primary components – an assessment module, and an adjustment module. The goal of this training was to give participants access to resources on how they can adjust their existing furniture, and allow them to make whatever adjustments they felt were necessary throughout the course of the experiment.

With respect to examining training protocol effectiveness, previous work has collected data at intervals of one month, six months, one year and two years post intervention (Amick et al., 2003; Ketola et al., 2002; Robertson et al., 2009). In these training protocols, the primary objective was to determine the overall impact of training on worker knowledge. For the purpose of the current study, the primary goal was to determine how effectively workers could complete a rapid screening tool for the assessment of risk factors within their office workstation. With this in mind, a shorter training protocol of one month (as found in Mastronardi, 2009) was appropriate in order to determine if there was any effect of the proposed online training before going to the expense of a much longer design.

An initial purpose of this study was to assess the use of feedback and open access to the ROSA online software. The first 19 participants recruited were purposely assigned to 4 different experimental groups (not 2, as described above). Two of these experimental groups were designed to assess the impact of additional assessments conducted by workers without the presence of an observer on self-reported scores. Of these 19 recruited participants, 2 dropped out, and 10 were assigned to an open access group. The remaining 7 participants were assigned to a restricted access group instructed

to complete assessments only at the time when the observer was in the office, and had their access to the software restricted between weeks. Upon reviewing the database of results from these participants, it was determined that the open access participants did not start, or complete any additional self-assessments, even though they were instructed that they had access to do so. Due to this, and the difficulty in recruiting participants that could complete the entire four week program over the busy summer months, the originally planned four groups were reduced to two groups: those receiving feedback, and those not receiving feedback. The access to the ROSA online application was restricted for these participants in between weekly assessments. A power analysis confirmed that the final population recruited (n=55) was sufficient for the two group design.

Participants received an initial training session (week 0 in Table 1) where they were instructed on how to use the ROSA online application. This training was given in the form of a PowerPoint presentation in a meeting room at the participating companies. A mock assessment screen was created to familiarize workers with how the ROSA software worked, but did not contain actual assessment materials. This was to control the exposure to ROSA between week 0 and week 1. Participants then registered their username and account within the ROSA application, and completed an online form on background and biographical data (age, sex, height, weight, and years of experience). The two groups were differentiated as follows:

Group 1: This group of participants completed their first self-assessment in week one of the study. A trained observer also completed an assessment of the workstation at the same time. The participant and trained observer then completed an assessment of the workstation once a week for 3 more weeks. No feedback regarding how the participant performed the assessment was provided. After each assessment, participants completed an online Discomfort Questionnaire (as outlined in Section 3.1.6).

Group 2: Similar to group 1, the second group of participants also performed an assessment once per week for four weeks. In contrast to group 1, a trained observer provided directed feedback on how each participant in group 2 performed their own assessment. Feedback was given verbally from the researcher to the participant immediately following the completion of the online assessment. In addition to verbal feedback, the participant was shown pictures illustrating the condition they and the observer selected. The online discomfort questionnaire was completed after each assessment by the participant.

3.2.3 Worker-Assessment

The worker-assessments were conducted using the online ROSA application (Section 3.2.3.1). All participants completed a worker-assessment once per week. Times for the weekly assessments were set up either through interview onsite or through email, to allow the trained observer and participants to do their assessments at the same time.

3.2.3.1 ROSA Online Application

The ROSA online application contains identical risk factor identification information to that found in the original ROSA tool (Sonne et al., 2010) (Appendix A). A sample screenshot of ROSA online is provided in Figure 10 for the subsection on chair height. For all workstation areas covered in ROSA, risk factors in the online version were presented as text, graphic and live action in video, with an audio narrative describing the risk factors.

The ROSA online application was designed to allow participants to log in using a username and password of their choosing. This username was used to track results for assessments and discomfort questionnaires over the course of the study. Upon logging in, participants were able to access their user profile (containing work information, such as department, company and contact information) and their previous ROSA worker-assessment scores. The participants were also able to start their next ROSA worker-assessment from this screen.

The ROSA online application was designed using Adobe Dreamweaver CS4 (San Jose, California, USA, 2010), and all of the data collection pages were written in the PHP hypertext pre-processing language. Forms located within the application interacted with a secure MySQL database via the PHP language. Participants were instructed to select postures and equipment positions one area at a time (chair height, chair depth, armrests, backrests, etc), as well as the corresponding duration values. Along the side of each form, a video was displayed indicating how to evaluate each component of the workstation (Figure 10). A tracking menu on the left side of the screen indicated where

the participant was in relation to completing the assessment. Screenshots of all sections can be found in Appendix C.

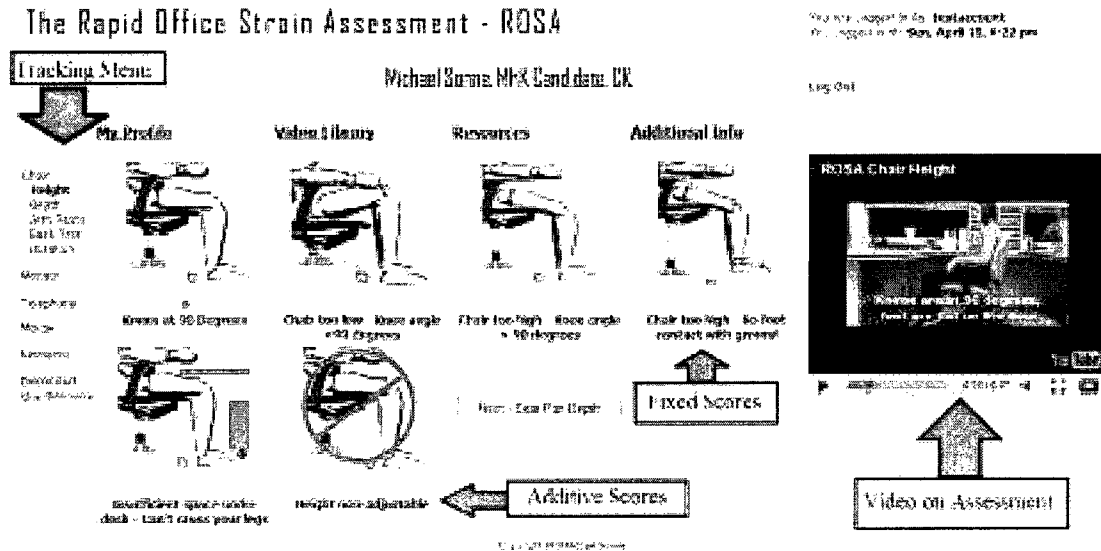


Figure 10: Screenshot for the ROSA online application – Chair Height section. Risk factors are presented as text, graphic and live action in video with an audio narrative describing the risk factors. The tracking menu is to the left of the risk factors, and allows the participant to view their progress through the assessment.

The scoring system from the original Rapid Office Strain Assessment developed by Sonne et al. (2010) featured two types of scores – fixed ROSA scores (those in which only one score could be chosen per area, such as chair height optimal, chair height low, or chair height high), and additive scores (those postures or configurations that can be added to the fixed ROSA scores, such as chair non-adjustability or insufficient space under the desk surface). In the ROSA online application, the fixed scores were coded as radio buttons, preventing the participant from selecting more than one. The additive scores were coded as check boxes, allowing the scores to be added to the fixed scores and also allowing the participant to select more than one score per section (Figure 10).

3.2.4 Trained Observer Assessment

The trained observer performed an assessment of the office workstation while the worker-assessment was performed. The two trained observers who performed assessments were graduate students in the field of ergonomics and biomechanics, and had previously provided ergonomic training and assessments in a consulting role to various private and public companies. Instead of using the online version of ROSA, the trained observers completed a paper or Microsoft Excel-based version of ROSA (Appendix A, detailed in Section 2.4). During the course of the study, 14 office workstations were assessed simultaneously by the two observers, and Intra-Class Correlation Coefficients (ICCs) were calculated to determine inter-rater reliability. ICCs of 0.69 (chair), 0.91 (monitor and telephone), 0.87 (mouse and keyboard) and 0.87 (final score) were comparable to results found in Sonne et al., (2010), indicating that the use of the Rapid Office Strain Assessment by multiple observers was an appropriate method of conducting this research.

The workstation assessment process that was used for this study differed from typical office ergonomic assessments, as interaction between the participant and the observer was purposely limited. Normally, risk factors would be recognized, and then immediate recommendations would be given to the worker on how to change their workstation. Since the focus of this study was on worker self-assessments of their office workstations, recommendations on the existing configuration were withheld until the study had concluded. During the course of each observer assessment, the trained observer asked the participant information on how long they sit, mouse, and key each day. Information on the chair, monitor, keyboard and mouse configuration and

positioning was collected through observation. This assessment procedure was repeated for each observer assessment conducted on the two groups over the four weeks of the experiment.

3.2.5 Trained Observer Feedback

For participants in Group 2 (Table 1), verbal feedback was given to them on the accuracy of their self-assessments by the trained observer based on their expert evaluation. The trained observer indicated which postures were assessed incorrectly, and what these postures or equipment configurations should have been scored as. This feedback occurred after the participant had completed their assessment, but before they completed their discomfort questionnaire. A script of the feedback language is included in Appendix D. To ensure that feedback was consistent, one of the trained observers was assigned to the feedback (FB) Group, while the other was assigned to the no feedback (NoFB) Group.

3.2.6 Discomfort Questionnaire

The Cornell University Discomfort Questionnaire contains self-report information on discomfort across 18 different body parts, which is further evaluated on the frequency of discomfort, the severity of discomfort, and the degree of work interference that the discomfort causes (Appendix B). To calculate scores for individual body parts, the scores for frequency experienced were coded as: 0 (never), 1.5 (1-2 times per week), 3.5 (3-4 times per week), 5 (once every day), and 10 (several times per day). The severity of discomfort was scored as: 1 (slightly uncomfortable), 2 (moderately uncomfortable), and 3 (very uncomfortable). Finally, the interference of work related to discomfort was

scored as: 1 (not at all), 2 (slightly interfered), and 3 (substantially interfered). To determine the score for each individual body part, the frequency, severity and interference scores were multiplied by one another, for a maximum possible score of 90. The discomfort scores from each body part were then added together to achieve a whole body discomfort score of 1620.

The online adaptation of the discomfort questionnaire was completed by participants after they completed their worker-assessments each week. The questionnaire was coded using Adobe Dreamweaver CS4 (San Jose, California, USA, 2010), and each body part was coded as three separate groups of radio buttons. As previously mentioned, frequency of discomfort, intensity of discomfort and the degree of work interference associated with discomfort were all factored into the online adaptation of the questionnaire. Values from each of these areas were exported from the online database and values for full body and localized discomfort were calculated in Microsoft Excel 2010 (Redmond, Washington, USA, 2010). This information was stored alongside ROSA scores in the database.

Localized discomfort scores were calculated using the following methods. Isolated discomfort related to the chair was determined by combining localized discomfort scores for the lower and upper back, shoulders, hips and buttocks and thighs. Monitor and Telephone-related discomfort were calculated as a function of discomfort scores from the head and neck, and upper back. Finally, mouse and keyboard-related discomfort was calculated by combining localized discomfort scores from the shoulders, upper back, forearm, upper arm, and wrist and hands section. These methods of calculating localized discomfort were previously established in Sonne et al. (2010).

3.2.7 *Workstation Modification Videos*

Workstation modification videos were filmed at a participating company before data collection at the other participating organizations. These videos were filmed in generic offices, and modifications that could be made without costing the company additional money to purchase new equipment (such as adding a rolled up towel to the back of a chair to add lumbar support), were emphasized. Upon completion of the discomfort questionnaire (Section 3.1.6) each week, all participants had access to the workstation modification videos and literature. This allowed participants to make changes to their workstation based on their online ROSA worker-assessment scores, and provided them with video on how changes could be made without the purchase of new equipment. Participants were asked to try and make changes to their workstation based on the deficiencies in their current setup (as indicated by conducting their assessment) and these videos. At the end of the study, feedback was given to all participants on how to adjust their workstations to optimally suit their work habits and body types. The workplace modification videos did not provide feedback to the participants on how accurately their assessment was completed, but did provide information on how their workstation could be adjusted.

3.3 Data Analysis

3.3.1 Experimental Groups

To ensure that the distribution of participants between groups was comparable for all anthropometric (height and body mass) and demographic information (time at company, time at job, initial level of discomfort), participants were purposefully assigned and a one-way ANOVA was used to assess Group differences (alpha set at 0.05). Participants were redistributed until all Group differences were not significant.

3.3.2 Research Question #1 & #2

1 - Are ROSA subsection and final scores reported by office workers using the online version of the tool comparable to those determined by a trained observer for the same workstations?

2- What is the impact of directed expert feedback and number of assessments on the agreement between trained observer and worker-reported ROSA scores?

To determine if worker-assessed ROSA scores differed from those determined by a trained observer, a 2 (Assessment Type: worker and observer) x 2 (Groups: FB, NoFB) x 4 (Time: week 1, 2, 3, 4) mixed ANOVA was performed on the dependent variables (ROSA chair, monitor and telephone, mouse and keyboard, and final scores) (Appendix E). The between-subject factor was Group and the two within-subject factors were Assessment Type and Time. Alpha was set at 0.05 for all comparisons. Pearson Product Moment Correlations were used to determine the relationship between worker and trained observer ROSA final scores. An r value of less than 0.1 was considered low, 0.3 to 0.5

was considered moderate, and greater than 0.5 was taken to be indicative of a strong positive relationship between variables (Cohen, 1988). Significant main effects of week were analyzed with pairwise comparisons and a Tukey's HSD post hoc test to determine during which weeks there were significant differences in ROSA scores.

For the purposes of this study, validity was defined as "the degree to which scores on a test are related to some recognized standard or criterion (Thomas & Nelson, pp 215, 1996)". The exploratory nature of this study seeks to establish validity of worker-reported ROSA scores through the online ROSA assessment process. Validity of self-assessments was deemed to have been established if mean worker- and observer-reported scores were not significantly different from one another, and if they were significantly correlated. Finally, in order to be considered valid, statistically significant positive correlations had to occur in 50% or more of the instances recorded for each evaluation (e.g. 4 out of the 8 possible instances (2 Groups x 4 Times)).

3.3.3 Research Question #3

3 - What are the relationships between worker-reported and trained observer ROSA scores and worker-reported discomfort scores?

Pearson Product Moment Correlations were calculated to establish the relationships between worker-reported discomfort and both worker-reported and trained observer ROSA scores. Correlations between whole body and localized discomfort were made with both area and ROSA final scores. The localized discomfort scores related to the expected body parts that may incur discomfort or injury as a result of office work (the head and neck (Hagberg & Wegman, 1987; Korhonen et al., 2003), upper limbs (Gerr et

al., 2002) and back (Jensen et al., 2002)) were correlated with the ROSA final, chair, monitor and telephone, and mouse and keyboard scores. Alpha was set at 0.05 for all comparisons. This comparison was made within each experimental Group (FB, NoFB), during each week of the experiment.

3.3.4 Research Question #4

4 - Is an office ergonomic training protocol using ROSA online effective in reducing musculoskeletal discomfort in office workers?

The effects of the two different training protocols on self-reported whole body musculoskeletal discomfort over the course of the four week experiment were assessed using a 4 (Time: weeks 1, 2, 3 and 4) x 2 (Groups: FB, NoFB) mixed ANOVA. The between-subject factor was Group, and the within-subject factor was Time. Alpha was set to 0.05 for all comparisons. Post hoc analysis was performed using Tukey's HSD test.

Chapter IV

Results

4.1 Distribution of Experimental Groups

There were no significant differences in mean (SE) height, body mass, time at company, time at job, or initial level of discomfort between the two experimental Groups ($p \leq 0.05$) (Table 2). As previously mentioned, 4 participants withdrew from the study for various reasons, and their data were excluded from the analyses.

Table 2: Mean (SE), maximum and minimum anthropometric and demographic information for participants in the feedback (FB) and no feedback (NoFB) Groups.

	<u>Feedback (n=27)</u>			<u>No Feedback (n=28)</u>		
	<u>Mean</u> <u>(SE)</u>	<u>Max</u>	<u>Min</u>	<u>Mean</u>	<u>Max</u>	<u>Min</u>
Age (years)	37.7 (2.1)	<u>55</u>	<u>23</u>	39.4 (2.1)	<u>59</u>	<u>23</u>
Males (n)	6			9		
Females (n)	21			19		
Height (cm)	166.0 (0.8)	187.9	157.5	167.4 (2.7)	188.0	150.0
Body Mass (kg)	71.3 (8.7)	118.2	50	73.1 (4.3)	100.9	45.9
Years at company (years)	9.7 (1.8)	25	0.8	9.8 (2.5)	43	0.5
Years at job (years)	8.8 (2.1)	25	0.8	7.3 (1.6)	43	0.5
Initial whole body discomfort (/1620)	57.9 (13.5)	270	0	44.2 (13.4)	265	0
University of Windsor (n)	11			11		
Private Construction Company (n)	9			11		
School Board (n)	4			1		
Not-for-profit organization (n)	3			5		

4.2 Research Question #1 & #2

Are ROSA final and subsection scores reported by office workers using the online version of the tool comparable to those determined by a trained observer for the same workstations?

What is the impact of directed expert feedback and number of assessments on the agreement between trained observer and worker-reported ROSA scores?

4.2.1 ROSA Final Scores

A significant main effect of Assessment Type was found between observer-reported (mean 3.75(standard error 0.11)) and worker-reported ROSA final scores (3.58(0.12)) [$F(1,53)=6.03$, $p\leq 0.05$] (Figure 11). A significant main effect of Time was also observed [$F(3,159)=11.38$, $p\leq 0.05$], with decreases in mean final ROSA scores seen during each week of the study (Figure 12). Tukey's HSD post hoc analysis revealed significant differences in ROSA final scores between weeks 1(3.9(0.12)) and 4 (3.5(0.17)) (Figure 12).

With respect to Group, those who received feedback reported significantly lower ROSA final scores on average than those who did not receive feedback [$F(1,53)=4.01$, $p\leq 0.05$] (Figure 13). The FB Group reported a mean ROSA final score of 2.57(0.18), and the NoFB Group reported a mean ROSA final score of 3.28 (0.17), averaged across the 4 weeks of the study.

There was no significant interaction effect seen between Assessment Type and Time, indicating that the differences in worker- and observer-reported scores did not change as a result of increased use of the ROSA online assessment method over time ($p>0.05$). Additionally, there was no significant interaction effect seen between any other combination of Group, Assessment Type or Time.

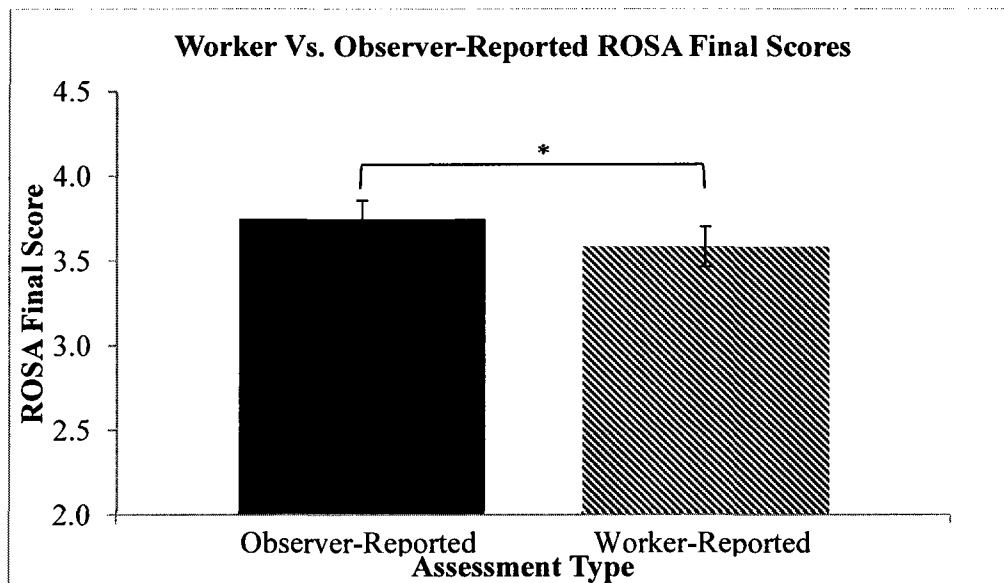


Figure 11: Main effect of Assessment Type on mean (SE) ROSA final scores (*=statistically significant at $p\leq 0.05$).

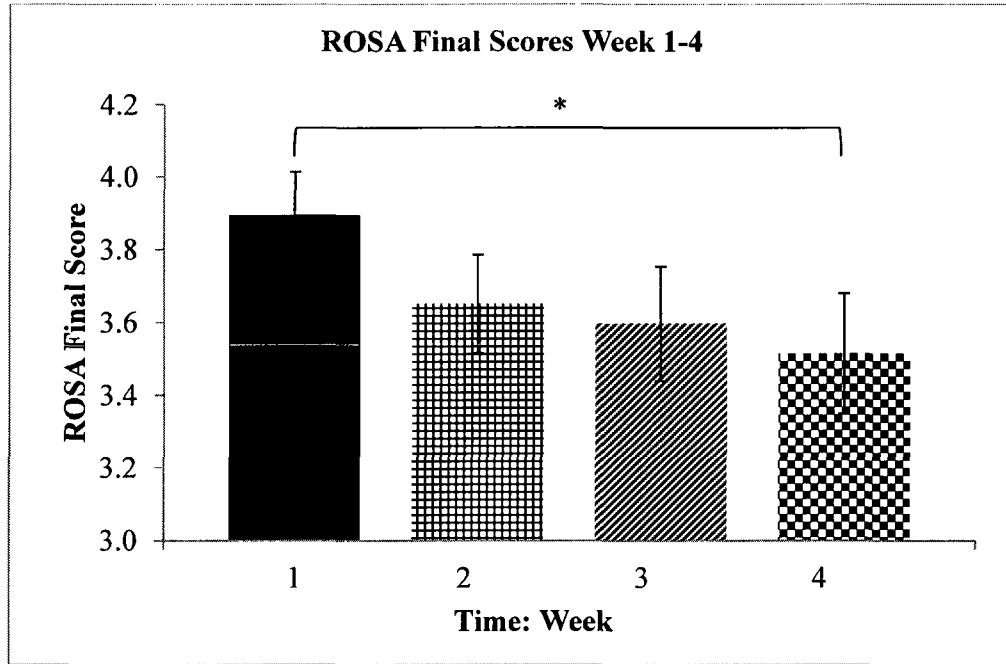


Figure 12: Main effect of Time on mean (SE) ROSA final scores through weeks 1-4 (*=statistically significant at $p \leq 0.05$).

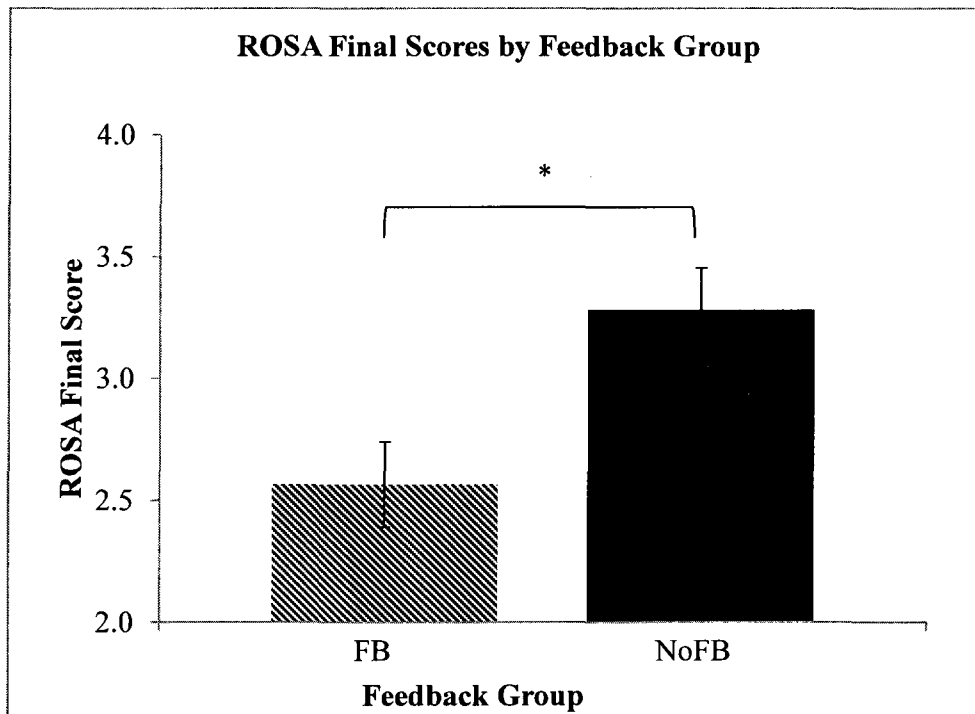


Figure 13: Main effect of Group on mean (SE) ROSA final scores (*=statistically significant at $p \leq 0.05$).

Nearly all correlations between worker- and observer-reported ROSA scores were significant (Table 3). Significant correlation values ranged in magnitude from moderate ($r=0.35$, week 3, FB) to large ($r=0.76$, week 4, NoFB) ($p \leq 0.05$) (Cohen, 1988).

Table 3: Correlation values (r) for ROSA scores between worker (W) and Observer (O) reported values throughout 4 weeks FB and NoFB Groups (*= statistically significant at $p \leq 0.05$).

	ROSA Final Score		Chair		Monitor and Telephone		Mouse and Keyboard	
Wk	FB	NoFB	FB	NoFB	FB	NoFB	FB	NoFB
1	0.48*	0.43*	0.70*	0.45*	0.44*	0.54*	0.44*	0.21
2	0.51*	0.46*	0.78*	0.35*	0.38*	0.57*	0.67*	0.54*
3	0.35*	0.61*	0.36*	0.23	0.44*	0.46*	0.72*	0.66*
4	0.22	0.76*	0.33	0.62*	0.30	0.62*	0.55*	0.76*

4.2.2 ROSA Chair Scores

There was a significant main effect of Time on ROSA chair scores [$F(3,159)=10.18$, $p \leq 0.05$], with mean scores differing significantly between week 1 and 3, and week 2 and 3 (Figure 14). There was a trend for ROSA chair scores to increase throughout the 4 week training program (week 1=3.05(0.11), week 4=3.23(0.09)). There was no significant main effect reported for Assessment Type (mean worker (3.02 (0.13)) and observer-reported ROSA chair scores (3.36(0.12)) ($p > 0.05$)), or Group (FB=3.19(0.12), NoFB=3.20(0.12), $p > 0.05$).

There was no significant interaction seen between Assessment Type and Week, indicating no change in the difference between worker- and observer-reported ROSA

chair scores as a result of repeated exposures to ROSA online ($p>0.05$). There were no significant interactions between any combination of Assessment Type, Group, or Time.

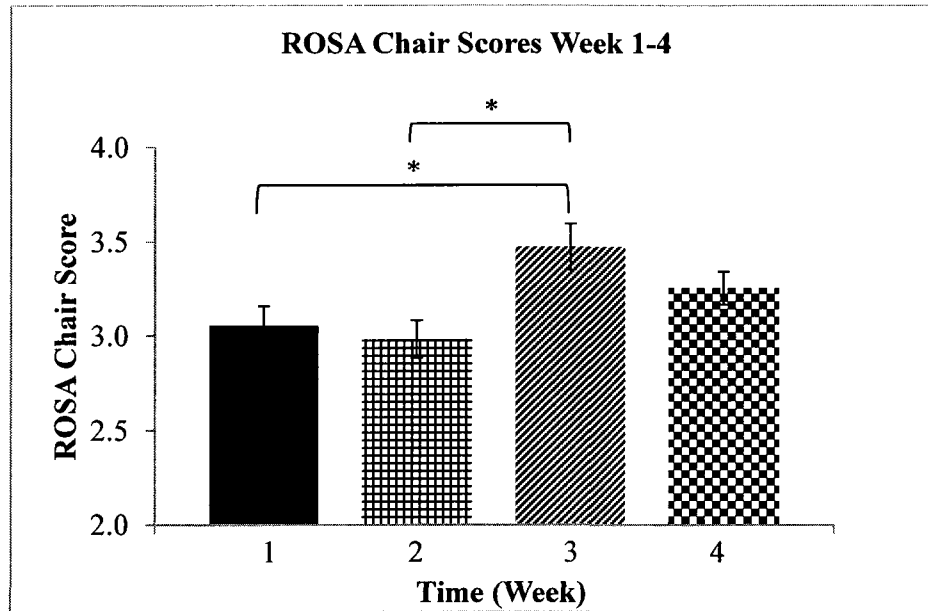


Figure 14: Main effect of Time on mean (SE) ROSA chair scores through weeks 1-4 (*=statistically significant at $p\leq 0.05$).

ROSA worker- and observer-reported chair scores were significantly correlated throughout the 4 weeks of the study. Significant correlations between ROSA worker- and observer-reported scores ranged from moderate ($r=0.35$, week 2, NoFB) to large ($r=0.78$, week 2, FB) (Cohen, 1988) (Table 3). Correlations were insignificant in week 4 of the FB Group, and week 3 of the NoFB Group.

4.2.3 ROSA Monitor and Telephone Scores

A significant main effect of Time was seen for monitor and telephone scores [$F(3,159)=10.18$, $p\leq 0.05$], with significant differences in ROSA scores between week 1 and 3, and week 2 and 3 (Figure 15). ROSA monitor and telephone scores followed an

increasing trend between week 1 (2.75(0.12)) and week 4 (2.99(0.16)). There was no significant main effect of Assessment Type (worker=2.54(0.15), observer=2.74(0.16)) or Group (FB=2.58(0.15), NoFB=2.80(0.15), $p>0.05$) seen for ROSA monitor and telephone scores.

No significant interaction was seen between Time and Assessment Type, indicating no significant change in the difference between worker- and observer-reported ROSA monitor and telephone scores. There were no significant interactions between any combination of Time, Assessment Type or Group.

Nearly all worker and observer-reported ROSA scores for the monitor and telephone section were significantly correlated (except week 4 for the feedback group). Correlation values between worker- and observer-reported ROSA monitor and telephone scores ranged from low ($r=0.38$, week 2, FB) to moderate ($r=0.62$, week 4, NoFB) (Table 3).

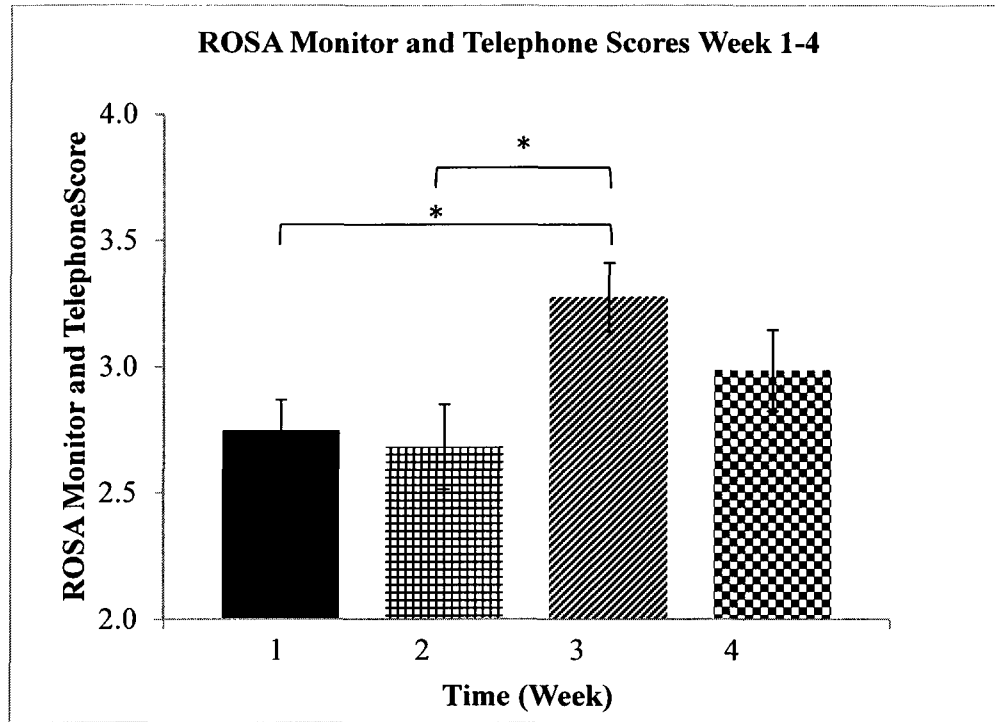


Figure 15: Main effect of Time on mean (SE) ROSA monitor and telephone scores through weeks 1-4 (*=statistically significant at $p \leq 0.05$).

4.2.4 ROSA Mouse and Keyboard Scores

There was a significant main effect of Assessment Type [$F(1,53)=4.732$, $p \leq 0.05$] found in the mouse and keyboard scores (worker=2.73(0.17), observer=3.13 (0.18)) (Figure 16). A significant main effect of Group was also found [$F(1,53)=8.50$, $p \leq 0.05$], with the FB Group reporting lower ROSA mouse and keyboard scores (Figure 17). Finally, a main effect of Time was seen, with significant differences in ROSA mouse and keyboard scores between week 1(3.13) and 4 (2.60) (Figure 18). There were no significant interactions seen between Assessment Type, Group, or Time for mouse and keyboard scores. This trend was maintained for all 4 weeks of the study.

All worker- and observer-reported mouse and keyboard scores were significantly correlated, except for week 1 in the NoFB Group. Correlations between worker- and observer-reported mouse and keyboard scores varied from moderate ($r=0.44$, week 1, FB) to large ($r=0.76$, week 4, NoFB) (Table 3) (Cohen, 1988).

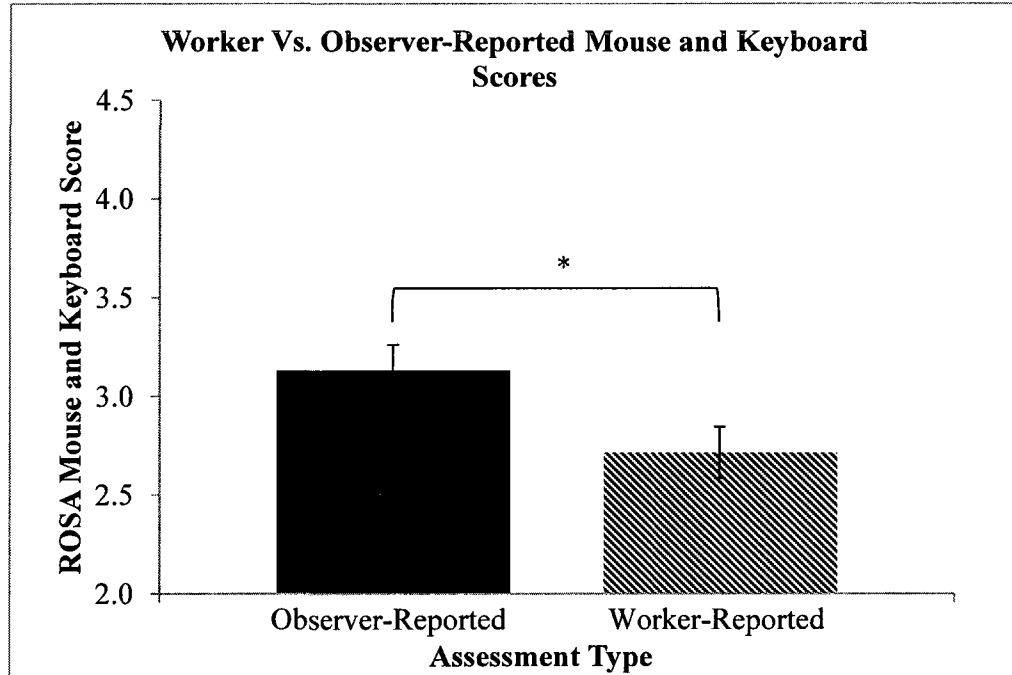


Figure 16: Main effect of Assessment Type on mean (SE) ROSA mouse and keyboard scores (*=statistically significant at $p \leq 0.05$).

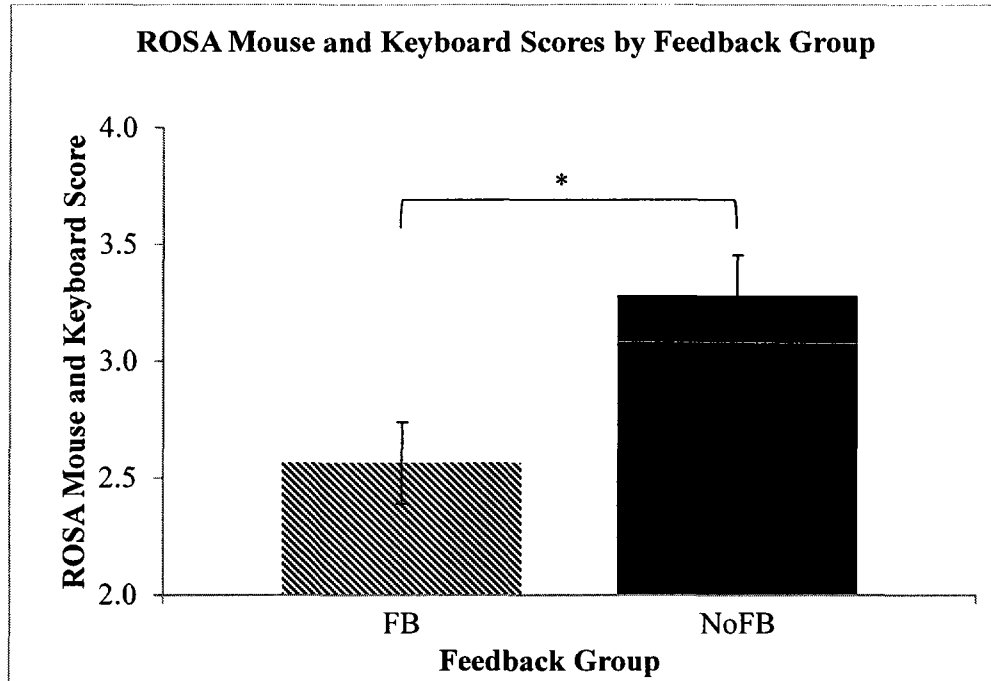


Figure 17: Main effect of Group on mean (SE) ROSA mouse and keyboard scores (*=statistically significant at $p \leq 0.05$).

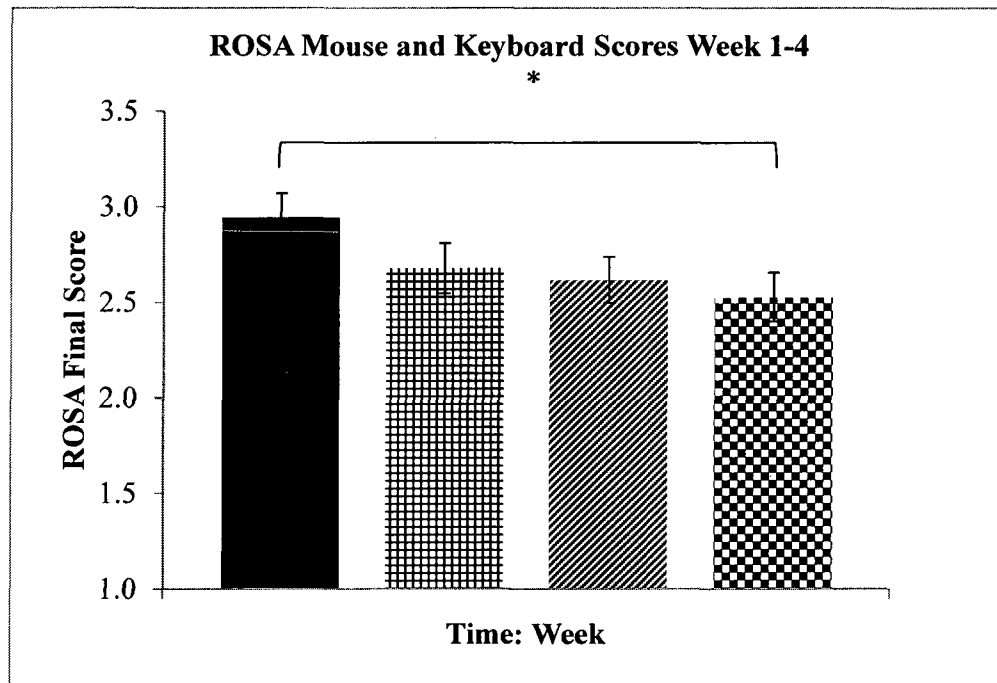


Figure 18: Main effect of Time on mean (SE) ROSA mouse and keyboard through weeks 1-4 (*=statistically significant at $p \leq 0.05$).

4.3 Research Question #3

What are the relationships between worker-reported and trained observer ROSA scores and worker-reported discomfort scores?

4.3.1 ROSA Final Score

Significant correlation values between worker-reported ROSA final scores and discomfort were generally higher (during weeks 1, 2, and 3) than those between observer-reported ROSA scores and discomfort. The only exceptions to this were in week 4 for all discomfort measures, and week 3 for total discomfort without leg scores ($r=0.36$ compared to $r=0.35$)(Table 4). There were no significant relationships between ROSA scores and worker-reported discomfort in the feedback Group, regardless of whether the scores were worker- or observer-reported. Correlation values were also higher between ROSA final scores and whole body-reported discomfort than when the leg scores were not considered. Significant correlations in the NoFB Group ranged between 0.36 and 0.68 (week 3, observer score, and week 4, observer score, respectively, $p \leq 0.05$).

Table 4: Correlation values (r) between ROSA final scores for the worker (W) and observer (O) and total body discomfort (total body and total body minus leg discomfort) for both FB and NoFB Groups (*= statistically significant at $p \leq 0.05$).

	Total Discomfort				Total Discomfort – No Leg Discomfort			
	FB		NoFB		FB		NoFB	
Wk	W	O	W	O	W	O	W	O
1	0.17	-0.23	0.22	0.01	0.19	-0.21	0.15	0.03
2	-0.17	-0.10	0.47*	0.14	-0.15	-0.06	0.43*	0.12
3	-0.09	-0.21	0.36*	-0.09	-0.09	-0.21	0.35	0.36*
4	-0.25	-0.20	0.45*	0.68*	-0.26	-0.19	0.44*	0.67*

4.3.2 ROSA Chair Score

Those correlations for the chair scores paralleled those for the final ROSA scores, with worker-reported ROSA chair scores more highly correlated with discomfort scores than observer-reported ROSA scores (except in week 4). There were no significant correlations found in the FB Group, but significant moderate correlations (Cohen, 1988) were found in the NoFB Group during weeks 2 and 4 (ranging from $r=0.36$ to $r=0.48$) (Table 5).

Table 5: Correlation values (r) between ROSA chair scores for the worker (W) and observer (O) and chair related discomfort for both FB and NoFB Groups (*= statistically significant at $p \leq 0.05$).

Wk	ROSA Chair Score			
	FB		NoFB	
	W	O	W	O
1	0.15	-0.24	0.19	0.03
2	-0.10	-0.04	0.41*	0.11
3	-0.05	-0.11	0.20	0.02
4	-0.14	-0.09	0.36*	0.48*

4.3.3 ROSA Monitor and Telephone Score

Comparable to the results for the ROSA final and chair scores, worker-reported ROSA monitor and telephone scores had a stronger positive relationship with discomfort than observer-reported scores (Table 6). Significant correlations between the ROSA monitor and telephone score and associated discomfort varied in magnitude within the moderate range (Cohen, 1988), between $r=0.35$ (worker-reported score, week 3, NoFB) and $r=0.39$ (worker-reported score, week 1, FB). Overall, there were fewer significant

correlations between monitor and telephone scores and discomfort in this section than any of the other ROSA subsections.

Table 6: Correlation values (r) between ROSA monitor and telephone scores for the worker (W) and observer (O) and monitor and telephone related discomfort for both FB and NoFB Groups (*=statistically significant at $p \leq 0.05$).

	ROSA Monitor & Telephone Score			
	FB		NoFB	
Wk	W	O	W	O
1	0.39*	0.26	0.10	-0.03
2	-0.36	-0.36	0.04	0.16
3	-0.27	-0.15	0.35*	0.27
4	0.20	-0.26	0.36*	0.08

4.3.4 ROSA Mouse and Keyboard Score

There were as many significant correlations for worker-reported scores and discomfort as there were for observer-reported scores and discomfort in this subsection (Table 7). Significant correlations ranged from $r=0.41$ to $r=0.44$ for worker-reported scores, and from $r=0.37$ to $r=0.57$ for observer-reported ROSA scores. There were no significant correlations in the FB Group, comparable to all other subsections and ROSA final scores. As seen in Table 7, there was a trend for correlation values to increase from week 1 to week 4 in the NoFB Group.

Table 7: Correlation values (r) between ROSA mouse and keyboard scores for the worker (W) and observer (O) and mouse and keyboard related discomfort for both FB and NoFB Groups (*= statistically significant at $p \leq 0.05$).

	ROSA Mouse & Keyboard Score			
	FB		NoFB	
Wk	W	O	W	O
1	-0.03	-0.12	0.19	0.06
2	0.19	-0.10	0.41*	0.09
3	-0.08	-0.14	0.29	0.37*
4	-0.19	-0.20	0.44*	0.57*

4.3.5 Additional ROSA Score and Discomfort Relationships

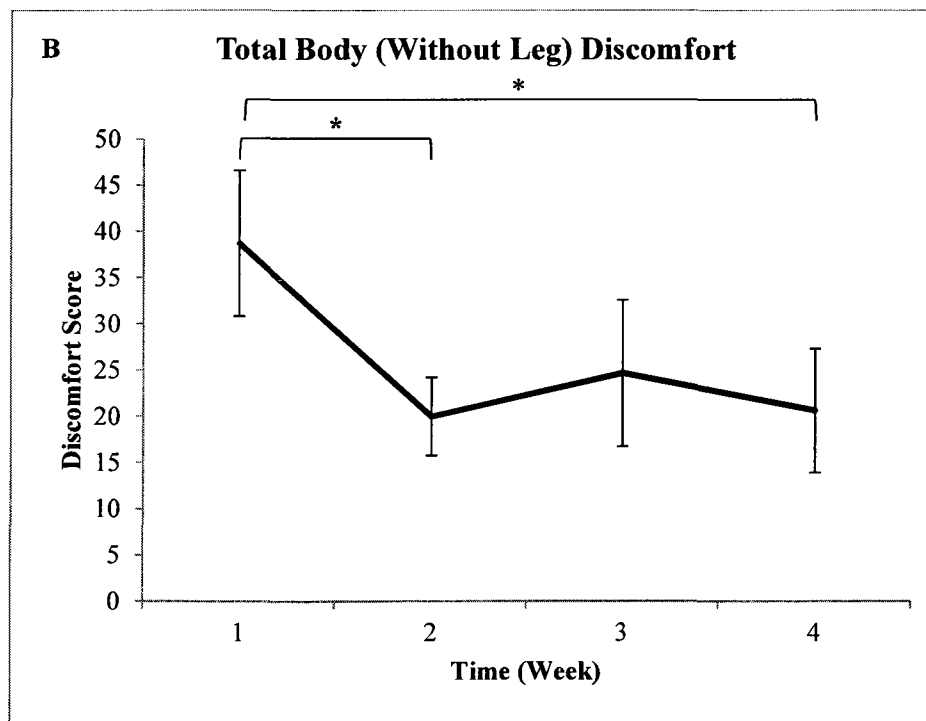
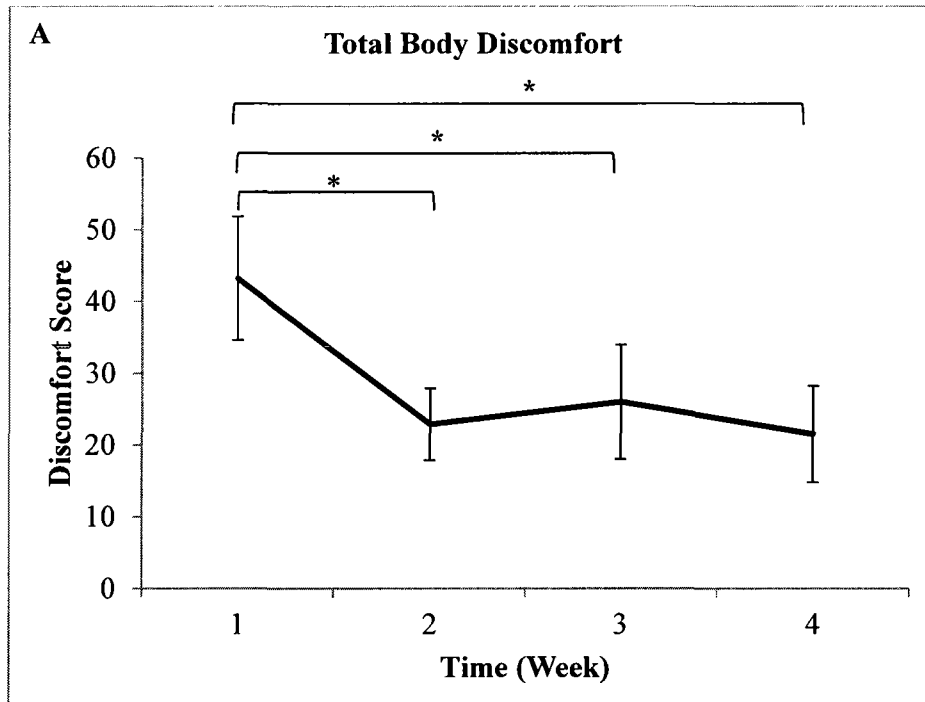
_____Sonne et al., (2010) found significant relationships between various combinations of ROSA final and subsection scores, and localized and total body discomfort measures. These relationships were also found in this study, and varied between $r=0.38$ (total body discomfort and mouse and keyboard score, NoFB, worker-reported ROSA score, week 3) and $r=0.68$ (chair-related discomfort, mouse and keyboard score, NoFB, observer-reported ROSA score, week 4). However, there were very few significant correlations between these localized discomfort scores and subsection scores. The full range of correlations between final and subsection ROSA scores can be seen in Appendix F.

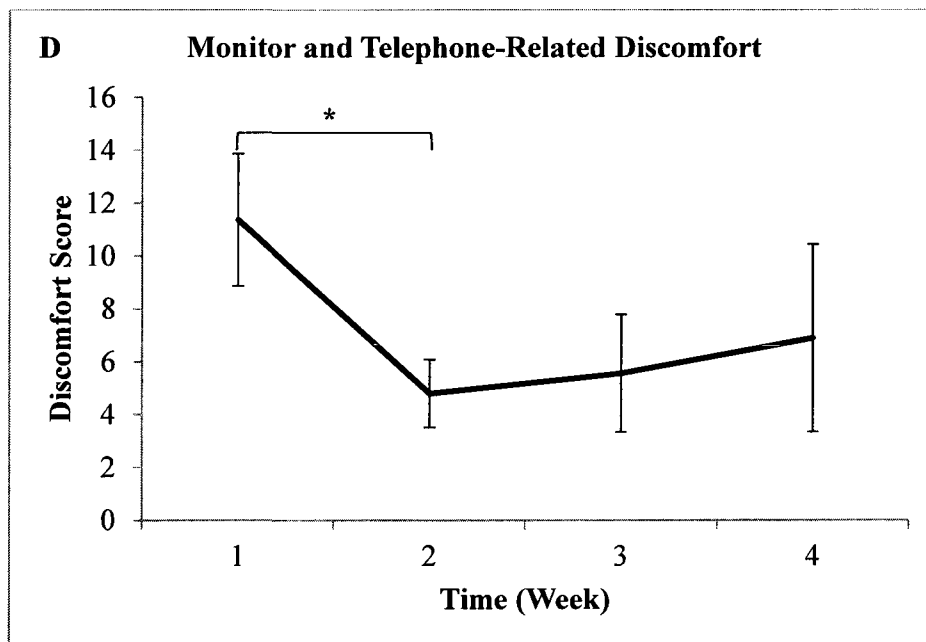
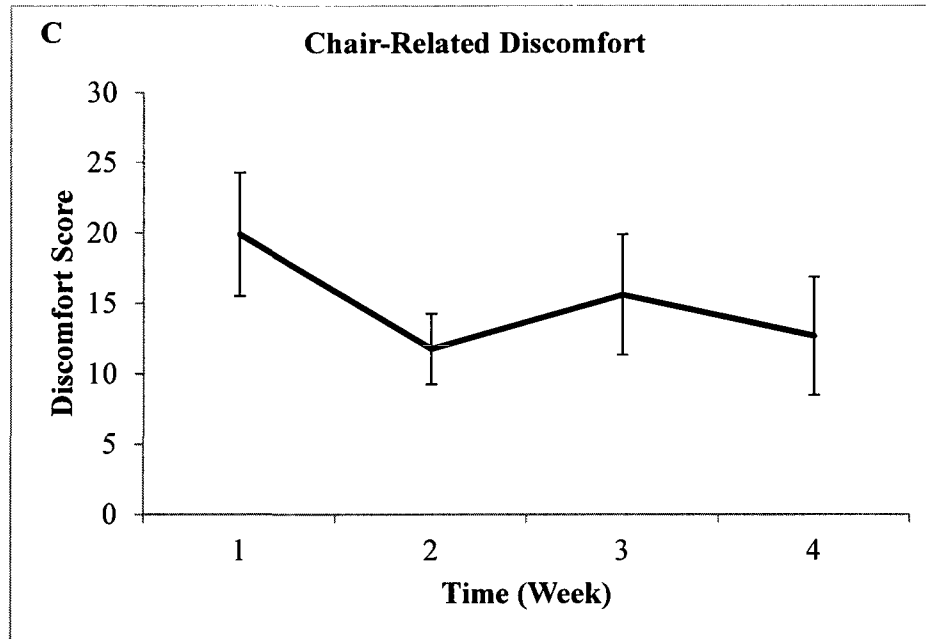
4.4 Research Question #4

Is an office ergonomic training protocol using ROSA online effective in reducing musculoskeletal discomfort in office workers?

All localized and total body discomfort measures trended to decrease from week 1 to week 4. A main effect of Time on reported discomfort emerged for total discomfort [$F(3,159)=5.64$ $p\leq 0.05$], total discomfort without leg scores [$F(3,159)=4.83$, $p\leq 0.05$], mouse and keyboard-related discomfort [$F(3,159)=3.51$, $p\leq 0.05$], and monitor and telephone related discomfort [$F(3,159)=3.28$ $p\leq 0.05$] (Figure 19 A, B, D, and E). Significant changes in discomfort occurred between week 1 (43.23(8.63)) and week 4 (49.88(6.75)), as well as week 1 and week 2 (22.88(5.02)) (Figure 19, A)). The greatest changes in mean discomfort collapsed across Groups were seen in the total body discomfort minus leg scores, with a 51.6% decrease in reported discomfort between weeks 1 and 2 of the analysis (Figure 19B).

There was no significant main effect of Time reported for chair-related discomfort (Figure 19 C). There was no significant main effect of Group (FB or NoFB) in any of the discomfort categories (final or localized discomfort). Finally, there were no significant interactions found between Time and Group.





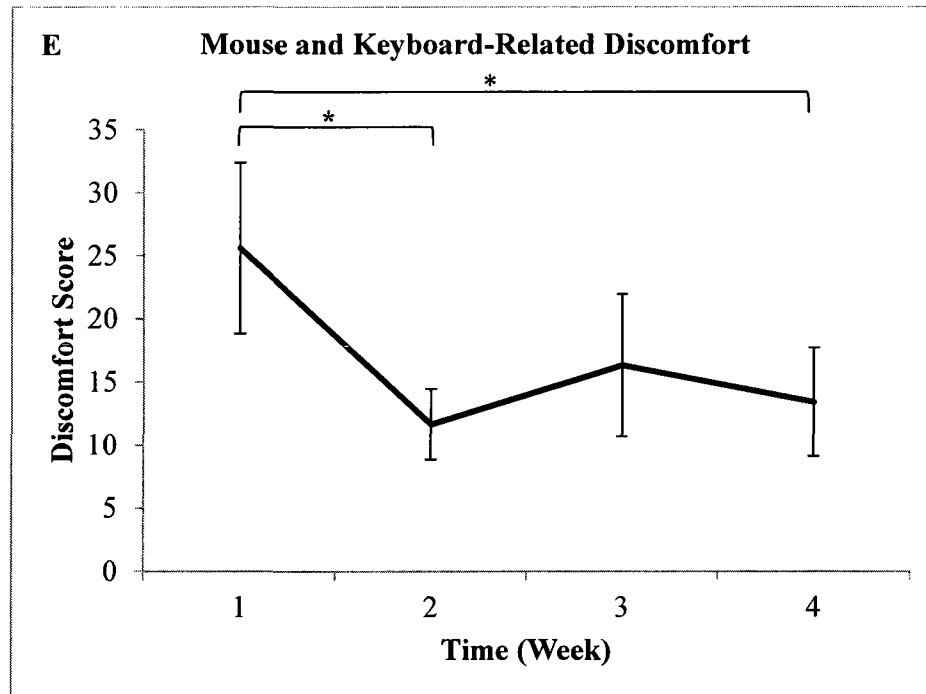


Figure 19: Main effects of Time on mean (SE) discomfort scores: total body discomfort (A), total body without leg discomfort (B), chair-related discomfort (C), monitor and telephone-related discomfort (D), and keyboard and mouse-related discomfort (E) (*= statistically significant at $p \leq 0.05$).

Chapter V

Discussion

Worker scores were not significantly different than observer scores for the monitor and telephone, and chair subsections. Significant differences emerged for Assessment Type (worker or observer) and Group (feedback or no feedback) for ROSA final scores, and for the mouse and keyboard subsections. Worker and observer scores were significantly correlated during all but 2 weeks for all subsections and final scores. There were significant relationships between discomfort and ROSA scores for groups that did not receive feedback, but not for groups who did receive feedback. Finally, there was a significant main effect of Time on worker-reported discomfort, indicating that discomfort decreased over the course of the four week protocol.

5.1 Research Question #1

Worker and observer scores were significantly different in the final score and the mouse and keyboard subsections, suggesting that self-reported ROSA scores for these sections are not accurate. As the ROSA final score is dependent on each area's subsection score, it is important to ensure that the scores from these subsections are accurate when comparing worker and observer-reported ROSA scores. The differences in ROSA final scores will be discussed after each of the subsections are addressed.

5.1.1 Chair

There was no statistically significant difference between observer- and worker-reported ROSA scores for the chair section (comprised of the chair height, depth, armrest and backrest subsections), and worker and observer-reported scores were significantly correlated. Assessments of the chair and seated posture generally required workers to evaluate postures of their legs and trunk; body postures for which self-assessment has been shown to be moderately accurate when compared to observer assessments in previous studies (Burdorf, 1995; Wiktorin, 1995). The non-significant difference between worker and observer scores, and 75% of the correlations between these scores registering as significant (Table 4; Figure 20), support the hypothesis that using ROSA for self-assessment of the chair appears to be a valid method of assessing risk factors related to this type of office furniture (validity defined in Section 3.3.2).

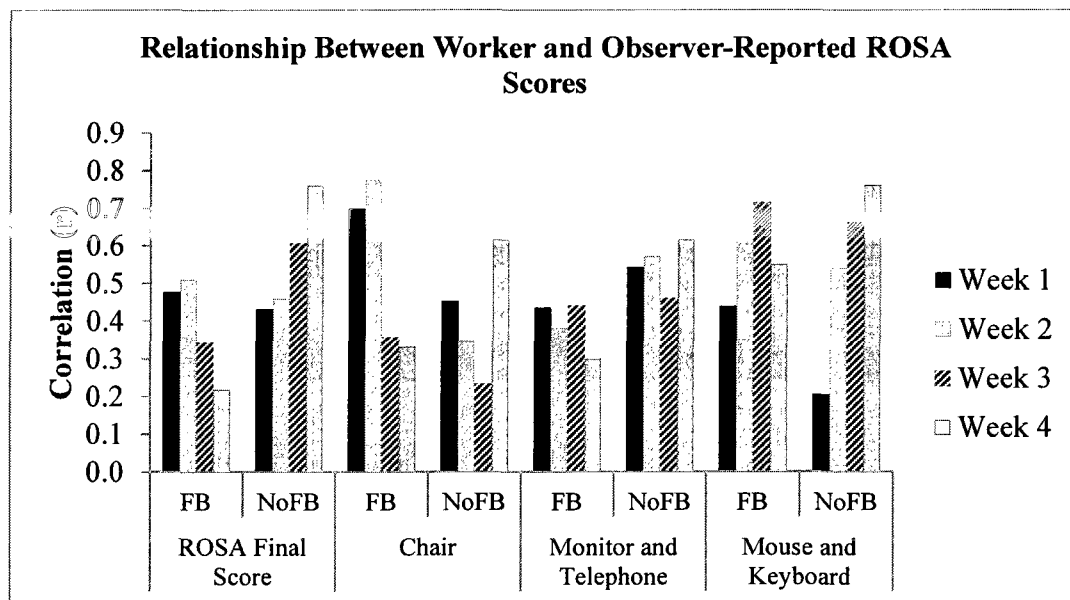


Figure 20: Correlation values (r) between worker and observer assessment ROSA scores for FB and NoFB Groups, during weeks 1-4.

5.1.2 Monitor and Telephone

Mean worker-reported monitor and telephone scores were not significantly different than those reported by the observers. In the monitor and telephone subsection of ROSA, postures of the neck and head are assessed, with one risk factor related to reaching to the phone. Previous research on head and neck posture self-assessment has achieved less than desired accuracy when compared to observer assessments (Heinrich et al., 2004). However, the posture results from ROSA may arise from the differences in the actual assessment methodologies. The setup of pictures, text and video in ROSA may have provided enough additional information to workers to enable them to successfully model their assessment responses for these body parts properly, compared to other approaches.

There was a tendency for ROSA scores to increase between weeks 1 and 4 for this subsection, as well as the chair subsection. The office is composed of many pieces of furniture, and in most cases all furniture can be adjusted. The increases in subsection scores may have come as a result of equipment from one area being adjusted, and making an impact on the equipment from another subsection. For example, if the chair was too high, but the monitor was at the ideal height, an adjustment to the proper height for the chair might lead to the monitor now being too high. None of the scores in week 4 for any subsections were significantly higher than the scores in week 1, indicating that any incorrect changes that possibly occurred in the middle weeks of the study may have been identified by the worker, re-assessed and re-adjusted in subsequent assessments.

The lack of significant difference between observer-reported and worker-reported ROSA scores for the monitor and telephone section, as well as having 87.5% of correlations between these measures registering as significant supports the hypothesis that this may be a valid method of assessing this aspect of the office workstation.

5.1.3 Mouse and Keyboard

There was a significant difference between observer- and worker-reported ROSA mouse and keyboard scores, with worker-reported scores being lower than observer-reported scores. However, there were large correlations between worker and observer scores in this subsection ($r=0.43$ to $r=0.76$). Self-assessments have previously shown to be effective in providing an accurate evaluation of keyboard and mouse working posture (Heinrich et al., 2004). The reason for this difference between worker- and observer-reported scores may be a result of the ROSA tool itself. In the evaluation of the shoulder position while using the mouse, there is a fixed option to select an abducted shoulder posture, as well as an additive option to indicate an abducted shoulder posture as a result of a different surface for the keyboard and the mouse. Both of these risk factors have a value of 2, and if one was consistently missed by individuals during self-assessments, this could result in the discrepancy between observer-assessment and worker-assessment scores observed in the present study. These were the only risk factors in ROSA that represented a similar body position that could be selected concurrently, therefore allowing an error of this nature.

While there were significant correlations seen between worker- and observer-reported ROSA scores in the mouse and keyboard section (87.5% of all cases), the

significant difference between these scores does not fit the definition of validity stated in Section 3.3.2. Therefore, worker-reported mouse and keyboard scores cannot be considered a valid measure of risk factors related to this equipment in the office.

5.1.4 ROSA Final Score

As previously mentioned (Section 5.1), the ROSA final score is determined from the scores achieved from the chair, monitor, telephone, keyboard and mouse subsections (see Section 2.4). The ROSA final score is achieved using scoring charts (Figure 9), and is highly reflective of the subsection where the highest score lies. Because there was a significant difference between observer- and worker-assessments in the mouse and keyboard subsection, this would have a marked influence on any assessment in which the mouse and keyboard score was the highest score of the three subsections.

Worker-reported ROSA final scores were generally lower than the observer-reported ROSA scores (Figure 11), which contradicts previous research regarding self-reporting. Other research has reported a tendency for users to over-report when identifying risk factors related to musculoskeletal disorders (Andrews et al., 1997; Wiktorin et al., 1993). The nature of these previous studies focused on industrial work (in manufacturing or automotive industries), and not computer work. While Heinrich and colleagues (2004) also indicated that there was a tendency to over-report exposure to risk factors in the office environment, this was confined to the issue of the duration of computer use.

While existing literature on self-reporting has indicated an over-reporting tendency, it is entirely possible that risk factor reporting related to office and computer

work could be predisposed to under-evaluation. One explanation for the under-reporting of worker scores is related to the current economic climate in the city where the study was conducted, along with the industries that participated in the study. While Windsor has the highest unemployment rate in Canada at approximately 14% (Hall, 2009), the majority of workers who participated in this study worked in the public service, which is regarded as one of the most secure industries (Clark & Vinay, 2009). Job security is a key component in job satisfaction (Blanchflower & Oswald, 2000; Heaney et al., 1994). Research has indicated that workers with higher levels of job satisfaction are less likely to report risk factors and discomfort in the workplace, which may have had an impact on the results of this study (Bigos, 1991; Demure et al., 2000).

The ROSA final score has an important practical application when considering the implementation of an online training protocol into a business. Like other ergonomic risk checklists, final evaluation on whether a job requires additional assessment or attention is based on one number that falls within specific intervention guidelines (Hignett & McAtamney, 2000; McAtamney & Corlett, 1993). Sonne and colleagues (2010) found that ROSA final scores of greater than 5 were associated with significant increases in discomfort, thus recommending that this value of 5 be used to determine when an office should receive a more in depth evaluation into the risk factors present. The goal of this cut-off point associated with the ROSA final score is to allow for an administrator to select which workers require additional training or even office furniture, without having extensive knowledge of ergonomics. Once the ROSA final score has been used to establish which offices should receive additional attention, the administrator

can then look to see which subsection is most heavily contributing to the high final score, and appropriate intervention can be sought.

In summary, the use of self-assessments performed by office workers of their own workstation using ROSA online appears to be a valid method of assessing risk factors related to the chair, monitor and telephone in an office environment. It was hypothesized that workers would be able to assess their workstations with reasonable accuracy compared to observer-assessments. This was confirmed for the chair, monitor and telephone subsections by a non-significant difference in worker and observer-reported scores, as well as several significant, large magnitude correlations between these scores. The ROSA scores for the mouse and keyboard section were significantly different between workers and observers; however, they were significantly correlated. The ROSA final, mouse and keyboard worker-reported scores cannot be considered valid measures of risk factors, but future work to increase the ease of identification of risk factors in these subsections could be performed in order to try to increase worker assessment accuracy.

5.2 Research Question #2

There was no significant interaction between Assessment Type (worker or observer) and Time for the ROSA final score, or any of the subsection scores, indicating that there was no change in the difference between either Assessment Type throughout the course of the four weeks of the study. There were no interaction effects between Assessment Type, Time or Group either, indicating that feedback had no role in increasing or decreasing the accuracy of worker-reported scores either. This result is

promising for the chair and monitor and telephone subsections, as a significant difference between worker- and observer-reported ROSA scores was not observed at any point during the four weeks of the study. However, it is concerning that workers did not improve in terms of being able to assess the mouse and keyboard position over the course of the month during which the study took place. The significant difference of Assessment Type could be a result of participants not taking their time and fully completing the assessment process (i.e. watching the videos each time they went through the assessment module). Previous research has indicated that workers tend to terminate their learning experience early when using computers in the realm of education and training (Tennyson, 1980), and when they receive negative feedback on their performance (Van Dijk & Kluger, 2000).

While careful consideration was given to the development of the online software, this was the first attempt to create such a training program. Research has indicated that issues such as posture bin size (van Wyk et al., 2009) and boundary definition (Andrews et al., 2008), as well as the salience of images within the tool (Fiedler, 2010) all need to be accounted for in order to optimize performance. The overall objective of this research was to examine if self-assessments in the office were a feasible method of conducting ergonomic assessments. While it is encouraging that worker-reported chair and monitor and telephone subsection scores showed promising validity, future research should focus on increasing the accuracy of the tool by modifying images and increasing the distinction of each individual risk factor.

Correlation values between worker and observer-reported ROSA scores tended to increase between weeks 1 and 4 for all scores in the no feedback Group. However, there

was a trend for r values to peak prior to the fourth week of the study for all scores in the feedback Group (Figure 20). It appears that once participants have had a chance to use the ROSA online application once, they became familiar enough to perform a more accurate assessment the second time they log in. After this point, it is possible that workers who were receiving feedback may not have performed their assessments with the diligence that they did in the first two weeks, and correlation values dropped off. This may be a result of the participants losing interest in the training, as they were completing the same assessment repeatedly. Repeated work can lead to decreased focus and reduced performance as a result of boredom (Fisher, 1993). If workers receive feedback on their performance, it appears that the second self-assessment is the most effective in producing valid ROSA scores. Those who do not receive feedback on their ROSA scores appear to produce the most accurate assessment results during the 4th week of the study.

The nature of the feedback given may have played a role in the lack of improvements in the validity of worker-reported ROSA scores. Lee and Carnahan (1990) found that when providing feedback on performance, exact performance feedback was not as effective in improving results as providing feedback that allowed for a margin of error both above and below the desired target (also known as bandwidth). Essentially, allowing workers to have a window of error that was deemed to be acceptable was seen to increase retention over a period of time as opposed to correcting every single error. Workers were corrected on every error they made in the current study, which may have resulted in an overwhelming amount of information to process, and would have reduced the participant's retention of information for their next assessment.

It was hypothesized that worker assessments would become more accurate with respect to observer assessments over the course of the 4 week training protocol. Based on the results of the study, this hypothesis is not supported, as there was no change in the accuracy of the worker assessments over time, even though correlations tended to increase between weeks 1 and 4.

5.3 Research Question #3

Significant correlations of a similar magnitude to those found by Sonne et al. (2010) emerged between discomfort and ROSA scores. Whole body discomfort and ROSA final score correlations varied between $r=0.40$ and $r=0.70$, which were slightly higher than values previously reported (Sonne et al., 2010). Total body discomfort scores were more highly correlated with ROSA scores than discomfort scores that did not include leg discomfort (Table 3), which is contrary to the discomfort relationships found originally (Sonne et al., 2010). Office workers tend to sit for long periods of time throughout the day, a risk factor for the development of lumbar disc herniation (Callaghan & McGill, 2001). A symptom of disc herniation is sciatica (pain resulting from irritation of the sciatic nerve, leading to shooting pain into the leg (Shiel, 2010)). Sciatica has been reported in up to 23% of all office workers (Tuomi et al., 1991). With this in mind, it is important to include leg discomfort in the analysis, as it could be a result of referred pain from a lower back injury.

The changes in the relationship between discomfort and ROSA scores may be a result of the different factors introduced in this study. Sonne et al. (2010) conducted assessments in a fairly traditional manner, with workers being observed and then

completing a paper version of the discomfort questionnaire. The introduction of feedback to the assessment could have impacted how workers reported discomfort for a variety of reasons. The majority of the feedback that was provided during the course of this study was negative in nature. Typically, feedback was given to inform workers that they had scored their assessment incorrectly, and that they needed to do something differently the next time. Van Dijk and Kluger (2000) concluded that in cases of negative feedback, trainees may lose motivation and could possibly terminate their learning experience early. Because the observer's assessment was treated as the gold standard in this study, all differences in worker assessment scores were treated as wrong answers. Furthermore, the quantity of feedback that was provided may have acted against workers actually learning from their errors. Stefanidis and colleagues (2007) found that when attempting to learn new techniques, limited feedback accompanied by video tutorials was more effective in improving performance than intense feedback sessions. As feedback was given for every risk factor that was not scored the same as the observer, there was a large quantity of information given to the worker after the assessment. The impact of feedback may have caused the training to be negatively affected, and caused the workers to not complete their assessment correctly or discomfort questionnaire truthfully. This could have prevented significant correlations between worker-reported ROSA scores and discomfort.

Feedback may also contribute to the appearance of a more traditional training program. While workers were not pressured for time during the course of their assessments, the fact remained that they were going to receive evaluation on how they performed after they completed them. This increases the structure of the training

program, and more closely represents a less effective, more lecture-based training program compared to an open access tutorial approach (Gist et al., 1988).

It was hypothesized that worker-reported discomfort would be more highly correlated to worker scores than observer-reported scores. There were more and stronger significant correlations with worker-reported ROSA scores, which supports this hypothesis.

5.4 Research Question #4

Decreases in discomfort over the 4 week period occurred across both feedback groups (Figure 19), and appeared for both total body discomfort as well as localized discomfort related to the monitor, telephone, mouse and keyboard. A previous study of the effectiveness of ergonomic training on the relief of discomfort has shown that all types of ergonomic intervention can lead to reduced worker-reported discomfort (Bayeh & Smith, 1999). Bohr (2000) showed that a participatory approach to ergonomics, where workers were instructed on how to make adjustments, followed by ergonomists helping the workers to make these changes, was the most effective in reducing symptoms of musculoskeletal disorders. The video-based training incorporated into ROSA appears to serve a similar purpose of educating workers on how to adjust office furniture with comparable results to these previous studies.

Discomfort and ROSA final scores showed similar decreasing trends over the course of the study (Figure 12, Figure 19A). Decreasing ROSA scores may be reflective of risk factors being removed from the office. This indicates that the changes made to

offices based on the videos, literature and assessment structure in the ROSA online application may have been effective in reducing discomfort.

What is promising about the changes to both office conditions and discomfort is that no new furniture purchases were made during the course of the study. Any changes made to the offices were a result of adjusting existing furniture and equipment, or using existing materials to improve the setup of the offices. Menozzi et al. (1999) found similar findings in office ergonomics research, with all forms of ergonomics training proving to be effective in reducing risk factors in the office environment. Amick et al. (2003) found that office ergonomic interventions were most successful when new furniture was brought in (primarily a new chair), and then workers were trained on adjustments. While there is no quantified evidence of the adjustments made by workers in the present study, the experimenter observed nearly all workers performing adjustments to their furniture throughout the assessment process. Using ROSA online appears to be an effective method of getting workers to adjust their furniture, which is a less expensive method of improving the office than making office-wide furniture purchases without assessing the need.

Similar decreases were seen with risk factors (as reflected in a decrease in ROSA scores) as well as worker-reported discomfort. While there was no control group to allow for confirmation of self-guided training being more effective than the training used in this study, self-reported discomfort did decrease in a manner similar to other studies (Mastronardi, 2009; Menozzi, 1999). With this in mind, the hypothesis of a self-reported training program being effective in reducing discomfort is not fully supported, but results are promising.

Chapter VI

Limitations

6.1 Rapid Office Strain Assessment Scoring System

A concern with the Rapid Office Strain Assessment research conducted to date (Sonne et al., 2010) was a lack of ROSA final scores recorded in the very low (1-2) and very high (7-10) range. Consequently, no relationships between discomfort and ROSA final score could be determined at these levels. The lack of very high scores in the previous and current study was due to the presence of adjustable office furniture, and relatively sound workstations in the facility where the research was conducted (Sonne et al., 2010). The reason for the lack of very low scores was related to the recruitment requirements for this study. Participants were required to spend at least 50% of their workday at their computer, which fulfilled the criteria for a +1 duration factor for most ROSA sections. As a result, the minimum score that could be achieved for each subsection was a score of 2, and any additional risk factors that exceeded neutral would lead to a score of 3 or higher. Due to a lack of previous ergonomic training within the workplaces, additional risk factors were present, which resulted in an increase in scores out of the lowest range of scores (ie., 1-2).

6.2 Recruitment and Training

Research question #4 aimed to examine the use of an online training program on worker-reported discomfort, as well as the identification and removal of risk factors in the office environment. A true self-guided program allows workers to access training materials whenever they choose, and complete tasks at their own pace (Gist et al., 1989). Originally, the intention of this study was to allow for two open access groups (with and

without feedback) that would have unfettered access to ROSA online, giving them a chance to review training materials and the self-assessment process at their own pace. During the course of the four weeks of the study with a group of 17 workers, no workers from these open access experimental groups conducted additional assessments of their office. As a result, the access groups were eliminated. A power analysis confirmed that the population recruited (n=55) was still sufficient to conduct the mixed models repeated measures ANOVA (recommended n=37) required to answer research questions 1, 2 and 4.

6.3 Feedback Administration

Feedback was provided after every trial over the course of the 4 week training protocol to those participants in the FB Group. As a result, participants may have used the feedback as a method of conducting their assessments, instead of using it as a learning tool for increasing the accuracy of their own assessments. Previous research has found that when feedback on results from a task is given too frequently, the learners may come to rely on it too heavily (Schmidt & Lee, 2005). For future research into the effectiveness of feedback in improving the validity of worker-reported ROSA scores, guiding instructions should be given at different set intervals to determine the optimal frequency in which to give feedback on performance.

Studying the use of feedback as a method of increasing the effectiveness of training is a beneficial aspect of this study, but may not be completely applicable in a real-world setting. As the primary goal of using ROSA in a large office is to quickly screen for risk factors, having to employ an individual to watch every person complete

their training, then give them feedback on their assessment, is not a time effective approach. In future research, an emphasis on creating methods of providing feedback (such as photographs of the workstation and the worker) without requiring additional observer interaction, would be desirable.

6.4 Feedback Recording

While the ineffectiveness of assessing the office seen in the FB Groups could be a result of decreased worker diligence over time, this cannot be confirmed, as the number of feedback items given was not recorded during each assessment. Diligence (or a decrease in diligence) could be confirmed if the same feedback points were given in multiple weeks, or if the total number of feedback points increased between weeks. As mentioned previously, extensive feedback can become a crutch for learners (Schmidt & Lee, 2005), and can lead to tasks not being fully learned. Additionally, frequent augmented feedback can cause degradation of the learning process through blocking long-term learning using short-term corrections (Schmidt, 1991). For future research, feedback should be conducted using the principles of bandwidth knowledge of results, as to not overload the participants with information. Working within an error rate of 5-10% (actual performance compared to ideal performance) has shown to increase retention in participants when compared to those who did not receive feedback, or received exact feedback over the course of a multi-week training program (Wright et al., 1997).

The goal of providing feedback to the participants was to increase the accuracy of worker-reported ROSA scores with respect to observer-reported scores. This feedback was provided on every error that was committed by the participants. Providing feedback

to the participants does somewhat limit the practical application of the ROSA online software. The goal of ROSA online is to provide a quick screen of an entire office for risk factors related to musculoskeletal disorders. To have an ergonomist monitor every worker's screening assessment would be very ineffective from a time and cost perspective. For future research, feedback could be provided by request from the participants.

6.5 Workplace Factors

Each office environment is slightly different in both its physical properties (desks, chairs, computers, etc.), and its psychosocial atmosphere (workplace stress, job satisfaction, job security, etc). Research has shown that psychosocial variables can play a large role in reporting discomfort, which could have had a substantial impact on the results of this study. However, the participants from this study were purposely distributed by company between both experimental groups with this in mind. For example, workers from the same company that worked in an open concept office area (with more than 2 participants separated by only a cubicle wall), were grouped together so that a member of the no feedback group would not receive secondary feedback resulting from an assessment of a worker in the feedback group that was working close by.

6.6 Control Group

No control group was included in the study, so it cannot be stated without some uncertainty that the general decrease in discomfort seen over the month of training was solely a result of the changes made to the office, and not due to the presence of an

observer. The presence of the observer might have led to lower discomfort reporting. However, previous research (Menozzi et al., 1999) has indicated that any type of ergonomics training has proven effective in lowering discomfort in office workers. Additionally, Amick and colleagues (2003) proved that the use of ergonomics training in office workers was effective in reducing risk factors related to musculoskeletal disorders and discomfort. As ROSA final scores were significantly correlated to discomfort, and ROSA final scores decreased throughout the course of the study, it does appear as if this training method was effective in reducing discomfort in the workers assessed.

6.7 Definition of Validity

This study was an exploratory venture into determining the validity of worker-reported scores. As a result, there needed to be a clear-cut criterion for when a measure becomes valid. This was done through examining the statistical procedures used, and setting cut-off points for each of the tests. These cut-off points were set in order to draw a yes or no answer on whether a measure was valid or not, but were not justified based on any previous work or definition for validity (such as the presence of a satisfactory relationship between two variables, as per Thomas & Nelson, 2001). Future work needs to address this issue, using the current work as a baseline.

Chapter VII

Future Directions

7.1 Risk Factor Identification Images

Existing research has shown that during video-based postural analysis, boundary definitions must be properly set (Andrews et al., 2008; van Wyk et al., 2009), and proper images must be used to allow for users to appropriately select the correct images. Additionally, the images must also be distinct enough to allow workers to differentiate between different conditions (Fiedler, 2010). These factors were not considered in great detail during the creation of ROSA online, due to the nature of this project. The researcher's intentions were to examine the existing ROSA checklist (Sonne et al., 2010), so the same images were used. From a modelling perspective, these animated graphics may have been difficult for the workers to relate to, and pictures of actual workers may have been more appropriate to promote more accurate selections of risk factors.

7.2 ROSA Scoring Ranges and Open Access to Training

A limitation in this and the previous study on ROSA was the lack of scoring in the very high (7-10), and very low range (1-2). Several reasons were given as to why the current range of scores existed (Section 6.1), including a lack of scores from workers that perform limited computer work in a day. A full scale study of a large office with no restrictions on the duration of computer use could contribute to a larger range of ROSA scores, from low to high (i.e. 1 to 10). Because ethical concerns would prevent researchers from exposing workers to known musculoskeletal disorder risk factors in the office environment, lab-based studies using techniques to measure muscle activity and

body posture could also be used to evaluate the strain on the worker during the very high range.

Another advantage of a long-term, large-scale study would be the confirmation of discomfort decreases as a result of using a truly self-guided training protocol. With a larger sample of workers, a control group could be implemented to confirm that decreases in discomfort are a result of changes made to the office workstation, and not just to the presence of the experimenter. Furthermore, the open access experimental groups that were originally proposed in this study could be used to determine the impact of a truly self-guided training program on discomfort and risk factor reduction.

7.3 Identification Through Photographs

ROSA final scores and discomfort decreased throughout the 4 weeks of the study, which may be a result of a decrease in risk factors. Changes to workstations by workers were observed by the experimenters, but their maintenance over 4 weeks cannot be confirmed. In future studies, photographs could be taken at the beginning and the end of the experimental protocol and evaluated for risk factors. A tool such as the Office Ergonomics Assessment checklist (Robertson et al., 2009) could be used to evaluate if the training actually was effective in adjusting furniture.

Another use of photographs could be to further evaluate workstations after they have been screened by the worker. A simple set of photos of the worker's activities could be used to conduct an evaluation of the office using ROSA, which could confirm the presence of risk factors. If assessing offices using photographs is a reliable approach for assessing risk factors, then travel and co-ordination issues would no longer be an

issue for the ergonomist. This would save time and money in the risk factor assessment process.

7.4 Establishing Worker-reported ROSA Score Cut-off Levels

Sonne et al. (2010) established a cut-off value of 5 for ROSA final score as the point above which significant increases in discomfort would be reported by workers. It was concluded that further analysis and training for those workstations above 5 should be considered in order to reduce worker discomfort and musculoskeletal disorder risk. The current study has shown that worker-reported ROSA final scores are significantly correlated with discomfort, and a significant difference existed between worker- and observer-reported ROSA final scores. A cut-off level for worker-reported scores should be established in order to help direct further assessments, training and equipment purchases within a company if needed.

7.5 Disadvantages of Using a Discomfort Questionnaire

As previously mentioned, the Cornell University Discomfort Questionnaire (Hedge et al., 1999) profiles discomfort in 18 different body parts, for frequency, intensity and degree of work interference related to discomfort. The large number of parts of this questionnaire, combined with a tendency for workers to over-report discomfort (Demure et al., 2000), may have led to some unwanted effects related to discomfort reporting in the current study. The decrease in discomfort could be a result of workers taking a few times to precisely identify their level of discomfort and use the questionnaire properly, or workers reporting significantly less discomfort because they were satisfied that changes had been made to their workstation. With these items

considered, a more accurate way to assess workstation impact on demands would be through research on muscle activation and various configurations of office furniture. Examining different office configurations and their corresponding ROSA scores would allow for a more clear-cut picture on the demands related to postures in the office.

Additionally, while discomfort has been shown to negatively impact productivity (Hagberg et al., 2002), the long term consequences of being exposed to risk factors in the office are musculoskeletal injuries. These can lead to lost time and expensive health care costs. Further validation of ROSA should be examined in a longitudinal study comparing ROSA scores against injury claims.

Chapter VIII

Conclusions

The results from this study can be summarized as follows:

1. Workers were able to validly assess the risk factors associated with the chair, monitor and telephone, but not with the mouse and keyboard or the ROSA final scores.
2. The trend of worker-reported ROSA final scores to decrease over 4 weeks was similar to those of the observer-reported ROSA final scores. In other words, there was no interaction effect of assessment type and time.
3. Providing augmented feedback to the worker on their performance negatively affected their reported scores.
4. There was a stronger significant relationship between worker-reported ROSA final scores and total body discomfort than between observer-reported scores and discomfort.
5. Worker-reported discomfort decreased throughout the 4 weeks of the study.

Self-reported scores were significantly different in the mouse and keyboard subsection, as well as the ROSA final score. As the final score is used to make final judgments on if a workstation requires additional assessment, self-reported scores cannot be considered valid at this point in time. Using the online version of ROSA allowed for the completion of over 200 assessments in a one-month time period. The demonstrated speed and ease with which access to online ergonomics training and assessments can be made warrants further research into how to increase the accuracy of worker-assessments using the ROSA online tool.

References

- Aaras, A., Dainoff, M., Ro, O., and Thoresen, M., 2002. Can a more neutral position of the forearm when operating a computer mouse reduce the pain level for VDU operators? *International Journal of Industrial Ergonomics*. 30, 307-324.
- Aguinis, H., Mazurkiewicz, M.D., and Heggstad, E.D., 2009. Using web-based frame-of-reference training to decrease biases in personality-based job analysis: An experimental field study. *Personnel Psychology*. 62, 405-438.
- Amick III, B.C., Robertson, M.M., DeRango, K., Bazzani, L., Moore, A., Rooney, T., and Harrist, R., 2003. Effect of office ergonomics intervention on reducing musculoskeletal symptoms. *Spine*. 28(24), 2706-2711.
- Andersson, B.J., and Ortengren, R., 1974. Lumbar disc pressure and myoelectric back muscle activity during sitting: 3 studies on a wheelchair. *Scandinavian Journal of Rehabilitative Medicine*. 6(3), 122-127.
- Andersson, G.B., 1999. Epidemiological features of chronic low-back pain. *Lancet*. 35, 581-585.
- Andrews, D.M., Norman, R.W., Wells, R.P., and Neumann, P., 1997. The accuracy of self-report and trained observer methods for obtaining estimates of peak load information during industrial work. *International Journal of Industrial Ergonomics*. 19, 445-455.
- Bandura, A., 1982. Self-efficacy mechanism in human agency. *American Psychologist*, 37, 122-147.
- Bayeh, A.D., and Smith, M.J., 1999. Effect of physical ergonomics on VDT worker's health: A longitudinal field study in a service organization. *International Journal of Human and Computer Interaction*. 11, 109-135.
- Bendix, T., Krohn, L., Jessen, F., and Aaras, A., 1985. Trunk posture and trapezius muscle load while working in standing, supported-standing, and sitting positions. *Spine*. 10(5), 433-439.
- Bergvist, U.O.V., and Knave, B.G., 1994. Eye discomfort and work with visual display terminals. *Scandinavian Journal of Work and Environmental Health*. 20, 27-33.
- Bernardin, H.J., and Buckley, M.R., 1981. Strategies in rating training. *Academy of Management Review*. 6(2), 205-212.
- Bigos, S.J., Battie, M.C., Spengler, D.M., Fisher, L.D., Fordyce, W.E., Hansson, T.H., Nachemson, A.L., and Wortley, M.D. A prospective study of work perceptions and psychosocial factors affecting the report of back injury. *Spine*. 16(1), 1-7.
- Black, P., and William, D., 1998. Assessment and classroom learning. *Assessment in Education*. 5(1), 70-75.

- Blanchflower, D.G., and Oswald, A.J., 2000. Is the UK moving up the international wellbeing rankings? NBER Conference, May 4th, 2000.
- Blatter, B.M., and Bongers, P.M., 2002. Duration of computer use and mouse use in relation to musculoskeletal disorders of the neck or upper limb. *International Journal of Industrial Ergonomics*. 30, 295-306.
- Bohr, P.C., 2000. Efficacy of office ergonomics education. *Journal of Occupational Rehabilitation*. 10(4), 243-255.
- Bohr, P.C., 2002. Office ergonomics education: A comparison of traditional and participatory methods. *Work*. 19, 185-191.
- Borg, R., and Burr, H., 1997. Danish employees working environment and health study 1990–1995. National Institute of Occupational Health. Report.
- Boudrifa, H., and Davies, B.T., 1985. The effect of backrest inclination, lumbar support and thoracic support on erector spinae muscles when lifting. *European Journal of Applied Physiology*. 54, 538-545.
- Brandt, L.P.A., Andersen, J.H., Lassen, C.F., Kryger, A., Overgaard, E., Vilstrup, I., and Mikkelsen, S., 2004. Neck and shoulder symptoms and disorders among Danish computer workers. *Scandinavian Journal of Work and Environmental Health*. 30(5), 399-409.
- Branton, P., and Grayson, G., 1967. An evaluation of train seats by observation of sitting behaviour. *Ergonomics*. 10, 35-51.
- Brattgard, S.O., 1969. Design of wheelchairs and wheelchair service based on scientific research. *Readaption*. 162-171.
- Brown, K.G., 2001. Using computers to deliver training: Which employees learn and why? *Personnel Psychology*. 54, 271-296.
- Burdorf, A., 1995. Reducing random measurement error in assessing postural load on the back in epidemiologic surveys. *Scandinavian Journal of Work and Environmental Health*. 21, 15-23.
- Burdorf, A., and Laan, J., 1991. Comparison of methods for the assessment of postural load on the back. *Scandinavian Journal of Work and Environmental Health*. 17, 425-429.
- Burgess-Limerick, R., Plooy, A., and Ankrum, D.R., 1998. The effect of imposed and self-selected computer monitor height on posture and gaze angle. *Clinical Biomechanics*. 13, 584-592.
- Callaghan, J.P., and McGill, S.M., 2001. Low back joint loading and kinematics during standing and unsupported sitting. *Ergonomics*. 44, 280-294.

- Canadian Standards Association, 2000. CSA-Z412: Guideline on office ergonomics. CSA International, Toronto, Canada.
- Carter, J.B., and Bannister, E.W., 1994. Musculoskeletal problems in VDT work: a review. *Ergonomics*. 37 (10), 1623-1648.
- Clark, A., and Postel-Vinay, F., 2009. Job security and job protection. *Oxford Economic Papers*. 61(2), 207-239.
- Cohen, J., 1988. *Statistical power analysis for the behavioural sciences* (2nd ed.). New Jersey: Lawrence Erlbaum.
- Cook, C.J., and Kothiyal, K., 1998. Influence of mouse position on muscular activity in the neck, shoulder and arm in computer users. *Applied Ergonomics*. 29(6), 439-443.
- Cook, D.A., 2007. Web-based learning: pros, cons and controversies. *Clinical Medicine*. 7, 37-42.
- Coury, H.J.C.G., 1998. Self-administered preventative programme for sedentary workers: reducing musculoskeletal symptoms or increasing awareness? *Applied Ergonomics*. 29 (6), 415-521.
- Coyte, P.C., Asche, C.V., Croxford, R., and Chan, B., 1998. The economic cost of musculoskeletal disorders in Canada. *Arthritis Care and Research*. 11(5), 315-325.
- Dane, D., Feuerstein, M., Huang, G.D., Dimberg, L., Ali, D., and Lincoln, A., 2002. Measurement properties of a self-report index of ergonomic exposures for user in an office work environment. *Journal of Occupational and Environmental Medicine*. 44(1), 73-81.
- David, G.C. 2005. Ergonomic methods for assessing exposure to risk factors for work-related musculoskeletal disorders. *Occupational Medicine*. 55, 190-199.
- de Wall, M., van Riel, M. P. J. M., Aghina, J. C. F. M., Burdorf, A., and Snijders, C. J., 1992. Improving the sitting posture of CAD/CAM workers by increasing VDU monitor working height. *Ergonomics*. 35, 427-436.
- Demure, B., Luippold, R.S., Bigelow, C., Ali, D., Mundt, K.A., and Liese, B., 2000. Video display terminal workstation improvement program: I. Baseline associations between musculoskeletal discomfort and ergonomic features of workstations. *Journal of Occupational and Environmental Medicine*. 42(8), 783-791.

- Dowell, W.R., Gscheidle G.M., and Walker, B., 2003. Importance of chair designs that support the lower back. *Interiors and Sources*. Retrieved February 14, 2010, from <http://www.interiorsandsources.com/ArticleDetails/tabid/3339/ArticleID/3797/Default.aspx>
- Dowell, W.R., Yuan, F., and Green, B., 2001. Office seating behaviors, an investigation of posture, task and job type. *Proceedings of the Human Factors and Ergonomic Society 45th Annual Meeting*.
- Fagarasanu, M., and Kumar, S., 2003. Carpal tunnel syndrome due to keyboarding and mouse tasks: a review. *International Journal of Industrial Ergonomics*. 31, 119-136.
- Fiedler, K., 2010. The effect of posture category salience on decision time and errors when using video-based posture assessment methods. Master's Thesis, Department of Kinesiology, University of Windsor, Windsor, Ontario, Canada.
- Fisher, C.D., 1993. Boredom at work: A neglected concept. *Human Relations*. 46(3), 395-418.
- Fogelman, M., and Lewis, R.J., 2002. Factors associated with self-reported musculoskeletal discomfort in video display terminal (VDT) users. *International Journal of Industrial Ergonomics*. 29, 311-318.
- Frese, M., Brodbeck, F., Heinbokel, T., Mooser, C., Schleiffenbaum, E., and Theimann, P. 1991. Errors in training computer skills: On the positive function of errors. *Human-Computer Interaction*. 6, 77-93.
- Genaidy, A.M., and Karwowski, W., 1993. The effects of neutral posture deviations on perceived joint discomfort ratings in sitting and standing postures. *Ergonomics*. 36(7), 785-792.
- Gerr, F., Letz, R., and Landrigan, P.J., 1991. Upper-extremity musculoskeletal disorders of occupational origin. *Annual Review of Public Health*. 12, 543-566.
- Gerr, F., Marcus, M., Ensor, C., Kleinbaum, D., Cohen, S., Edwards, A., Gentry, E., Ortiz, D.J., and Monteilh, C., 2002. A prospective study of computer users: I. Study design and incidence of musculoskeletal symptoms and disorders. *American Journal of Industrial Medicine*. 41, 221-235.
- Gist, M.E., Rosen, B., and Schwoerer, C., 1988. The influence of training method and trainee age on the acquisition of computer skills. *Personnel Psychology*. 41, 255-265.
- Gist, M.E., Schwoerer, C., and Rosen, B., 1989. Effects of alternative training methods on self efficacy and performance in computer software training. *Journal of Applied Psychology*. 74(6), 884-891.

- Grieco, A., Molteni, G., Piccoli, B., and Perris, R., 1982. Field study in newspaper printing: A systematic approach to VDU operator strain. In E. Grandjean & E. Vigliani (Eds.), *Ergonomic aspects of visual display terminals*. 185–194. London: Taylor & Francis.
- Hagberg, M., Wegman, D.H., 1987. Prevalence rates and odds ratios of shoulder-neck diseases in different occupational groups. *British Journal of Industrial Medicine*. 44, 602-610.
- Hagberg, M., Tornqvist, E.W., and Toomingas, A., 2002. Self-reported reduced productivity due to musculoskeletal symptoms: Association with workplace and individual factors among white-collar computer users. *Journal of Occupational Rehabilitation*. 12(3), 151-162.
- Hall, D., 2009. Windsor's unemployment rate falls but still highest in Canada. *The Windsor Star*, October 9th, 2009. Retrieved July 30, 2010 from <http://www.windsorstar.com/business/Windsor+unemployment+rate+falls+still+highest+Canada/2085944/story.html>
- Harisinghani, M.G., Blake, M.A., Saksena, M., Hahn, P.F., Gervais, D., Zalis, M., da Silva Dias Fernandes, L., and Mueller, P.R., 2004. Importance and effects of altered workplace ergonomics in modern radiology suites. *RadioGraphics*. 24, 615-627.
- Harrison, D.D., Harrison, S.O., Croft, A.C., Harrison, D.E., and Troyanovich, S.J., 1999. Sitting biomechanics part I: Review of Literature. *Journal of Manipulative and Physiological Therapeutics*. 22(9), 594-609.
- Hart L.G., Deyo R.A., and Cherkin D.C., 1995. Physician office visits for low back pain. *Spine*. 20, 11–19.
- Harvey, R., and Peper, E., 1997. Surface electromyography and mouse use position. *Ergonomics*. 40(8), 781-789.
- Hasegawa, T., and Kumashiro, M., 1998. Effects of armrests on workload with ten-key operation. *Journal of Physiological Anthropology*. 17(4), 123-129.
- Hattie, J., and Timperly, H., 2007. The power of feedback. *Review of Educational Research*. 77(10), 81-112.
- Haughie, L.J., Fiebert I.M., and Roach K.E., 1995. Relationship of forward head posture and cervical backward bending to neck pain. *Journal of Manual Manipulative Therapy*. 3, 91-97.
- Heaney, C.A., Israel, B.A., and House, J.S., 1994. Chronic job insecurity among automobile workers: effects of job satisfaction and health. *Social Science and Medicine*. 38(10), 1431-1437.

- Hedge, A., Morimoto, S., and McCrobie, D., 1999. Effects of keyboard tray geometry on upper body posture and comfort. *Ergonomics*. 42, 1333-1349.
- Heinrich, J., Blatter, B.M., Bongers, P.M., 2004. A comparison of methods for the assessment of postural load and duration of computer use. *Occupational Environmental Medicine*. 61, 1027-1031.
- Hignett, S., and McAtamney, L., 2000. Rapid entire body assessment (REBA). *Applied Ergonomics*. 31, 201-205.
- Hill, S.G., and Kroemer, K.H.E., 1986. Preferred declination and the line of sight. *Human Factors*. 28, 127-134.
- Homan, M.M., and Armstrong, T.J., 2003. Evaluation of three methodologies for assessing work activity during computer use. *American Industrial Hygiene Association Journal*. 64(1), 48-55.
- Jaschinski, W., Heuer, H., and Kylian, H., 1998. Preferred position of visual displays relative to the eyes: a field study of visual strain and individual differences. *Ergonomics*. 41(7), 1034-1049.
- Jensen, C., Finsen, L., Søgaaard, K., and Christensen, H., 2002. Musculoskeletal symptoms and duration of computer and mouse use. *International Journal of Industrial Ergonomics*. 30, 265-275.
- Johnson, J.J., Cattledge, G.T.H., and Collins, J.W., 1994. The efficacy of training for occupational injury control. *Occupational Medicine*. 9, 147-158.
- Juul-Kristensen, B., and Jensen, C., 2005. Self-reported workplace related ergonomic conditions as prognosticators for musculoskeletal symptoms: the "BIT" follow up study on office workers. *Occupational Environmental Medicine*. 62, 188-194.
- Karhu, O., Kansi, P., and Kuorinka, I., 1977. Correcting working postures in industry: A practical method for analysis. *Applied Ergonomics*. 8, 199-201.
- Katz, Y.J., 2002. Attitudes affecting college students preferences for distance learning. *Journal of Computer Assisted Learning*. 18(1), 2-9.
- Keegan, J.J., 1953. Alteration of the lumbar curve related to posture and seating. *Journal of Bone and Joint Surgery*. 35, 589-603.
- Keir, P.J., Bach, J.M., and Rempel, D., 1999. Effects of computer mouse design and task on carpal tunnel pressure. *Ergonomics*. 42, 1350-1360.
- Ketola, R., Toivonen, R., Häkkinen, M., Luukkonen, R., Takala, E., Viikari-Juntura, E., and the Expert Group in Ergonomics, 2002. Effects of ergonomic intervention in work with video display units. *Scandinavian Journal of Work and Environmental Health*. 28(1), 18-24.

- Korhonen, T., Ketola, R., Toivonen, R., Luukkonen, R., Hakkanen, M., and Viikari-Juntura, E., 2003. Work related and individual predictors for incident neck pain among office employees with video display units. *Occupational and Environmental Medicine*. 60, 465-482.
- Kryger, A.I., Andersen, J.H., Lassen, C.F., Brandt, L.P.A., Vilstrup, I., Overgaard, E., Thomsen, J.F., and Mikkelsen, S., 2003. Does computer use pose an occupational hazard for forearm pain; from the NUDATA study. *Occupational and Environmental Medicine*. Downloaded from oem.bmj.com on December 7, 2009.
- Kulhavy, R.W., 1977. Feedback in written instruction. *Review of Educational Research*. 47(1), 211-232.
- Kulik, C.C., and Kulik, J.A., 1991. Effectiveness of computer-based instruction: An updated analysis. *Computers in Human Behavior*. 7, 75-94.
- Kulik, J.A., Kulik, C.C., and Cohen, P.A., 1980. Effectiveness of computer-based college teaching: A meta-analysis of findings. *Review of Educational Research*. 50(4), 525-544.
- Lassen, C.F., Mikkelsen, S., Kryger, A.I., Brandt, L.P., Overgaard, E., Thomsen, J.F., Vilstrup, I., and Andersen, J.H., 2004. Elbow and wrist/hand symptoms among 6,943 computer operators: a 1-year follow-up study (the NUDATA study), *American Journal of Industrial Medicine*. 46(5), 521-533.
- Lee, T.D., and Carnahan, H., 1990. Bandwidth knowledge or results and motor learning: More than just a relative frequency effect. *Quarterly Journal of Experimental Psychology*. 42, 777-789.
- Lin, Z., and Popovic, A., 2003. Working with computers in Canada: An empirical analysis of incidence, frequency and purpose. Final Report: Human Resources Development Canada. Catalog: RH63-1/574-05-03E.
- Linton, S.J., and Kamwendo, K. 1989. Risk factors in the psychosocial work environment for neck and shoulder pain in secretaries. *Journal of Occupational and Environmental Medicine*. 31(7), 609-619.
- Lowe, G.S., 1997. Computers in the workplace. Statistics Canada: Perspectives on Labour and Income. 75-001-XPE, 29-36.
- Lueder, R., 1986. The ergonomics pay-off: Designing the electronic office New York: Nichols.
- Lueder, R., 1996. A proposed RULA for computer users. Proceedings of the Ergonomics Summer Workshop, UC Berkley Center for Occupation and Environmental Health Continuing Education Program, San Francisco, August 8-9, 1996.

- Lueder, R., and Allie, P., 1997. Ergonomics Review: Armrest design and use. An ergonomics review of the literature for Steelcase Furniture. 28 pp. Updated May, 2001. Viewed on September 8, 2009 on www.humanics-es.com/armrest-ergonomics.htm
- Marcus, M., Gerr, F., Monteilh, C., Ortiz, D.J., Gentry, E., Cohen, S., Edwards, A., Ensor, C., and Kleinbaum, D., 2002. A prospective study for computer users: II. Postural risk factors for musculoskeletal symptoms and disorders. *American Journal of Industrial Medicine*. 41, 236-249.
- Marshall, K., 2001. Working with computers. Statistics Canada: Perspectives on Labour and Income. Catalogue: 75-001, 9-15.
- Mastronardi, L., 2009. An investigation of ergonomic intervention strategies in an office work environment. Internship Report, University of Windsor, Department of Kinesiology.
- Mathieu, J.E., Tannenbaum, S.I., and Salas, E., 1992. Influences of individual and situational characteristics on measures of training effectiveness. *Academy of Management Journal*. 35(4), 828-847.
- McAtamney, L., and Corlett, E.N., 1993. RULA: a survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics*. 24, 45-57.
- McLean, L., Tingley, M., Scott, R.N., and Rickards, J., 2001. Computer terminal work and the benefit of microbreaks. *Applied Ergonomics*, 32, 225-237.
- Menozzi, M., Von Buol, A., Walkdmann, H., Kundig, S., Krueger, H., and Spieler, W., 1999. Training in ergonomics at VDU workplaces. *Ergonomics*. 42(6), 835-845.
- Mikkelsen, S., Butcher I., and Andersen J.H., 2003. Factors influencing self-reported computer use compared to objectively measured computer use in the NUDATA study. The challenge of equity in safety and health at work. 27th International Congress on Occupational Health, 23–28 February, ICOH, Iguassu Falls, Brazil, 49,1.
- Moore, R., Mao, Y., Zhang, J., and Clarke, K., 1993. Economic burden of illness in Canada. Health Canada, Ottawa, ON. Catalogue: H21-126/1993E.
- Nachemson, A.L., 1966. The load on lumbar disks in different positions of the body. *Clinical Orthopaedics and Related Research*. 45, 107 - 122.
- National Institute for Occupational Safety and Health, 1997. Alternative keyboards. US Department of Health and Human Services, Centers for Disease Control and Prevention Publication No. 97-148.
- Niemiec, R.P., Blackwell, M.C., and Walberg, H.J., 1986. CAI can be doubly effective. *The Phi Delta Kappan*. 67(10), 750-751.

- Nietfeld, J.L., Cao, L., and Osborne, J.W., 2006. The effect of distributed monitoring exercises and feedback on performance, monitoring accuracy, and self-efficacy. *Metacognition Learning*. 1(2), 159-179.
- Noe, R.A., and Schmitt, N., 1986. The influence of trainee attitudes on training effectiveness: Test of a model. *Personnel Psychology*. 39, 497-523.
- Occupational Health and Safety Council for Ontario 2008, Part 1: MSD prevention guideline for Ontario. Toronto: Workplace Safety and Insurance Board.
- Orlansky, J., and String, J., 1979. Cost-effectiveness of computer based instruction in military training. Institute for defense analyses science and technology division. Arlington, Virginia. Report.
- Picoli, G., Ahmad, R., and Ives, B., 2001. Web-based virtual learning environments: A research framework and preliminary assessment of effectiveness in basic IT skills training. *MIS Quarterly*. 25(4), 401-426.
- Pulakos, E.D., 1984. A comparison of rater training programs: Error training and accuracy training. *Journal of Applied Psychology*. 69(4), 581-588.
- Rempel, D., Barr, A., Brafman, D., and Young, E., 2007. The effect of six keyboard designs on wrist and forearm postures. *Applied Ergonomics*. 38, 293-298.
- Rempel, D., Nathan-Roberts, D., Chen, B.Y., and Odell, D., 2009. The effects of split keyboard geometry on upper body postures. *Ergonomics*. 52(1), 104-111.
- Robertson, M., Amick III, B.C., DeRango, K., Rooney, T., Bazzani, L., Harrist, R., and Moore, A., 2009. The effects of an office ergonomics training and chair intervention on worker knowledge, behaviour and musculoskeletal risk. *Applied Ergonomics*. 40, 124-135.
- Schiell, W.C., 2010. Sciatica. MedineNet.com, retrieved July 31, 2010 from <http://www.medicinenet.com/sciatica/article.htm>
- Schleicher, D.J., and Day, D.V., 1998. A cognitive evaluation of frame-of-reference rater training: Content and process issues. *Organizational Behavior and Human Decision Processes*. 73(1), 76-101.
- Schleicher, D.J., Day, D.V., Mayes, B.T., and Riggio, R.E., 2002. A new frame for frame-of-reference training: Enhancing the construct validity of assessment centers. *Journal of Applied Psychology*. 87(4), 735-746.
- Schmidt, R.A., 1991. Frequent augmented feedback can degrade evidence and interpretations. *Tutorials in Motor Neuroscience*. 59-75. Dordrecht, The Netherlands, Kluwer Academic Publishers.
- Schmidt, R.A., and Lee, T.D., 2005. Motor control and learning: a behavioural emphasis. Champagne, Illinois, Human Kinetics Publishers.

- Seidel, R.J., Wagner, H., Rosenblatt, R.D., Hillelsohn, M.J., and Stelzer, J., 1978. Learner control of instructional sequencing within an adaptive tutorial CAI environment. *Instructional Science*. 7, 37-80.
- Serina, E.R., Tal, R., and Rempel, D. 1999. Wrist and forearm posture and motions during typing. *Ergonomics*. 42(7), 938-951.
- Smith, M. J., Cohen, B. G. F., Stammerjohn, L. W., and Happ, A., 1981. An investigation of health complaints and job stress in video display operations. *Human Factors*. 23, 387-400.
- Sommerich, C.M., Joines, S.M.B., and Psihogios, J.P., 2001. Effects of computer monitor viewing angle and related factors on strain, performance and preference outcomes. *Human Factors: The Journal of the Human Factors and Ergonomics Society*. 43(1), 39-55.
- Sonne, M.W.L., Villalta, D.L., and Andrews, D.M., 2010. The development and evaluation of an office ergonomic checklist: ROSA The rapid office strain assessment. Internship Report, Department of Kinesiology, University of Windsor, Windsor, Ontario, Canada.
- Sotoyama, M., Jonai, H., and Saito, S., 1996. Analysis of ocular surface area for comfortable VDT workstation layout. *Ergonomics*. 39, 877–884.
- Spielholz, P., Silverstein, B., and Stuart, M., 1999. Reproducibility of a self-report questionnaire for upper extremity musculoskeletal disorder risk factors. *Applied Ergonomics*. 30, 429-433.
- Steinberg E.R., 1989. Cognition and learner control: A literature review, 1977-1988. *Journal of Computer-Based Instruction*, 16, 1 17-121.
- Straker, L., Pollock, C., Burgess-Limerick, R., Skoss, R., and Coleman, J., 2008. The impact of computer display height and desk design on muscle activity during information technology work by young adults. *Journal of Electromyography and Kinesiology*. 18(4), 606-617.
- Sulsky, L.M., and Day, D.V., 1992. Frame-of-reference training and cognitive categorization: An empirical investigation of rater memory issues. *Journal of Applied Psychology*. 77(4), 501-510.
- Swanson, N.G., Galinsky, T.L., Cole, L.L., Pan, C.S., and Sauter, S.L., 1997. The impact of keyboard design on productive in a text entry task. *Applied Ergonomics*. 28(1), 9-16.
- Szabo, R.M. and Gelberman, R.H., 1987. The pathology of nerve entrapment syndromes. *The Journal of Hand Surgery*, 12(5), 880 to 884.

- Szeto, G.P.Y., and Ng, J.K.F., 2000. A comparison of wrist posture and forearm muscle activities while using an alternative keyboard and a standard keyboard. *Journal of Occupational Rehabilitation*. 10(3), 189-197.
- Taylor, K., 2007. An analysis of computer use across 95 organizations in Europe, North America and Australasia. *Wellnomics White Paper*, Ref: 2.03-8/2007.
- Tennyson, R.D., 1980. Instructional control strategies and content structure as design variables in concept acquisition using computer-based instruction. *Journal of Educational Psychology*. 72(4), 525-532.
- Tichauer, E.R., and Gage, H., 1978. *The biomechanical basis of ergonomics*. New York: John Wiley & Sons.
- Tuomi, K., Ilmarinen, J., Eskelinen, L., Jarvinen, E., Toikkanen, J., and Klockars, M., 1991. Prevalence and incidence rates of diseases and work ability in different categories of municipal occupations. *Scandinavian Journal of Work and Environmental Health*. 17(1), 67-74.
- Turville, K.L., Psihogios, J.P., Ulmer, T.R., and Mirka, G.A., 1997. The effects of video display terminal height on the operator: a comparison of 15° and 40° recommendations. *Applied Ergonomics*. 29(4), 239-246.
- Van-Dijk, D., and Kluger, A.N., 2000. Positive (negative) feedback: Encouragement or discouragement? Presentation, 15th Annual Convention of the society for Industrial and Organizational Psychology. New Orleans, Louisiana.
- van Wyk, P.M., Weir, P.L., Andrews, D.M., Fiedler, K.M., and Callaghan, J.P., 2009. Determining the optimal size for posture categories used in video-based posture assessment methods. *Ergonomics*. 52(8), 921-930.
- Village, J., Rempel, D., and Teschke, K., 2005. Musculoskeletal disorders of the upper extremity associated with computer work: A systematic review. *Occupational Ergonomics*. 5, 205-218.
- Wahlström, J., 2005. Ergonomics, musculoskeletal disorders and computer work. *Occupational Medicine*. 55, 168-176.
- Wiktorin, C., Karlqvist, L., and Winkel, J., 1993. Validity of self-reported exposures to work postures and manual materials handling. *Scandinavian Journal of Work and Environmental Health*. 19, 208-214.
- Wilder, D.G., and Pope, M.H., 1996. Epidemiological and aetiological aspects of low back pain in vibration environments – an update. *Clinical Biomechanics*. 11(2), 61-73.
- Wright, D.L., Smith-Munyon, V.L., and Sidaway, B., 1997. How close is too close for precise knowledge of results? *Research Quarterly for Exercise and Sport*. 68, 172-176.

Wu, C.S., Miyamoto, H., and Noro, K., 1998. Research on pelvic angle variation when using a pelvic support. *Ergonomics*. 41(3), 317-327.

Wulff-Pabilonia, S., and Zoghi, C., 2004. Returning to returns to computer use. US Bureau of Labor Statistics, JEL: J31, O30.

Section 1: Identification		Section 2: Description		Section 3: Classification	
Item No.	Item Name	Item Description	Item Classification	Item Status	Item Location
1	Item 1	Item 1 Description	Item 1 Classification	Item 1 Status	Item 1 Location
2	Item 2	Item 2 Description	Item 2 Classification	Item 2 Status	Item 2 Location
3	Item 3	Item 3 Description	Item 3 Classification	Item 3 Status	Item 3 Location
4	Item 4	Item 4 Description	Item 4 Classification	Item 4 Status	Item 4 Location
5	Item 5	Item 5 Description	Item 5 Classification	Item 5 Status	Item 5 Location
6	Item 6	Item 6 Description	Item 6 Classification	Item 6 Status	Item 6 Location
7	Item 7	Item 7 Description	Item 7 Classification	Item 7 Status	Item 7 Location
8	Item 8	Item 8 Description	Item 8 Classification	Item 8 Status	Item 8 Location
9	Item 9	Item 9 Description	Item 9 Classification	Item 9 Status	Item 9 Location
10	Item 10	Item 10 Description	Item 10 Classification	Item 10 Status	Item 10 Location
11	Item 11	Item 11 Description	Item 11 Classification	Item 11 Status	Item 11 Location
12	Item 12	Item 12 Description	Item 12 Classification	Item 12 Status	Item 12 Location
13	Item 13	Item 13 Description	Item 13 Classification	Item 13 Status	Item 13 Location
14	Item 14	Item 14 Description	Item 14 Classification	Item 14 Status	Item 14 Location
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57	Item 57	Item 57 Description	Item 57 Classification	Item 57 Status	Item 57 Location
58	Item 58	Item 58 Description	Item 58 Classification	Item 58 Status	Item 58 Location



SCIENTIFIC QUALITY PROGRAM

SCIENTIFIC QUALITY PROGRAM

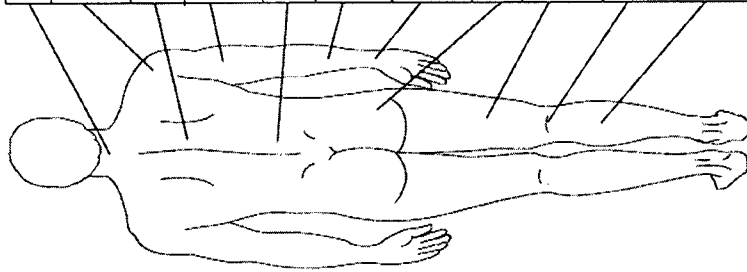
- SCIENTIFIC QUALITY PROGRAM

SCIENTIFIC QUALITY PROGRAM

Appendix B: The Cornell University Discomfort Questionnaire (Hedge et al., 1999).

	During the last work week how often did you experience ache, pain, discomfort in:					If you experienced ache, pain, discomfort, how uncomfortable was this?			If you experienced ache, pain, discomfort, did this interfere with your ability to work?		
	Never	1-2 times last week	3-4 times last week	Once every day	Several times every day	Slightly uncomfortable	Moderately uncomfortable	Very uncomfortable	Not at all	Slightly interfered	Substantially interfered
Neck / Head	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Shoulder (Right) (Left)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Upper Back	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Upper Arm (Right) (Left)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lower Back	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Forearm (Right) (Left)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wrist / Hand (Right) (Left) / Fingers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hip/Buttocks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Thigh (Right) (Left)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Knee (Right) (Left)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lower Leg / Foot (Right) (Left)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The diagram below shows the approximate position of the body parts referred to in the questionnaire. Please answer by marking the appropriate box.



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2. Informed Consent

The Rapid Office Strain Assessment - ROSA

Michael Sonna, MEd, Candidate, UK

You are logged in as: testaccount
You logged in on: Tue, July 16, 11:24 am

Logout

My Profile

Video Library

Resources

Additional Info

Informed Consent

Informed Consent to Participate in Research

I agree to participate in the research project entitled, "The Rapid Office Strain Assessment - ROSA" and I understand that I will receive no financial benefit from this research. I understand that I will receive no financial benefit from this research. I understand that I will receive no financial benefit from this research.

A full version of the Informed Consent Form is available below.

Informed Consent

☐ I agree to participate

☐ I do not agree to participate

Continue to ROSA

Copyright © 2014 Michael Sonna

3. Chair Height

The Rapid Office Strain Assessment - ROSA

Michael Sonna, MEd, Candidate, UK

You are logged in as: testaccount
You logged in on: Tue, July 16, 11:24 am

Logout

Chair
Height
Depth
Arm Height
Backrest
Rotation

Trunk
Tilt
Rotation

Keyboard
Mouse
Position
Questionnaire



height adjustable



depth adjustable



arm height adjustable



backrest rotation



trunk tilt adjustable

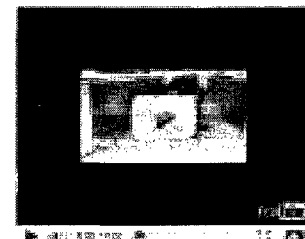


rotation adjustable

Keyboard Mouse

Copyright © 2014 Michael Sonna

Help



4. Chair Depth

The Rapid Office Strain Assessment - ROSA

Michael Eason, MHA, Candidate, CK


You are logged in as: TestAccount
You are logged in at: Fri, July 16, 11:24 am

Test Data


LEGS
Height
Depth
Arm Rests
Back Rest
Duration

Monitor
Ergonomics


Mouse
Keyboard
Ergonomics
Questionnaire




1. Approximately 3-4 inches (inches) of space between edge of chair and back of the knees.



2. Seat Pan Too Long. Less than 3-4 inches (inches) of space between the edge of the chair and the back of the knees.



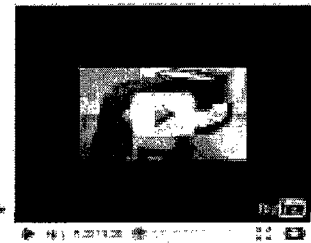
3. Seat Pan Too Short. More than 3-4 inches (inches) of space between the edge of the chair and the back of the knees.



4. Chair Depth Not Adjustable

Item - Arm Rests
1. Arm Rests are not adjustable

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5. Armrests

The Rapid Office Strain Assessment - ROSA

Michael Eason, MHA, Candidate, CK


You are logged in as: TestAccount
You are logged in at: Fri, July 16, 11:24 am

Test Data

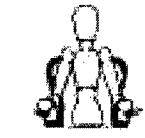
Mouse
Height
Depth
Arm Rests
Back Rest
Duration

Monitor
Ergonomics

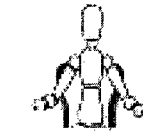
Keyboard
Ergonomics
Questionnaire




1. Armrests are supported at 90 degrees. The armrests are adjusted so the elbows are in line with the shoulders.



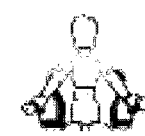
2. Armrests are too high and the shoulders are slumped.




3. No Armrests. Off armrests are too low to provide support for the entire forearm.



4. There is a hard or damaged surface on the armrest causing a pressure point on the forearm.



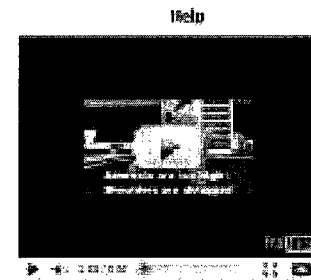
5. Armrests are too wide to support the arms.

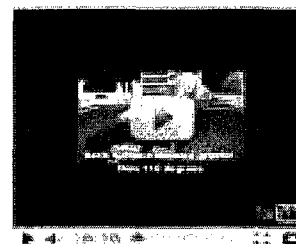


6. Armrests must be adjusted.

Item - Arm Rests
1. Arm Rests are not adjustable

Copyright © 2019 by Michael Eason





8. Telephone

The Rapid Office Strain Assessment - ROSA

Michael Sarna, MPH, Carddata, CK

You are logged in as: **TestAccount**
You logged in at: **Wed July 16, 8:13:44 am**

Logout

Check

- Height
- Depth
- Arm Length
- Neck/Head Rotation

Monitor


Anticipation

Mouse

Keyboard

Posture/Post

Open Windows




1

The Telephone is held by hand or is held in one hand during use.

Telephone Orientation


1. Hold the telephone only with 1 hand (no other hand/arm/leg/foot/shoulder/shoulder/shoulder)



2

Hand and Shoulder hold is used during phone use.


1. Hold the telephone between 1 and 2 hand/arm/leg/foot/shoulder/shoulder/shoulder



3

The Telephone is speaker. Over a 15-minute work day, the phone is held from the chair (greater than an arm's length).

1. Hold the telephone between 1 and 2 hand/arm/leg/foot/shoulder/shoulder/shoulder



4

There are no hand/arm/leg/foot/shoulder/shoulder/shoulder options available.

1. Hold the telephone between 1 and 2 hand/arm/leg/foot/shoulder/shoulder/shoulder

9. Mouse

The Rapid Office Strain Assessment - ROSA

Michael Sarna, MPH, Carddata, CK

You are logged in as: **TestAccount**
You logged in at: **Wed July 16, 8:13:44 am**

Logout

Check

- Height
- Depth
- Arm Length
- Neck/Head Rotation

Monitor


Anticipation

Mouse

Keyboard

Posture/Post

Open Windows




1

Mouse is held by the hand, wrist, or forearm while using the mouse.

Mouse Orientation


1. Hold the mouse only with 1 hand/arm/leg/foot/shoulder/shoulder/shoulder



2

Mouse is held by the hand and shoulder while using the mouse.

1. Hold the mouse between 1 and 2 hand/arm/leg/foot/shoulder/shoulder/shoulder



3

Mouse and keyboard are located on two different surfaces causing an awkward reaching to the mouse.

1. Hold the mouse between 1 and 2 hand/arm/leg/foot/shoulder/shoulder/shoulder

124

10. Keyboard

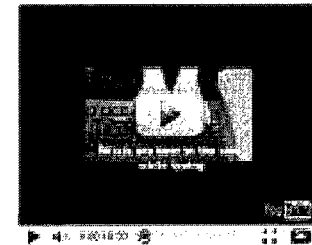
The Rapid Office Strain Assessment - ROSEA

Michael Gernig, MHB Consulting, UK

You are logged in as: testaccount
You logged in on Fri, July 16, 11:24 am

11:42 AM

Help



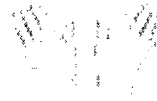
1. Wrist
- Height
- Depth
- Arm Rests
- Back Rest
- Controls



Wrist: Neutral while typing



Wrist: Extended while typing



Wrist: Flexion while typing

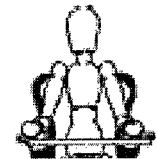
Monitor

Tray/Chair

Mouse

Keyboard

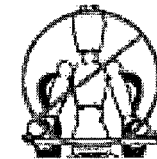
Chair/Desk
Control/Keyboard



Keyboard Tray Too High causing shoulders to be slumped while typing



Reaching for overhead items



Keyboard Tray Not Adjustable

Keyboard Strain

1. The keyboard is too high and the user has to reach up to type. This causes the shoulders to be slumped while typing.

2. The keyboard is too low and the user has to reach down to type. This causes the shoulders to be rounded while typing.

3. The keyboard is too far to the right and the user has to reach across the body to type. This causes the shoulders to be rounded while typing.

100% - 100% (100% - 100%)

Copyright 2000 Michael Gernig

11. Adjustment Videos

The Rapid Office Strain Assessment - ROSA

Michael Sonne, MMK Candidate, CK

You are Logged in As:
krestaccount
You Logged in On: Sat, July 08,
11:28 am

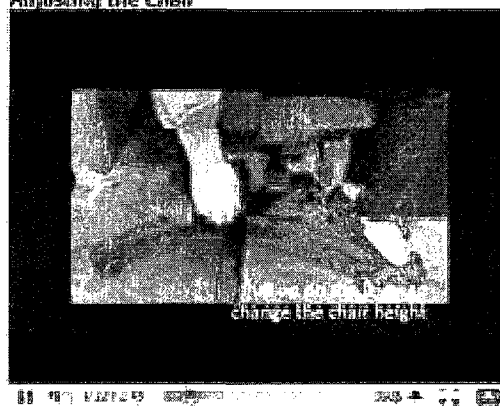
Logout

[My Profile](#) [Video Library](#) [Resources](#) [Additional Info](#)

Video Library

[Chair](#)
[Monitor](#)
[Telephone](#)
[Keyboard](#)
[Mouse](#)
[Stretching](#)

View the Adjustment Videos, return to the Profile screen, or Log Out
Adjusting the Chair



Adjusting the monitor



Appendix D: Feedback Script

The chair height you selected was:	Too low	The chair height I selected was:	Too low	This was because:	The angle of the knee is less than 90 degrees. The seam of your pants can be used to determine your knee angle.
	Too high		Too high		The angle of the knee is greater than 90 degrees. The seam of your pants can be used to determine your knee angle.
	No foot contact		No foot contact		When turning in the chair, you can only touch your toes to the ground, and your feet dangle off of the edge of the chair.
	Insufficient space under desk		Insufficient space under desk		There is not sufficient room for you to cross your lower legs under the desk surface.
	Non-adjustable		Non-adjustable		There is no height adjustment mechanism under your chair.

The seat pan depth you selected was:	Ideal (approximately 8cm of space between seat pan edge and the back of the knee)	The seat pan depth I selected was:	Ideal (approximately 8cm of space between seat pan edge and the back of the knee)	This was because:	There was enough space to fit your fist between the edge of the seat pan and the back of your knee.
	Too long (less than 8cm of space)		Too long (less than 8cm of space)		There was not enough space for you to fit your fist between the edge of the seat pan and the back of your knee.
	Too short (more than 8cm of space)		Too short (more than 8cm of space)		There was more than a "fist" of space between the edge of the seat pan and the back of the knee.
	Non-adjustable		Non-adjustable		There was no seat pan depth mechanism.

The armrest position you selected was:	Elbows supported in line with the shoulder, shoulders relaxed	The armrest position I selected was:	Elbows supported in line with the shoulder, shoulders relaxed	This was because:	The shoulders were relaxed and the elbows were supported at 90 degrees when sitting.
	Armrests too high (shoulders shrugged)		Armrests too high (shoulders shrugged)		The shoulders were shrugged when the arms were on the armrests.
	Armrests too low (arms unsupported)		Armrests too low (arms unsupported)		The elbow angle was greater than 90 degrees, and the forearms are not in full contact with the armrests while sitting.
	No arm support		No arm support		There were no arm supports on the chair, or the armrests were positioned so low that there was no contact with the armrests.
	Hard or damaged armrest surface		Hard or damaged armrest surface		The armrests surface has damage on it, or the armrest surface is made of a hard material that creates a pressure point on the forearm.
	Too wide		Too wide		The elbows and forearms are rested on the armrest, but the upper arm is not straight in line with the armrest.
	Non-adjustable		Non-adjustable		There are no adjustment mechanisms to change the positioning of the armrests.

The backrest position you selected was:	Adequate lumbar support and backrest recline between 95-110 degrees	The backrest position I selected was:	Adequate lumbar support and backrest recline between 95-110 degrees	This was because:	The lumbar support was positioned in the small of the back, and you were slightly reclined while sitting.
	No lumbar support, or lumbar support not positioned in the small of the back		No lumbar support, or lumbar support not positioned in the small of the back		The lumbar support was not positioned in the small of the back OR there was no lumbar support on the seat back.
	Chair angled too far back, or too far forward		Chair angled too far back, or too far forward		The recline of the chair was set too far back, and you were having to reach too far to things on the desk surface OR you were sitting so that you were leaning forward when reaching to items on the desk surface.
	No back support (leaning forward)		No back support (leaning forward)		There is no back support on the chair OR you were leaning forward and not making contact with the backrest while sitting.

	Work surface is too high - shoulders shrugged		Work surface is too high - shoulders shrugged		when putting your arms on the desk surface to write, or use the mouse and keyboard.
	Back rest non-adjustable		Back rest non-adjustable		The lumbar support or the backrest angle was not adjustable.

The monitor position you selected was:	An arm's length distance, with the top of the screen at eye level	The monitor position I selected was:	An arm's length distance, with the top of the screen at eye level	This was because:	The top of the viewing area of the screen was level with your sitting eye height, and the monitor was an arm's length away from you.
	Too low		Too low		The top of the monitor was below your sitting eye height, causing your head to be tilted forward while looking at the computer.
	Too far		Too far		The monitor was positioned outside of an arm's length away from you.
	Too high		Too high		The top of the monitor was above your sitting eye height, causing your neck to be extended while sitting and viewing the screen.
	Neck twisted		Neck twisted		The monitor was not in a direct line with you and your keyboard while typing. As a result, you had to twist your neck to the right/left to view the screen.
	Glare on screen		Glare on screen		Artificial/natural light is falling on the screen, and it can lead to eye fatigue because of the strain associated with attempting to focus around the glare.
	Documents - no holder		Documents - no holder		You are referring to paper documents, which are currently positioned on the desk surface to the right/left of the screen and cause your neck to be twisted and flexed.

The telephone position you selected was:	Headset / one hand on phone and neutral neck posture	The telephone position I selected was:	Headset / one hand on phone and neutral neck posture	This was because:	You use a wired or wireless headset, allowing you to type with the head in a neutral posture.
	Too far of a reach		Too far of a reach		The telephone was positioned outside of an arm's length away from you where you sit.
	Neck and shoulder hold		Neck and shoulder hold		The phone is cradled between your neck and shoulder while you talk on the phone and use the computer or write simultaneously
	No hands free options		No hands free options		There is no speaker phone/speaker phone is not an option, and there is not way to keep the head/neck in a neutral posture while typing while using the phone.

The mouse position you selected was:	Mouse in line with the shoulder	The mouse position I selected was:	Mouse in line with the shoulder	This was because:	The mouse was positioned in line with the shoulder, with no reaching.
	Reaching to the mouse		Reaching to the mouse		The mouse was positioned wide of the keyboard, and the arm had to be abducted in order to reach to the mouse.
	Mouse and keyboard on different surfaces		Mouse and keyboard on different surfaces		The mouse was on a different surface than the keyboard, making it impossible to move the mouse close to the keyboard and reduce strain on the shoulder while mousing.
	Pinch grip on the mouse		Pinch grip on the mouse		The mouse was too small to support the width of the hand and the palm while mousing.
	Palmrest in front of the mouse		Palmrest in front of the mouse		A palmrest is positioned in front of the mouse, causing pressure on the wrist which may contribute to symptoms of wrist discomfort.

The keyboard position you selected was:	Wrists straight, shoulders relaxed	The keyboard position I selected was:	Wrists straight, shoulders relaxed	This was because:	The wrists were straight while typing, and the keyboard platform was at a height that allowed the shoulders to be relaxed.
	Wrists extended / keyboard on a positive angle		Wrists extended / keyboard on a positive angle		The legs on the back of the keyboard were extended/ the keyboard tray was on a positive angle, causing the wrists to be bent back while typing, and contributing to increased forearm muscle activity.
	Deviation while typing		Deviation while typing		The keyboard was too small and caused the wrists to be bent to the side during typing.
	Keyboard tray/surface too high		Keyboard tray/surface too high		The platform where the keyboard was located was too high, and as a result the shoulders were shrugged while typing.
	Platform non adjustable		Platform non adjustable		The platform was non adjustable, and as a result it wasn't possible to get into a proper typing height

Appendix E: ANOVA Tables

Tests of Within-Subjects Effects

ROSA Final Scores						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	34.490	3	11.497	11.680	.000	.181
Time * Group	2.162	3	.721	.732	.534	.014
Error(Time)	156.497	159	.984			
AssessmentType	2.935	1	2.935	6.033	.017	.102
AssessmentType * Group	.025	1	.025	.052	.820	.001
Error(AssessmentType)	25.779	53	.486			
week * AssessmentType	3.262	3	1.087	2.283	.081	.041
week * AssessmentType* Group	.244	3	.081	.171	.916	.003
Error(week*AssessmentType)	75.751	159	.476			

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	5905.603	1	5905.603	1113.609	.000	.955
Group	21.239	1	21.239	4.005	.050	.070
Error	281.065	53	5.303			

Tests of Within-Subjects Effects

ROSA Chair Scores						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	16.111	3	5.370	10.180	.000	.161
Time * Group	.830	3	.277	.524	.666	.010
Error(Time)	83.884	159	.528			
AssessmentType	.749	1	.749	1.375	.246	.025
AssessmentType * Group	.158	1	.158	.290	.593	.005
Error(AssessmentType)	28.856	53	.544			
week * AssessmentType	3.084	3	1.028	2.479	.063	.045
week * AssessmentType* Group	.221	3	.074	.177	.912	.003
Error(week*AssessmentType)	65.948	159	.415			

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	4478.501	1	4478.501	1394.490	.000	.963
Group	.001	1	.001	.000	.990	.000
Error	170.213	53	3.212			

Tests of Within-Subjects Effects

ROSA Monitor and Telephone Scores

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	17.546	3	5.849	7.156	.000	.119
Time * Group	5.128	3	1.709	2.091	.103	.038
Error(Time)	129.958	159	.817			
AssessmentType	3.448	1	3.448	3.917	.056	.069
AssessmentType * Group	.012	1	.012	.014	.908	.000
Error(AssessmentType)	46.656	53	.880			
week * AssessmentType	2.600	3	.867	1.626	.186	.030
week * AssessmentType* Group	1.019	3	.340	.637	.592	.012
Error(week*AssessmentType)	84.768	159	.533			

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	3185.720	1	3185.720	677.854	.000	.927
Group	5.120	1	5.120	1.089	.301	.020
Error	249.085	53	4.700			

Tests of Within-Subjects Effects

ROSA Mouse and Keyboard Scores

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	23.738	3	7.913	8.071	.000	.132
Time * Group	1.538	3	.513	.523	.667	.010
Error(Time)	155.889	159	.980			
AssessmentType	2.719	1	2.719	4.732	.034	.082
AssessmentType * Group	1.137	1	1.137	1.979	.165	.036
Error(AssessmentType)	30.454	53	.575			
week * AssessmentType	3.042	3	1.014	1.921	.128	.035
week * AssessmentType* Group	.115	3	.038	.072	.975	.001
Error(week*AssessmentType)	83.949	159	.528			

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	3758.169	1	3758.169	566.265	.000	.914
Group	56.442	1	56.442	8.504	.005	.138
Error	351.749	53	6.637			

Tests of Within-Subjects Effects						
Total Body Discomfort						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	16675.75	3.00	5558.58	5.64	.00	.10
Week * Group	768.84	3.00	256.28	.26	.85	.00
Error(Time)	156791.58	159.00	986.11			

Tests of Between-Subjects Effects						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	177294.29	1.00	177294.29	20.33	.00	.28
Group	177.11	1.00	177.11	.02	.89	.00
Error	462203.07	53.00	8720.81			

Tests of Within-Subjects Effects						
Total Body Discomfort - No Leg Scores						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	12585.98	3.00	4195.33	4.83	.00	.08
Week * Group	657.47	3.00	219.16	.25	.86	.00
Error(Time)	137982.69	159.00	867.82			

Tests of Between-Subjects Effects						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	148292.90	1.00	148292.90	18.72	.00	.26
Group	251.22	1.00	251.22	.03	.86	.00
Error	419864.49	53.00	7921.97			

Tests of Within-Subjects Effects						
Chair-related Discomfort						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	2200.43	3.00	733.48	2.44	.07	.04
Week * Group	492.26	3.00	164.09	.55	.65	.01
Error(Time)	47829.21	159.00	300.81			

Tests of Between-Subjects Effects						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	49587.33	1.00	49587.33	19.60	.00	.27
Group	120.08	1.00	120.08	.05	.83	.00
Error	134099.73	53.00	2530.18			

Tests of Within-Subjects Effects						
Monitor and Telephone-Related Discomfort						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	1432.62	3.00	477.54	3.28	.02	.06
Week * Group	284.26	3.00	94.75	.65	.58	.01
Error(Time)	23177.77	159.00	145.77			

Tests of Between-Subjects Effects						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	11251.71	1.00	11251.71	11.37	.00	.18
Group	2.28	1.00	2.28	.00	.96	.00
Error	52434.59	53.00	989.33			

Tests of Within-Subjects Effects						
Mouse and Keyboard Related-Discomfort						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	6343.74	3.00	2114.58	3.50	.02	.06
Week * Group	401.18	3.00	133.73	.22	.88	.00
Error(Time)	96186.26	159.00	604.95			

Tests of Between-Subjects Effects						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	61340.25	1.00	61340.25	15.38	.00	.22
Group	1078.56	1.00	1078.56	.27	.61	.01
Error	211403.92	53.00	3988.75			

Appendix F: Correlation Tables

MonTel – Monitor and Telephone

MouKey – Mouse and Keyboard

Final – ROSA Final Score

Worker – Worker Reported Scores

Observer – Observer Reported Scores

*= statistically significant at $p \leq 0.05$.

Week 1 - Feedback					
	Total Body Discomfort	Total Body (No Leg)	Chair Discomfort	Monitor and Telephone Discomfort	Mouse and Keyboard Discomfort
Chair Worker	0.20	0.20	0.15	0.30	.13
MonTel Worker	0.20	0.21	0.13	0.39*	.12
MouKey Worker	0.08	0.11	-0.01	0.36	-.03
Worker Final	0.17	0.18	0.13	0.38	.08
Chair Observer	-0.18	-0.19	-0.24	-0.08	-.22
MonTel Observer	0.12	0.13	0.09	0.26	.00
MouKey Observer	-0.11	-0.10	-0.26	0.04	-.12
ObserverFinal	-0.23	-0.21	-0.29	-0.10	-.24

Week 1 - No Feedback					
	Total Body Discomfort	Total Body (No Leg)	Chair Discomfort	Monitor and Telephone Discomfort	Mouse and Keyboard Discomfort
Chair Worker	0.28	0.27	0.19	0.19	0.29
MonTel Worker	0.21	0.18	0.07	0.10	0.17
MouKey Worker	0.25	0.18	-0.03	-0.07	0.19
Worker Final	0.23	0.16	-0.02	-0.03	0.19
Chair Observer	0.06	0.06	0.03	-0.07	0.08
MonTel Observer	-0.12	-0.13	-0.12	-0.03	-0.10
MouKey Observer	0.11	0.15	0.04	0.14	0.06
ObserverFinal	0.01	0.03	-0.01	0.14	-0.03

Week 2 - Feedback					
	Total Body Discomfort	Total Body (No Leg)	Chair Discomfort	Monitor and Telephone Discomfort	Mouse and Keyboard Discomfort
Chair Worker	-0.06	-0.01	-0.10	0.05	0.10
MonTel Worker	-0.34	-0.31	-0.43*	-0.21	-0.24
MouKey Worker	0.06	0.12	-0.04	0.12	0.19
Worker Final	-0.17	-0.13	-0.21	-0.01	-0.04
Chair Observer	0.05	0.09	-0.04	0.02	0.18
MonTel Observer	-0.34	-0.34	-0.38	-0.36	-0.44*
MouKey Observer	-0.02	-0.03	-0.12	0.00	-0.10
ObserverFinal	-0.10	-0.07	-0.16	-0.13	-0.04

Week 2 - No Feedback					
	Total Body Discomfort	Total Body (No Leg)	Chair Discomfort	Monitor and Telephone Discomfort	Mouse and Keyboard Discomfort
Chair Worker	0.51*	0.52*	0.41*	0.33	0.47*
MonTel Worker	0.23	0.22	0.19	0.04	0.20
MouKey Worker	0.52*	0.46*	0.23	0.39*	0.41*
Worker Final	0.47*	0.43*	0.31	0.35*	0.43*
Chair Observer	0.18	0.17	0.11	0.09	0.22
MonTel Observer	0.20	0.17	0.13	0.16	0.18
MouKey Observer	0.19	0.14	0.09	0.24	0.09
ObserverFinal	0.15	0.12	0.05	0.15	0.12

Week 3 - Feedback					
	Total Body Discomfort	Total Body (No Leg)	Chair Discomfort	Monitor and Telephone Discomfort	Mouse and Keyboard Discomfort
Chair Worker	-0.03	-0.03	-0.05	-0.03	-0.01
MonTel Worker	-0.27	-0.29	-0.30	-0.27	-0.32
MouKey Worker	-0.06	-0.07	-0.05	-0.07	-0.08
Worker Final	-0.09	-0.09	-0.10	-0.08	-0.09
Chair Observer	-0.12	-0.12	-0.11	-0.09	-0.13
MonTel Observer	-0.18	-0.19	-0.21	-0.15	-0.19
MouKey Observer	-0.18	-0.17	-0.15	-0.19	-0.14
ObserverFinal	-0.19	-0.19	-0.18	-0.14	-0.21

Week 3 -No Feedback					
	Total Body Discomfort	Total Body (No Leg)	Chair Discomfort	Monitor and Telephone Discomfort	Mouse and Keyboard Discomfort
Chair Worker	0.30	0.29	0.20	0.28	0.27
MonTel Worker	0.34	0.33	0.06	0.35	0.27
MouKey Worker	0.38*	0.36	0.32	0.37	0.29
Worker Final	0.36*	0.35	0.25	0.33	0.28
Chair Observer	0.00	-0.01	0.02	0.06	-0.04
MonTel Observer	0.21	0.20	0.03	0.27	0.20
MouKey Observer	0.45*	0.41*	0.33	0.45*	0.37
ObserverFinal	0.39*	0.36*	0.18	0.43*	0.33

Week 4 - Feedback					
	Total Body Discomfort	Total Body (No Leg)	Chair Discomfort	Monitor and Telephone Discomfort	Mouse and Keyboard Discomfort
Chair Worker	-0.14	-0.15	-0.14	-0.14	-0.15
MonTel Worker	0.22	0.21	0.20	0.20	0.26
MouKey Worker	-0.16	-0.16	-0.21	-0.12	-0.19
Worker Final	-0.25	-0.26	-0.25	-0.19	-0.31
Chair Observer	-0.07	-0.07	-0.09	-0.06	-0.03
MonTel Observer	-0.34	-0.35	-0.35	-0.26	-0.34
MouKey Observer	-0.23	-0.22	-0.21	-0.18	-0.20
ObserverFinal	-0.18	-0.18	-0.18	-0.12	-0.15

Week 4 - No Feedback					
	Total Body Discomfort	Total Body (No Leg)	Chair Discomfort	Monitor and Telephone Discomfort	Mouse and Keyboard Discomfort
Chair Worker	0.33	0.33	0.36*	0.23	0.35
MonTel Worker	0.34	0.33	0.25	0.36*	0.31
MouKey Worker	0.47*	0.45*	0.35	0.42*	0.44*
Worker Final	0.46*	0.44*	0.42	0.40*	0.44*
Chair Observer	0.33	0.33	0.48	0.19	0.34
MonTel Observer	0.06	0.04	0.07	0.08	0.03
MouKey Observer	0.61*	0.59*	0.50*	0.59*	0.57*
ObserverFinal	0.70*	0.69*	0.68*	0.65*	0.67*

Appendix G: Development and Evaluation of an Office Ergonomic Checklist: ROSA – Rapid Office Strain Assessment (Sonne et al., 2010).

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Abstract: The Rapid Office Strain Assessment (ROSA) was designed to quickly quantify risks associated with computer work and to establish an action level for change based on reports of worker discomfort. Computer use risk factors were identified in previous research and standards on office design for the chair, monitor, telephone, keyboard and mouse. The risk factors were diagrammed and coded as increasing scores from 1-3. ROSA final scores ranged in magnitude from 1 to 10, with each successive score representing an increased presence of risk factors. Total body discomfort and ROSA final scores for 72 office workstations were significantly correlated ($R=0.384$). ROSA final scores exhibited high inter- and intra-observer reliability (ICCs of 0.88 and 0.91, respectively). Mean discomfort increased with increasing ROSA scores, with a significant difference occurring between scores of 3 and 5 (out of 10). A ROSA final score of 5 might therefore be useful as an action level indicating when immediate change is necessary. ROSA proved to be an effective and reliable method for identifying computer use risk factors related to discomfort.

Keywords:

Office ergonomics; Checklists; Risk Assessment

1.0 Introduction

The amount of computer work has dramatically increased in the past 20 years. In 2000, 60% of workers were required to use a computer as part of their job duties, with 80% of those workers reporting that they used a computer on a daily basis (Marshall, 2001; Lin and Popovic, 2003). This number is up from 50% in 1994, and 39% in 1989 (Lowe, 1997). This increasing trend in computer usage in the workplace has not come without a cost to the wellbeing of workers. In a review by Wahlström (2005), the prevalence of musculoskeletal disorders was reported to be between 10 and 62% for all computer workers. Furthermore, since the inception of occupational computer use, there has been a similar increase in the number of musculoskeletal disorders reported (Bayeh and Smith, 1999; Wahlstrom, 2005).

Musculoskeletal disorders associated with occupational computer use are primarily linked to the upper limbs (Gerr et al., 2002), head and neck (Korhonen et al., 2003; Hagberg and Wegman, 1987), and back (Jensen et al., 2002). Repetitive motion of the fingers, hands and wrists, sustained awkward postures of the wrist and forearm, and contact pressures in the wrist have been proposed as possible mechanisms of injury related to the use of the keyboard and mouse (Village et al., 2005). Elevated pressure in the tissues surrounding nerves in the upper extremities have been shown to increase with sustained non-neutral postures, which may lead to further discomfort and injury (Keir et al., 1999). Mechanisms of injury and discomfort for the back while computing include muscle fatigue, which results from increased levels of erector spinae activation when sitting as compared to standing (Callaghan and McGill, 2001), as well as improper sitting

posture contributing to a lack of support while sitting (Keegan, 1953; Harrison et al., 1999).

Graphics-based checklists are commonly used to perform ergonomic analyses, specifically in jobs that feature low intensity, repetitive work, or require workers to perform awkward postures (McAtamney and Corlett, 1993; Hignett and McAtamney, 2000; Karhu et al, 1977). The Rapid Upper Limb Assessment (RULA) tool has previously been used to examine worker interactions with a computer in an office environment (McAtamney and Corlett, 1993; Lueder, 1996; Robertson et al., 2009). Hazardous postures, such as wrist extension or radial or ulnar deviation (Serina et al., 1999) can be directly attributable to the use of improper office equipment and equipment setup. However, the direct influence of office equipment (e.g. chair, telephone and monitor) on the worker is not necessarily identified using RULA. The Office Ergonomic Assessment tool (OEA) (Robertson et al., 2009) offers an alternative approach for assessing the office using a checklist format. While the OEA is as an excellent method for measuring workstation adjustability and worker training outcomes, it doesn't result in outcomes that have been directly correlated with worker discomfort, nor are there scoring or action levels like in RULA that indicate when further intervention is required.

Traditional approaches to office ergonomic risk management, training and assessment have come in the following forms: literature, ergonomic redesign, individual assessment and group training (Bohr, 2002). Ideally, an ergonomic redesign of the entire workspace is the most effective method of intervention if the goal is to completely eliminate risk factors in the office environment instead of just control them. However, this approach is very costly and time intensive. With respect to cost, the next best

approach is to provide training to workers, and then allow them to actively make adjustments to their workspace (Bohr, 2002). However, in certain situations, workers may not be able to make adjustments (due to non-adjustable furniture, space constraints or a lack of equipment). Consequently, ergonomic redesign or equipment purchase may be the only option to eliminate hazards from the workstation. Traditional ergonomic assessments may highlight risk factors, and possible solutions, but do not provide a clear picture of how to prioritize the risks and allow for the most effective solutions to be purchased or implemented. This problem is amplified as the number of employees and workstations in a given office environment that would benefit from new products increases. A combined approach of workers receiving adjustable furniture, followed by training to use the furniture, appears to be the most effective method of reducing musculoskeletal disorder symptoms (Amick et al., 2003). In order to prioritize risks in the office to identify who should receive furniture or other equipment first, a quantifiable method must be used to indicate which problem areas pose the greatest risk, and how urgently these risks need to be addressed.

Therefore, the purpose of this study was to develop and evaluate a new office risk assessment tool, the Rapid Office Strain Assessment (ROSA), that can quickly quantify hazards associated with each component of a typical office workstation, and provide information to the user regarding the need for change based on reports of discomfort related to office work.

2.0 Methods

2.1 Tool development

The Rapid Office Strain Assessment (ROSA) was created using postures that were described in the CSA Z412 guidelines for office ergonomics (Canadian Standards Association (CSA), 2000) and on the Canadian Centre for Occupational Health and Safety website (Canadian Centre for Occupational Health and Safety (CCOHS), 2005). All postures that were described as ideal or neutral in the CSA standards were given a score of 1 and became the minimum score for each area within the sub-sections of the tool (see below). Deviations from the neutral postures were scored in a linearly increasing manner from values of 1 to 3. Certain factors that could be used concurrently with base risk factors (for example, chair height and chair height adjustability) were given scores of +1. These scores can be added to the base section scores. Risk factors were grouped into the following areas: chair, monitor, telephone, keyboard and mouse. In each of these areas, the maximum score that can reasonably be achieved is tallied and set as the highest possible value on the developed scoring charts (Figure 1).

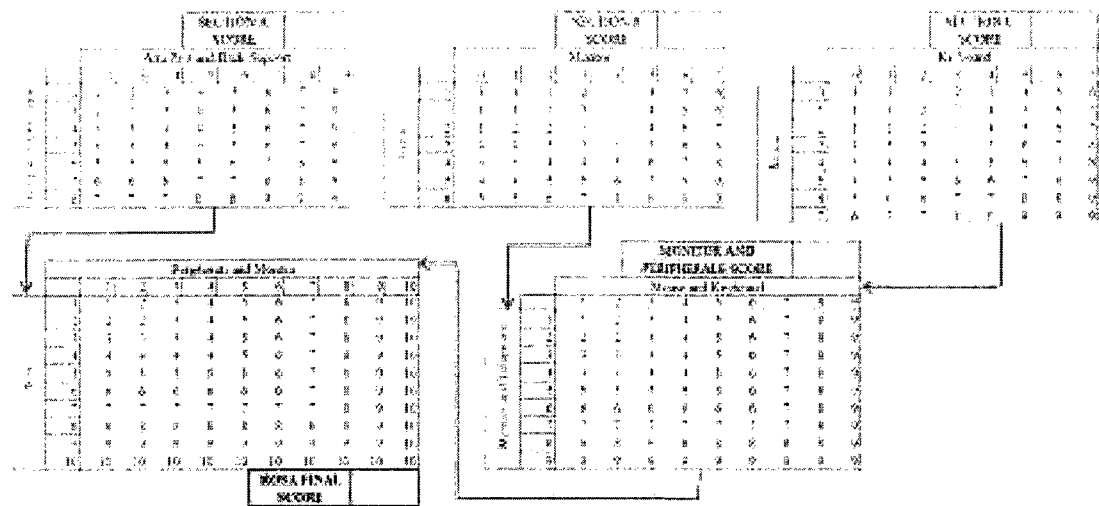


Fig. 1. Scoring charts for sub-sections (A, B and C), monitor and peripherals score, and ROSA final score.

The scoring charts were developed by matching two office sub-sections against each other in order to get a complete score for that area. These sub-sections were seat pan height and seat pan depth, backrest and arm supports, monitor and telephone, and keyboard and mouse. The maximum scores from each of the sections were used as the horizontal and vertical axes for the sub-section scores (which were subsequently used to create the ROSA final score). The scores from the monitor and telephone, and keyboard and mouse are then compared in another chart to receive the peripheral score. The ROSA final score is derived by comparing the peripheral chart against the chair score (Section 2.2).

A draft of the completed ROSA tool was given to 5 expert reviewers that worked as professional ergonomists, and conducted regular office ergonomic analyses and training. The experts were given a training package that outlined how ROSA was to be used and detailed breakdowns of each of the scoring sections and scoring charts. The ergonomists were told to use the tool and provide feedback on or report any issues with

the images selected in the tool, the individual posture scores, or any of the scores within the charts. The feedback from the individual reviewers was then collated, and changes were made to the tool via consensus.

2.2 Creation of scoring charts

The design of the section A, B, C, peripheral and final score charts in ROSA (Figure 1) is reflective of the increasing values (related to risk level) found within the head/trunk/neck and grand score charts in RULA (McAtamney and Corlett, 1993). The scores used to select values along the axes in these scoring charts are achieved by summing the values associated with the individual risk factors in the specific sub-sections (chair components, monitor, telephone, mouse and keyboard) (Figure 2). The maximum possible score that can be achieved for the sub-sections is reflective of the presence of all possible risk factors, as well as the maximum duration of use value (Section 2.3.7 below). Within the chair scoring chart and the peripherals scoring chart, the highest possible score that can be achieved is a score of 10. This is also the case in the final score chart. The value of 10 was chosen to provide users with an easy to understand 1-10 scoring system that would reflect the amount of risk that was present in the workstation.

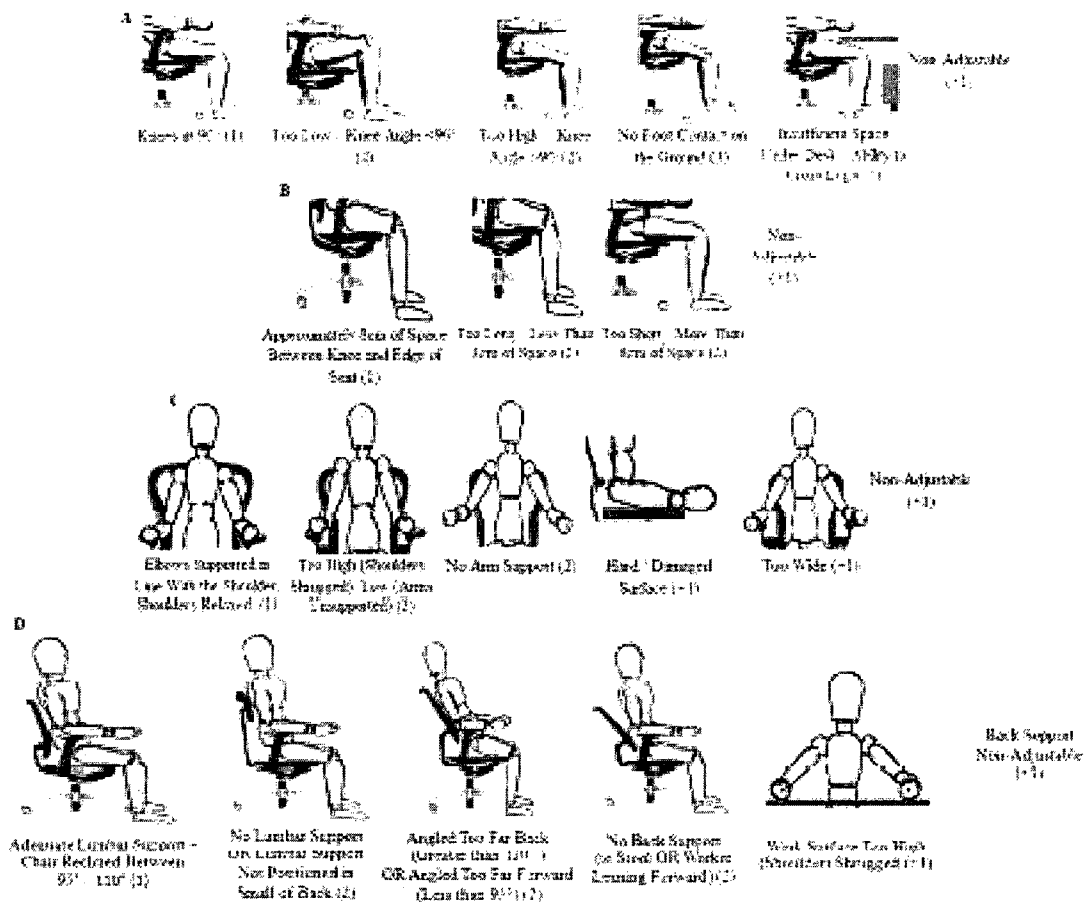


Fig. 2. Scores and diagrams for the risk factors associated with seat pan height (A), seat pan depth (B), arm rest (C) and back support (D).

2.3 Individual posture and equipment scores

The scores for each risk factor were modelled after deviations from the neutral posture, as cited by the CSA standards on office ergonomics (CSA International, 2000).

The deviations are also supported as risk factors for the onset of musculoskeletal disorders based on supporting literature, as well as information contained within the CSA standards.

2.3.1 Office chair scores

As indicated in CSA standard Z412 (CSA International, 2000), the neutral seated posture for an individual is to have the knees bent at approximately 90° with the feet flat on the floor. The lumbar support should be adjusted to fit in the small of the back in order to maintain the natural curve of the lumbar spine. The worker should be sitting reclined at approximately 95-110°. The armrests should be positioned so the elbows are at 90° and the shoulders are in a relaxed position.

The chair section was partitioned into 4 smaller sub-sections: the seat pan height, the seat pan depth, the armrest position and the back support position. The risk factors and associated scores and diagrams for each of these sub-sections are outlined in Table 1 and Figure 2.

Table 1. Risk factors (including references) and scores associated with seat pan height, seat pan depth, arm rests, and back support. The risk factors and scores correspond to the diagrams in Figure 2.

Risk Factor (Reference)	Score
<u>Seat Pan Height</u>	
• Knees bent to approximately 90° (CSA International, 2000).	(1)
• Seat too low – knee angle less than 90° (CSA International, 2000).	(2)
• Seat too high – knee angle greater than 90° (Tichauer and Gage, 1978).	(2)
• No foot contact with ground (Tichauer and Gage, 1978).	(3)
• Insufficient space for legs beneath the desk surface (CSA International, 2000).	(+1)
• Seat pan height is non-adjustable (CSA International, 2000).	(+1)
<u>Seat Pan Depth</u>	
• Approximately 3” of space between the edge of the chair and the back of the knee (CSA International, 2000).	(1)
• Seat pan length too long (less than 3” of space between the edge of chair and the back of the knee (Tichauer and Gage, 1978; CSA International, 2000).	(2)
• Seat pan too short (more than 3” of space between the edge of the chair and the back of the knee (Tichauer and Gage, 1978).	(2)
• Seat pan depth is non-adjustable (CSA International, 2000).	(+1)
<u>Arm Rests</u>	
• Elbows are supported at 90°, shoulders are relaxed (CSA International, 2000)	(1)
• Armrests are too high (shoulders are shrugged) (Leuder and Allie, 1997)	(2)
• Armrests are too low (elbows are not supported) (CSA International, 2000).	(2)
• Armrests are too wide (elbows are not supported, or arms are abducted while using the armrests (Hasegawa and Kumashiro, 1998).	(+1)
• The armrests have a hard or damaged surface – creating a pressure point on the forearm (Szabo and Gelberman, 1987).	(+1)
• There is no arm support (Hasegawa and Kumashiro, 1998).	(2)
• Armrests or arm support is non adjustable (CSA International, 2000).	(+1)
<u>Back Support</u>	
• Proper back support – lumbar support and chair is reclined between 95 and 110° (CSA International, 2000)	(1)
• No lumbar support (Harrison, et al., 1999).	(2)
• Back support is reclined too far (greater than 110°) (Harrison et al., 1999).	(2)
• No back support (ie., stool or improper sitting posture) (Harrison et al., 1999).	(2)
• Back support is non-adjustable (CSA International, 2000).	(+1)

2.3.2 Monitor scores

According to the CSA Standards, the monitor should be positioned between 40 cm and 75 cm from the user. The most effective method to determine the proper viewing distance for workers is to instruct them to position the monitor at an arm’s length. The user should be able to view the screen while sitting back in the chair. The height of the

screen should be positioned at eye level, or just below the worker's seated eye height.

The bottom of the screen should be at no greater than 30° below the worker's eye level.

The risk factors and scores for the monitor are found in Table 2, and the corresponding diagrams associated with the monitor in the ROSA checklist are shown in Figure 3A.

Table 2. Risk factors (including references) and scores associated with monitor, telephone, mouse, and keyboard. The risk factors and scores correspond to the diagrams in Figure 3.

Risk Factor (Reference)	Score
<u>Monitor</u>	
• Screen at arm's length / Screen positioned at eye level (CSA International, 2000)	(1)
• Screen too low (causing neck flexion to view screen) (Burgess-Limerick et al., 1998).	(2)
• Screen too high (causing neck extension to view screen) (Burgess-Limerick et al., 1998).	(3)
• User required to twist neck in order to view screen (Tittiranonda et al., 1999).	(+1)
• Screen too far (outside of arm's length (75cm)) (CSA International, 2000)	(+1)
• Document holder not present to hold documents (CSA International, 2000).	(+1)
<u>Telephone</u>	
• Headset used / One hand on telephone and neck in a neutral posture, telephone positioned within 300 mm (CSA International, 2000).	(1)
• Telephone positioned outside of 300mm (Tittiranonda et al., 1999).	(2)
• Neck and shoulder hold used (CSA International, 2000).	(+2)
• No hands free options (CSA International, 2000).	(+1)
<u>Mouse</u>	
• Mouse in line with the shoulder (CSA International, 2000).	(1)
• Reach to mouse/mouse not in line with the shoulder (Cook and Kothyal, 1998).	(2)
• Pinch grip required to use mouse/mouse too small (CSA International, 2000).	(+1)
• Mouse/keyboard on different surfaces (Cook and Kothyal, 1998).	(+2)
• Hard palm rest/pressure point while typing (CSA International, 2000; McMillan, 1999).	(+1)
<u>Keyboard</u>	
• Wrists are straight, shoulders are relaxed (CSA International, 2000).	(1)
• Wrists are extended beyond 15° of extension (Fagarasanu and Kumar, 2003).	(2)
• Wrists are deviated while typing (Gerr et al., 2006; Khan et al., 2009).	(+1)
• Keyboard tray too high – shoulders are shrugged (Leuder and Allie, 1997).	(+1)
• Keyboard platform is non-adjustable (CSA International, 2000).	(+1)

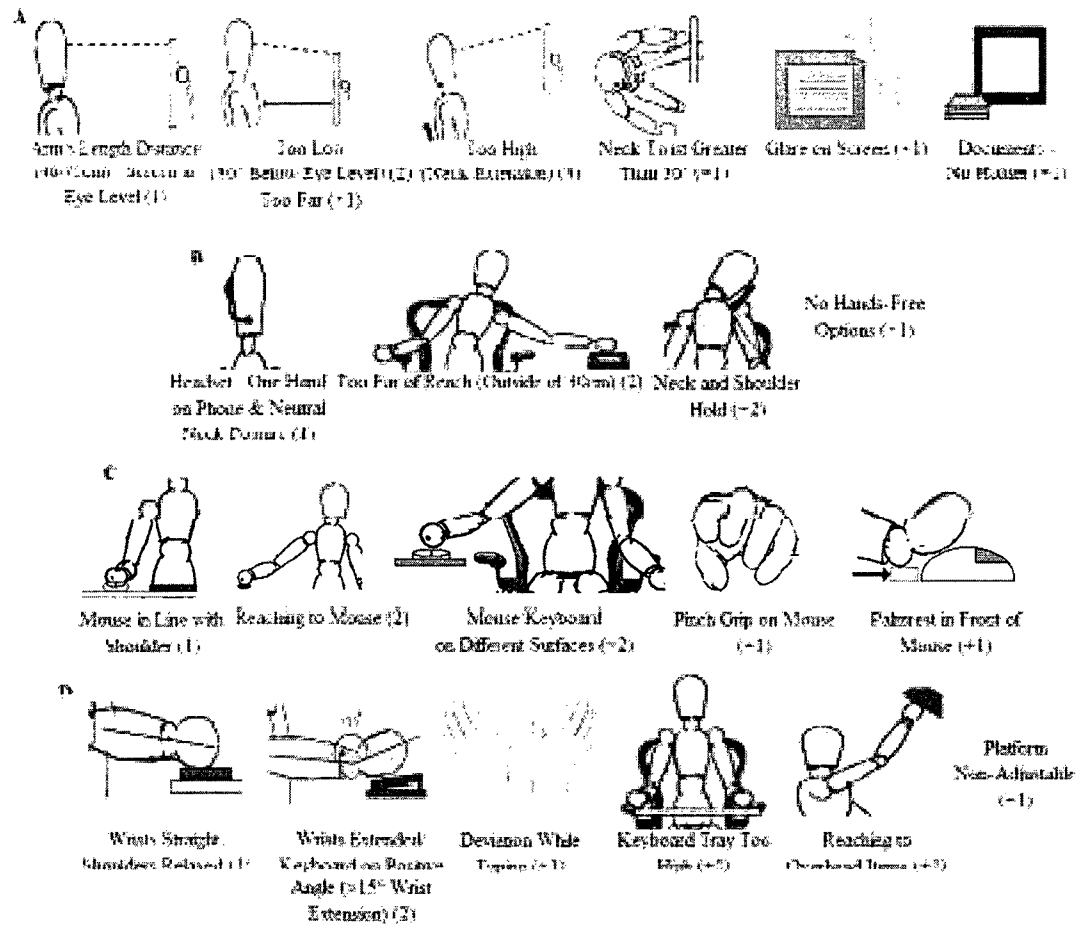


Fig. 3. Scores and diagrams for the risk factors associated with the monitor (A), telephone (B), mouse (C) and keyboard (D).

2.3.3 Telephone scores

The risk factors and scores for the telephone and the corresponding diagrams in ROSA are provided in Table 2 and Figure 3B, respectively. As shown, the telephone should be positioned within 300 mm of the worker in order to eliminate extensive reaching (CSA International, 2000). Additionally, it is recommended that using a static contraction to hold the telephone headset between the neck and shoulder should be avoided. To accomplish this, it is recommended that the worker use a hands free device, such as speaker phone or a headset.

2.3.4 Mouse scores

The mouse should be positioned so it is in a direct line with the shoulder. It should also not cause the worker to extend or deviate the wrist while moving the mouse. The mouse should be positioned on the same level as the keyboard in order to keep the shoulder relaxed. The mouse itself should accommodate the size of the worker's hand, not creating a pinch grip or pressure points. Mouse-related risk factors and diagrams are shown in Table 2 and Figure 3C.

2.3.5 Keyboard scores

The keyboard placement should allow the worker to use the keyboard with the elbows bent at approximately 90° and the shoulders in a relaxed position. The wrists should also be straight. The majority of the risk factors associated with keyboard use are a result of the posture of the wrist, which is similar to the wrist-related risk factors of wrist extension (Fagarasanu and Kumar, 2003) and wrist deviation (Serina et al., 1999) found in RULA (McAtamney and Corlett, 1993). Additionally, there should be no hard surfaces that can cause a pressure point on the carpal tunnel, as this may lead to carpal tunnel syndrome (CCOHS, 2005). Table 2 and Figure 3D depict the risk factors and ROSA checklist diagrams for the keyboard.

2.3.6 Other workstation scores

Other risk factors that did not have their own section were included in specific sub-sections of ROSA based on their mechanical relationships. These were: (1) Reaching to overhead items (+1) was located in the keyboard section (Figure 3), as it is predominantly an upper limb movement (Tittiranonda et al., 1999); (2) Work surface is too high (+1) was located in the back support section (chair) (Figure 2) as a work surface

that is too high would affect the shoulders and upper back. This risk factor is similar to that of an improper back support that causes a worker to sit forward on the chair. A work surface that is too high may also cause the worker to sit in the chair without back support (Leuder and Allie, 1997).

2.3.7 Duration of use scores

For each section of ROSA, the area score is influenced by a duration score. A significant increase in the prevalence of musculoskeletal disorders in workers that use the computer for greater than 4 hours per day has been reported (Blatter and Bongers, 2002). Other studies have indicated that signs of muscle fatigue in the upper extremities may occur within an hour as a result of static contractions under 10% of maximum voluntary contraction (Jorgensen et al., 1988). Office work has been shown to cause workers to exert between 7% and 15% of their maximum voluntary contraction (MVC) in the trapezius muscles (Hagberg and Sundelin, 1986).

After scores are calculated for the chair, monitor, telephone, keyboard and mouse sections, they are modified by a duration score. If a worker uses a piece of equipment for more than 1 hour continuously or 4 hours per day, the duration score is assigned a value of +1. If the worker uses the equipment for between 30 minutes and 1 hour continuously or between 1 and 4 hours per day, then the duration score will be given a value of zero. For less than 30 minutes of continuous work or 1 hour of total work per day, the duration score is given a value of -1.

2.4 Tool use instructions

When using the ROSA, an observer selects the appropriate scores based on the posture of the worker as they are observed at their computer workstation. A brief interview with the worker should also be conducted to understand their work composition. The scores for the seat pan height and pan depth are added together to compose the vertical axis of the “Section A” scoring chart, and the scores for the armrest and back support are combined to compose the horizontal axis of “Scoring Chart A” (Figure 1). The score from the chair scoring chart is then modified based on the duration score (1, 0, or -1).

The monitor score is achieved by observing the interactions of the user with the monitor and any associated documents. This area score is then modified based on the duration score for monitor use, and the final score for the monitor is used to form the horizontal axis on the “Section B” scoring chart. The telephone interaction score is recorded and modified by the duration value to produce the score along the vertical axis of the “Section B” scoring chart.

Mouse usage is also observed, and the corresponding score recorded based on the user’s equipment and work techniques with their cursor control device. The score from the mouse area is also modified based on the duration value for mouse use, and forms the horizontal axis for “Scoring Chart C”. Keyboard usage is similarly observed and recorded and modified by the duration value for keyboard use. This score forms the vertical axis for “Scoring Chart C”.

The monitor and peripherals scoring chart is used to compare the risk level between the chair and the user's computer input and office peripheral devices. To obtain the monitor and peripherals score, the observer uses the score received in "Section B" as the value for the horizontal axis, and the score received in "Section C" as the value for the vertical axis. This area score is then used as the value on the horizontal axis for the ROSA final score scoring chart (Figure 1).

To receive the final risk factor score for ROSA, the value from Chart A (the chair) – is used as the vertical axis score on the final score chart, and the value from the monitor and peripherals scoring chart is used as the horizontal axis. This score is a reflection of the overall risk level in the office environment, similar to the grand score presented in RULA (McAtamney and Corlett, 1993).

3.0 Experimental Design

3.1 Assessing discomfort relationships in ROSA

Seventy two office ergonomic assessments (7 males, 65 females) were conducted to examine the relationship between the ROSA area and final scores and the workers' reported levels of discomfort. Subjects were recruited from the administrative support staff at a hospital, and fit the inclusion criterion of spending at least 50% of their workday at the computer. Subjects were informed of the experimental procedure (which was approved by the University of Windsor and Hotel-Dieu Grace Hospital Research Ethics Boards), and signed an informed consent form.

In each office assessment, subjects were first asked to complete the Cornell University Discomfort Questionnaire (Hedge et al., 1999). The Cornell University

discomfort questionnaire (Hedge et al., 1999) examines the frequency and intensity of discomfort that a worker experiences and the effects that this discomfort has on workers' productivity. The frequency of discomfort was coded as – never (0), 1-2 times weekly (1.5), 3-4 times weekly (3.5), once every day (5) and several times daily (10). This score was multiplied by the intensity of the discomfort, which was coded as slightly uncomfortable (1), moderately uncomfortable (2) and severely uncomfortable (3). Finally, the impact on productivity was used as a final multiplier, and was coded as not at all (1), slightly interfered (2), and substantially interfered (3). Therefore, each body part could receive a maximum score of 90. Subjects also reported their age (mean=45.4 years (SD=9.1 years), gender (65 females, 7 males), height (mean=165cm (SD=7.0cm)), body mass (mean=71.3kg (SD=14.2kg)) , years of experience in their specific job (mean=8.2 years (SD=8.3years) and years of service to the hospital (mean=16.6 years (SD=10.9years)).

To examine the effects of discomfort on areas that are known to become injured during office work, such as the head and neck (Gerr et al., 2002; Korhonen et al, 2003; Hagberg and Wegman, 1987), shoulder (Borg and Burr, 1997), hands and wrists (Jensen et al., 2002) and lower back (Burdorf et al., 1993; Wilder and Pope, 1996), a discomfort total was created without the leg discomfort scores factored in.

Participants were then allowed to work at their own workstation for approximately 15 minutes while postures and interactions with equipment were observed. The ROSA scores for the workstation components were recorded on paper, and were later input into a spreadsheet that calculated the ROSA final score. Subjects were asked questions related to how long they would use each piece of equipment continuously and

during the entire work day. Assistance was then given to each subject on how to better set up their workstation.

Pearson product moment correlations were calculated to determine the relationship between the various ROSA scores and reported discomfort scores. The cumulative scores for the upper back, shoulders, lower back, thigh and buttocks were correlated independently with the ROSA chair score. The cumulative head/neck and upper back scores were examined in relation to the ROSA monitor and telephone scores. The combined shoulder, upper arm, lower arm and hand/wrist discomfort scores were correlated against the mouse and keyboard ROSA score. Finally, the ROSA final score was correlated against total body discomfort (with and without the leg discomfort included).

3.2 Action levels

Action levels found in the Rapid Upper Limb Assessment (McAtamney and Corlett, 1993) classify the risk associated with a task into one of four categories: posture is acceptable; further investigation is needed and change may be required; investigation and changes are required soon; and investigation and changes are required immediately. To identify which final score values in ROSA are associated with a need to perform immediate change, the mean discomfort scores at each level across the range of ROSA scores were compared using a one –way ANOVA with a Tukey’s HSD post hoc test. Significant increases in discomfort from one ROSA score to another might indicate a change in risk. Such changes in risk could be used as action levels for decision makers based on what office configurations are acceptable and which ones require additional

assessment. A sensitivity and specificity analysis was also performed (as per Chu, 1999) to examine positive and negative predictive values with respect to mean discomfort levels at corresponding ROSA final score levels.

3.3 ROSA reliability

To assess inter-observer reliability of ROSA, three trained observers completed evaluations of 14 workstations simultaneously in the participating organization. The observers were all experienced graduate students in ergonomics who had performed office workplace assessments in the past 6 months. Each observer was given a 30 minute training presentation that outlined how ROSA was used, and how to identify commonly occurring risk factors. To assess intra-observer reliability, a workstation in a vacant office at the University of Windsor was mocked-up such that each of the three trained observers evaluated it in three different configurations once per week for four weeks. The final scores and the chair, monitor, telephone, mouse and keyboard scores from each observer were examined using the intra-class coefficient (ICC), with two-way random analysis for absolute agreement. Intra-observer reliability was examined using a two-way random analysis ICC for each observer, and average values were reported.

4.0 Results

4.1 ROSA scores

The mean ROSA final score for the 72 offices analyzed was 4.13 (out of 10). The mean (SD) section scores for the chair, monitor and telephone, and mouse and keyboard were 3.08 (1.02), 2.58 (1.21), 3.65 (1.28) and 4.13 (1.14), respectively.

4.2 Relationships between discomfort and ROSA scores

The body parts reported to have the most significant levels of discomfort were the neck and head (mean 17.7 (SD 24.7), lower back (mean 11.7 (SD 22.7)) and right shoulder (mean 10.7 (SD 18.8)) The areas with the lowest reported discomfort were the left forearm (mean 1.28 (SD 3.9), left thigh (mean 1.1 (SD 4.3)) and left upper arm (mean 1.6 (SD 6.13)). The mean discomfort scores for each body part can be found in table 3.

Table 3. Discomfort profiles for all body parts collected using the Cornell University Discomfort Questionnaire (Hedge et al., 1999).

Mean Discomfort /90 (SD)			
Neck/Head	17.72 (24.46)	Right Hand/Wrist	7.85 (20.12)
Right Shoulder	10.74 (18.68)	Left Hand/Wrist	4.26 (16.18)
Left Shoulder	7.52 (16.64)	Hips/Buttocks	8.83 (21.06)
Upper Back	8.42 (15.62)	Right Thigh	3.15 (13.22)
Right Upper Arm	3.76 (10.28)	Left Thigh	1.13 (4.28)
Left Upper Arm	1.64 (6.13)	Right Knee	5.08 (13.89)
Lower Back	11.70 (22.71)	Left Knee	3.93 (12.99)
Right Forearm	4.09 (12.97)	Right Leg	3.08 (15.53)
Left Forearm	1.28 (3.91)	Left Leg	3.63 (16.47)

All correlations between ROSA scores and discomfort were significant ($p < 0.05$), except between chair and chair discomfort, and mouse and keyboard ROSA score and chair discomfort (Table 4). The highest correlation was between total body discomfort (without leg discomfort) and the monitor and phone ROSA score ($R = 0.432$). The total body discomfort (without leg discomfort) and ROSA final score were moderately correlated ($R = 0.384$) (as per Cohen, 1988).

Table 4. Correlations between total and area discomfort scores (Cornell University discomfort questionnaire: Hedge et al. (1999)) and ROSA final and area scores.

ROSA Score	Total Discomfort			Area Discomfort	
	With Legs	Without Legs	Chair	Monitor and Telephone	Mouse and Keyboard
Final	0.363*	0.384*	0.341	0.357*	0.394*
Chair	0.245*	0.281*	*	0.300*	0.248*
Monitor and Telephone	0.408*	0.432*	0.247	0.321*	0.417*
Mouse and Keyboard	0.245*	0.281*	0.228	0.320*	0.366*

* Significant at $p < 0.05$

Mean reported total discomfort scores (without leg discomfort) generally increased between ROSA final scores of 2 and 5. The mean discomfort score at a ROSA final score 5 was significantly more than at a ROSA final score 3, with the largest increase in mean discomfort occurring between levels 4 and 5 of the ROSA final scores (Figure 4A). A similar trend was seen for the individual areas of chair (Figure 4B), monitor and telephone (Figure 4C), and mouse and keyboard (Figure 4D).

The sensitivity at a ROSA score of 5 was 76%, with specificity measured at 68%. Positive and negative likelihood ratios were measured to be 2.39 (CI: 1.49-3.84) and 0.34 (CI: 0.12-0.93), respectively. The sensitivity increased to 84% at ROSA final score 4, however specificity dropped to 45%, and the positive likelihood ratio decreased to 1.56 (CI: 1.14-2.13). The negative likelihood ratio remained was comparable between score 4 and 5 at 0.34 (CI: 0.13-0.88).

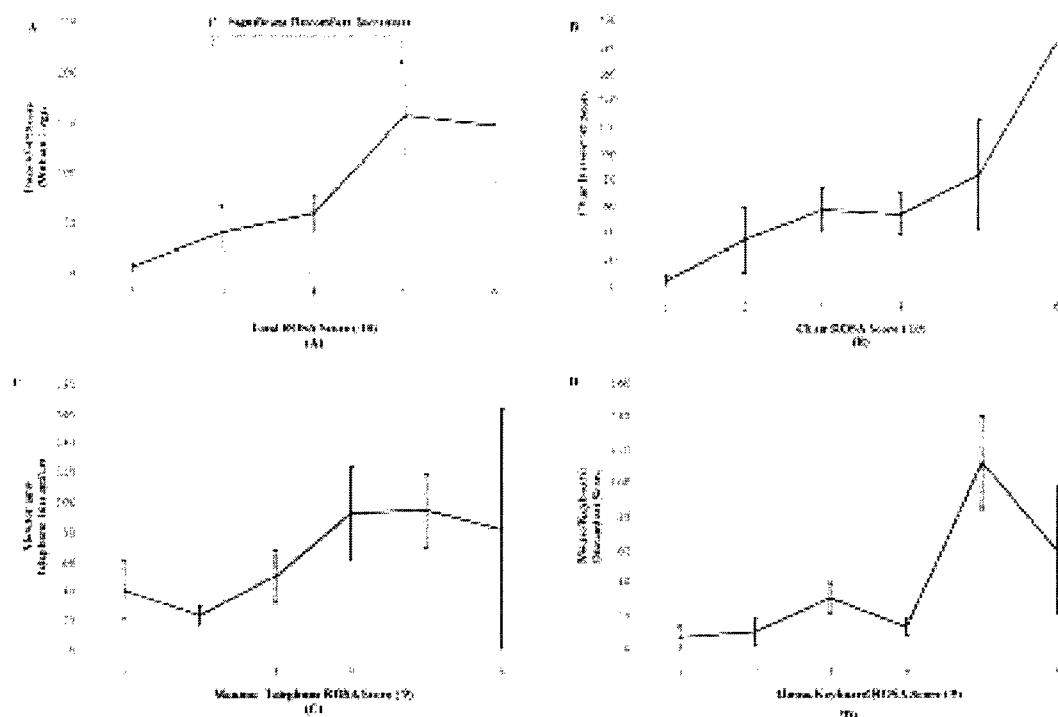


Fig. 4. Localized mean (SE) discomfort scores vs. corresponding ROSA scores: (A) Total Discomfort Score (without legs) and ROSA final score; (B) Chair discomfort and ROSA score; (C) Monitor/telephone discomfort and Monitor/telephone ROSA score; (D) Mouse/keyboard discomfort and Mouse/keyboard ROSA score.

4.3 Reliability of ROSA

Inter-observer reliability was found to be strong in general, with ICCs ranging from good (0.74) for the monitor and telephone ROSA score, to excellent (0.83 and 0.91) for the mouse and keyboard ROSA score and the final ROSA score, respectively (Portney and Watkins, 2000). Moderate inter-observer reliability was seen for the chair ROSA score, with an ICC of 0.51. Intra-observer reliability was also found to be excellent with ICCs of 0.80 for the chair, 0.88 for the final score, 0.89 for the mouse and keyboard and 0.95 for the monitor and telephone.

5.0 Discussion

The goals of developing the Rapid Office Strain Assessment tool were to provide the health and safety professional or ergonomist with a way of quantifying ergonomic risks in the office environment, and provide action levels based on worker discomfort that can serve as screening points between workstations that require further assessment and those that do not. These goals were achieved by establishing significant positive correlations between discomfort and ROSA scores, as well as a proposed action level of 5.

5.1 Relationships between discomfort and ROSA scores

Significant positive correlations were found between the ROSA area and total scores and total discomfort, indicating that increasing ROSA scores are reflective of increasing musculoskeletal discomfort. Correlations between total body pain and increasing RULA scores were also seen in an office environment in a study conducted by Dalkiliniç and colleagues in 2002. Mean discomfort scores were found to generally increase across all levels of the ROSA final score collected, with a significant increase in discomfort scores between level 3 and 5. In other words, a ROSA final score of 5 or greater was found to be associated with a significant increase in worker discomfort, and may indicate an increased potential for injury. The value of 5 as an action level is further supported by balanced sensitivity (77%) and specificity (68%) values when compared to values at ROSA final scores of 4 (85% sensitivity and 46% specificity) and 6 (100% sensitivity and 9.8% specificity). The balance between sensitivity and specificity is important to achieve, as it indicates that the tool will be more effective in distinguishing between false positives and negatives (Chu, 1999). The likelihood ratio for a score of 5

(2.4) was also higher than at scores of 4 (1.6) and 6 (1.1). A likelihood ratio of greater than 2 has been associated with a significant probability of musculoskeletal discomfort, whereas a ratio of less than 2 is not associated with a significant ability to predict discomfort or outcome (Jaeschke et al., 1994).

Having a discomfort-based action level is important, as it aids in the decision making process for the individual interpreting the ROSA scores. Similar to the action levels found in RULA (McAtamney and Corlett, 1993), the ROSA final score of 5 and greater should be used as the score that indicates an office workstation requires further assessment, and that changes should be considered immediately.

5.2 Reliability of ROSA

Inter-observer reliability was found to be good ($ICC > 0.5$) for the ROSA final and keyboard scores and excellent (> 0.75 (Portney and Watkins, 2000) for the mouse and keyboard scores. Low inter- and intra-observer reliability ($ICC < 0.5$) was seen for the chair scores, perhaps indicating that a redesign of the images that identified specific postures and equipment conditions should be further investigated. The reliability measures found in the study are similar to those presented for other posture-based tools that have been used to investigate office ergonomic issues (e.g. RULA grand score ICCs between 0.65 and 0.85 (McAtamney and Corlett, 1993); OEA ICCs of 0.91 (Robertson et al., 2009)). The relatively high reliability values found in this study indicate that, with a small amount of training, observers with ergonomic expertise can reliably identify risk factors in the office environment using the ROSA checklist.

5.3 Limitations

5.3.1 ROSA values found during assessment

A full range of ROSA final scores were not observed in this study for several reasons. The low number of scores in the low end of the range (scores 1 and 2) was due primarily to the lack of optimally designed workstations in the workplace evaluated. However, most workstations featured adjustable chairs, and surfaces that varied in height between 66cm and 81 cm; standard working heights as indicated by CSA standard Z412 (CSA International, 2000). The adjustability of the workstations prevented any ROSA final scores from rising above a level of 7 on the 10 point scale. Although the workstations evaluated in this study did not have enough risk factors present to result in ROSA final scores above 6, scores greater than this are not difficult to obtain. For example, a ROSA final score of 8 would result if the following common conditions were present: chair pan too high so worker could not touch their feet to the ground; there was interference under the desk with the worker's legs; the chair height was non-adjustable; the seat pan length was too long and non-adjustable and the user worked on the computer for 1.5 hours consecutively. This scenario is realistic for any worker that is shorter than average and who sits on a non-adjustable chair. Therefore, the limited range of ROSA final scores in this study was directly related to the overall conditions in the particular workplace that was evaluated, and is therefore not a critical limitation of the tool itself.

5.3.2 Reporting of discomfort related to the workstation

Workers were asked to report the discomfort they had while at work over the last week, regardless of what they believed the source to be. This may have led to higher discomfort scores than were directly associated with the workstation components alone.

Furthermore, self-reports of working posture, musculoskeletal discomfort and office work duration have been shown to be overestimated by workers (Wiktorin et al., 1993; Homan and Armstrong, 2003; Heinrich et al., 2004). While the discomfort scores reported may have been exaggerated, the ease of collecting discomfort data through the use of questionnaires made this method appropriate for this study. Additionally, the practice of using self-reported discomfort questionnaires is consistent with other research conducted in the field of office ergonomics (Hedge et al., 1991; Blatter and Bongers, 2002; Diepenmaat et al., 2004).

6.0 Conclusions

The Rapid Office Strain Assessment proved to be an effective method of assessing office workstations for risk factors related to discomfort in the office environment. This initial evaluation has shown high levels of inter and intra-observer reliability using the ROSA, and a moderate correlation between total body discomfort and ROSA final scores. Further research needs to be conducted with a wider range of ROSA final scores in order to determine if more precise action levels can be established. Determining the relationship between ROSA scores and other outcome measures such as injury incidence may also provide new information that will help establish additional action levels in the tool.

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References

- Amick III, B.C., Robertson, M.M., DeRango, K., Bazzani, L., Moore, A., Rooney, T., Harrist, R., 2003. Effect of office ergonomics intervention on reducing musculoskeletal symptoms. *Spine*. 28(24), 2706-2711.
- Bayeh, A.D., Smith, M.J., 1999. Effect of physical ergonomics on VDT worker's health: A longitudinal field study in a service organization. *Int J Hum-Comput Int*. 11, 109-135.
- Blatter, B.M., Bongers, P.M., 2002. Duration of computer use and mouse use in relation to musculoskeletal disorders of the neck or upper limb. *Int. J. Ind. Ergon*. 30, 295-306.
- Bohr, P.C., 2002. Office ergonomics education: A comparison of traditional and participatory methods. *Work*. 19, 185-191.
- Borg, R., Burr, H., 1997. Danish employees working environment and health study 1990–1995. National Institute of Occupational Health. Report.
- Burdorf, A., Naaktgeboren, B., de Groot, H.C.W.M., 1993. Occupational risk factors for low back pain among sedentary workers. *Occup. Environ. Med*. 35(12), 1213-1220.
- Burgess-Limerick, R., Plooy, A., Ankrum, D.R., 1998. The effect of imposed and self-selected computer monitor height on posture and gaze angle. *Clin. Biomech*. 13, 584-592.
- Callaghan, J.P., McGill, S.M., 2001. Low back joint loading and kinematics during standing and unsupported sitting. *Ergonomics*. 44, 280-294.
- Canadian Centre for Occupational Health and Safety (CCOHS), 2005. Office Ergonomics. Retrieved March 8, 2010 from <http://www.ccohs.ca/oshanswers/ergonomics/office/>
- Canadian Standards Association (CSA) International, 2000. CSA-Z412: Guideline on office ergonomics. CSA, Toronto.
- Chu, K., 1999. An introduction to sensitivity, specificity, predictive values and likelihood ratios. *Emerg. Med*. 11, 175-181.
- Cohen, J., 1988. Statistical power analysis for the behavioural sciences (2nd ed.). New Jersey: Lawrence Erlbaum.
- Cook, C.J., Kothiyal, K., 1998. Influence of mouse position on muscular activity in the neck, shoulder and arm in computer users. *Appl. Ergon*. 29(6), 439-443.
- Dalkiliniç, M., Bumin, G., Kayihan, H., 2002. The effects of ergonomic training and preventive physiotherapy in musculo-skeletal pain. *The Pain Clinic*. 14(1), 75-79.

- Diepenmaat, A.C.M., van der Wal, M.F., de Vet, H.C.W., Hirasing, R.A., 2004. Neck/shoulder, low back, and arm pain in relation to computer use, physical activity, stress and depression among Dutch adolescents. *Pediatrics*. 117(2), 412-416.
- Fagarasanu, M., Kumar, S., 2003. Carpal tunnel syndrome due to keyboarding and mouse tasks: a review. *Int. J. Ind. Ergon.* 31, 119-136.
- Gerr, F., Marcus, M., Ensor, C., Kleinbaum, D., Cohen, S., Edwards, A., Gentry, E., Ortiz., Monteilh, C., 2002. A prospective study of computer users: I. Study design and incidence of musculoskeletal symptoms and disorders. *Am. J. Ind. Med.* 41, 221-235.
- Gerr, F., Monteilh, C.P., Marcus, M., 2006. Keyboard use and musculoskeletal outcomes among computer users. *J. Occup. Rehabil.* 16, 256-277.
- Hagberg, M., Sundelin, G., 1986. Discomfort and load on the upper trapezius muscle when operating a word processor. *Ergonomics*. 29, 1637-1645.
- Hagberg, M., Wegman, D.H., 1987. Prevalence rates and odds ratios of shoulder-neck diseases in different occupational groups. *Br. J. Ind. Med.* 44, 602-610.
- Harrison, D.D., Harrison, S.O., Croft, A.C., Harrison, D.E., Troyanovich, S.J., 1999. Sitting biomechanics part 1: Review of the literature. *J. Manipulative. Physiol. Ther.* 22(9), 594-609.
- Hasegawa, T., Kumashiro, M., 1998. Effects of armrests on workload with ten-key operation. *J. Physiol. Anthropol.* 17(4), 123-129.
- Hedge, A., Morimoto, S., McCrobie, D., 1999. Effects of keyboard tray geometry on upper body posture and comfort. *Ergonomics*. 42, 1333-1349.
- Heinrich, J., Blatter, B.M., Bongers, P.M., 2004. A comparison of methods for the assessment of postural load and duration of computer use. *Occup. Environ. Med.* 61, 1027-1031.
- Hignett, S., McAtamney, L., 2000. Rapid entire body assessment (REBA). *Appl. Ergon.* 31, 201-205.
- Homan, M.M., Armstrong, T.J., 2003. Evaluation of three methodologies for assessing work activity during computer use. *Am. Ind. Hyg. Assoc. J.* 64, 48-55.
- Jaeschke, R., Guyatt, G.H., Sacket, D.L., 1994. User's guide to the medical literature. III. How to use an article about a diagnostic test: B. What are the results and will they help me in caring for patients? *J. Am. Med. Assoc.* 271, 703-707.
- Jensen, C., Finsen, L., Søgaard, K., Christensen, H., 2002. Musculoskeletal symptoms and duration of computer and mouse use. *Int. J. Ind. Ergon.* 30, 265-275.

- Jorgensen, K., Fallentin, N., Krogh-Lund, C., Jensen, B., 1988. Electromyography and fatigue during prolonged, low-level static contractions. *Eur. J. Appl. Physiol.* 57, 316-321.
- Karhu, O., Kansi, P., Kuorinka, I., 1977. Correcting working postures in industry: A practical method for analysis. *Appl. Ergon.* 8, 199-201.
- Keir, P.J., Bach, J.M., Rempel, D., 1999. Effects of computer mouse design and task on carpal tunnel pressure. *Ergonomics.* 42, 1350-1360.
- Keegan, J.J., 1953. Alteration of the lumbar curve related to posture and seating. *J. Bone Joint Surg.* 35, 589-603.
- Khan, A.A., O'Sullivan, L., Gallwey, T.J., 2009. Effects of combined wrist deviation and forearm rotation on discomfort score. *Ergonomics.* 52(3), 345-361.
- Korhonen, T., Ketola, R., Toivonen, R., Luukkonen, R., Häkkinen, M., Viikari-Juntura, E., 2003. Work related and individual predictors for incident neck pain among office employees working with video display units. *Occup. Environ. Med.* 60, 475-482.
- Lueder, R., 1996. A proposed RULA for computer users. *Proceedings of the Ergonomics Summer Workshop, UC Berkley Center for Occupation and Environmental Health Continuing Education Program, San Francisco, August 8-9, 1996.*
- Lueder, R., Allie, P., 1997. Ergonomics Review: Armrest design and use. An ergonomics review of the literature for Steelcase Furniture. Retrieved September 8, 2009 from www.humanics-es.com/armrest-ergonomics.htm
- Lin, Z., Popovic, A., 2003. Working with computers in Canada: An empirical analysis of incidence, frequency and purpose. Final Report: Human Resources Development Canada. Catalog: RH63-1/574-05-03E.
- Lowe, G., 1997. Computers in the workplace. Statistics Canada: Perspectives. Catalog: 75-001-XPE, 29-36.
- Marshall, K., 2001. Working with computers. Statistics Canada: Perspectives. Catalog: 75-001, 9-15.
- McAtamney, L., Corlett, E.N., 1993. RULA: a survey method for the investigation of work-related upper limb disorders. *Appl. Ergon.* 24, 45-57.
- Portney, L.G., Watkins, M.P. 2000. Foundation of clinical research applications to practice. Prentice Hall, Inc. New Jersey.
- Robertson, M., Amick III, B.C., DeRango, K., Rooney, T., Bazzani, L., Harrist, R., Moore, A., 2009. The effects of an office ergonomics training and chair intervention on worker knowledge, behaviour and musculoskeletal risk. *Appl. Ergon.* 40, 124-135.

- Serina, E.R., Tal, R., and Rempel, D. 1999. Wrist and forearm posture and motions during typing. *Ergonomics*. 42(7), 938-951.
- Szabo, R.M. Gelberman, R.H., 1987. The pathology of nerve entrapment syndromes. *J Hand Surg. Am.* 12(5), 880 to 884.
- Tichauer, E.R., Gage, H., 1978. The biomechanical basis of ergonomics. John Wiley & Sons. New York.
- Tittiranonda, P., Burastero, S., Rempel, D., 1999. Risk factors for musculoskeletal disorders among computer users. *Occup. Med. (Chic Ill)*. 14, 17–38.
- Village, J., Rempel, D., Teschke, K., 2005. Musculoskeletal disorders of the upper extremity associated with computer work: A systematic review. *Occup. Erg.* 5, 205-218.
- Wahlström, J., 2005. Ergonomics, musculoskeletal disorders and computer work. *Occup. Med. (Chic Ill)*. 55, 168-176.
- Wiktorin, C., Karlqvist, L., Winkel, J., 1993. Validity of self-reported exposures to work postures and manual materials handling. *Scand. J. Work. Environ. Health*. 19, 208-214.
- Wilder, D.G., and Pope, M.H. 1996. Epidemiological and aetiological aspects of low back pain in vibration environments – an update. *Clin. Biomech.* 11(2), 61-73.

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