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Sub-clinical Neck Symptoms, Disability, Posture, and Muscle Function in Computer Users, and the Effect of Education versus Education and Deep Cervical Flexor Exercise

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by

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

Nova Southeastern University
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Department of Physical Therapy

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We hereby certify that this dissertation, submitted by Donna L. Skelly, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirement for the degree of Doctor of Philosophy in Physical Therapy.

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2016

Sub-clinical Neck Symptoms, Disability, Posture, and Muscle Function in Computer Users, and the Effect of Education versus Education and Deep Cervical Flexor Exercise

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Purpose: 1, to determine effect of education and exercise on neck pain, disability, cervical posture and muscle function in office workers with sub-clinical neck symptoms; 2, to determine differences in forward head posture in preferred and standardized posture, and 3, to explore the influence of time on work posture in a sub-group of office workers. **Subjects:** Sixty-six office workers with sub-clinical neck symptoms who utilize computers at least 4 hours per day participated. A sub-group of 27 were videotaped to assess posture over a workday. **Methods:** Videotaping was performed 15 minutes of the first and last hour of the workday for analysis of the craniovertebral angle. Cervical posture using the CROM was measured on all subjects in standardized and preferred positioning of the trunk and lower extremities. Subjects were randomly assigned to one of three groups: education only (EOG), education and exercise (EEG), or control (CG). Pre and post-test measurements of pain (Visual Analog Scale), disability (Neck Disability Index), forward head posture (FHP), and deep cervical flexor muscle function (Craniocervical Flexion Test and Short Neck Flexor Endurance Test) were assessed for change within group as well as differences between groups over the 8 week period. **Results:** No difference was found for FHP over 8 hours in the subgroup. FHP was greater in preferred position compared to standardized by 7.59 mm (95% CI 6.27-8.92, $p<.001$). Median and mean scores improved for all 3 groups on pain and disability with greater improvement in intervention groups. FHP was unchanged/slightly worse in the CG and EOG, and improved in the EEG. Muscle function improved for the EEG. Statistical significance was not found for change scores between groups. Posttest scores were statistically significant for the NDI between EEG (20.45) and the CG (34.47), $p=.042$, and between the EEG and the EOG (34.59), $p=.023$ using Kruskall Wallis with adjusted significance for pairwise comparisons. **Discussion/Conclusions**: Posture over the workday did not change, differences were found based on preferred and standardized positions. Exercise and education intervention for those with sub-clinical neck symptoms show promise but did not demonstrate significance improvement over controls in this study.

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CHAPTER ONE

INTRODUCTION

Introduction to the Chapter

This chapter will provide a general background relative to the study including incidence of neck pain, an overview of the conceptual model of neck pain used in the study, and an explanation of sub-clinical neck symptoms. Interventions currently utilized in the management of individuals working with computers by occupational health physical therapists will be discussed with an emphasis on exercise and educational methods. An argument will be presented related to the potential impact of preferred versus standardized position utilized in the majority of research on neck pain and posture. The limited research regarding the influence of time at work in the study of posture and neck symptoms will also be presented. The relevance and clinical significance within the physical therapy profession will be discussed. Three research questions, hypotheses and expected results of each will be outlined. Key definitions including operational definitions will be included for terms which will be utilized throughout this document.

Background

Neck pain is a common complaint in the general population, with a 12 month prevalence ranging from 12-72%, and more specifically in the working population 27-48%.[1] Neck pain with associated disability is less common, with

12 month prevalence of 1.7 – 11.5%.[1] Many individuals with neck pain continue to report symptoms a year later, particularly office workers.[2] Office workers have the highest incidence of neck pain, estimated at 36-57.5 per hundred worker years.[3] Individuals who perform jobs involving sitting the majority of the day have an identified risk factor for neck pain that is double that of other workers.[4] Many jobs today performed in sitting include use of computer workstations.

The Scientific Secretariat of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders developed a conceptual model of neck pain for researchers, clinicians, and policy makers.[5] A multidisciplinary task force including a physical therapist developed this model, after a 6 year review of existing models and research, to bring cohesiveness to the study and management of neck pain. A description of subjects developed by the Task Force enables researchers to define a subject pool in terms of how and from what setting subjects were recruited, and to describe the severity, duration, and pattern of their symptoms. This model of neck pain, unlike others currently in use in physical therapy literature, includes a classification of individuals with sub-clinical symptoms that is similar to "clients" described in the Guide to Physical Therapist Practice.[6] The Task Force model was used as the framework for this study. Office workers who utilized computers at least 4 hours/day and have sub-clinical neck symptoms are the focus population for the current study. These computer users may be recipients of group educational or exercise interventions provided by physical therapists practicing in occupational health. Use of computer workstations has been identified as a risk factor for the development of neck pain and disorders[7] and it has been theorized that postures assumed while working at the computer result in this increased risk.[8,9]

Many individuals working in office jobs have complaints of low level neck pain or discomfort, for which they do not seek medical treatment.[9,10] Researchers have termed this level of symptoms "sub-clinical neck pain".[10] Many of those with sub-clinical neck pain present with additional physical findings of reduced range of motion and muscle function in the cervical region.[10-13] There is a need to determine methods of preventing sub-clinical neck symptoms (pain/discomfort, stiffness and tenderness) from developing into disabling neck pain in the working population.[1] This study focused on this population to determine which interventions utilized by occupation health physical therapists are effective in addressing sub-clinical neck symptoms.

Physical therapists are frequently consulted to provide programming to clients in the workplace to address and prevent musculoskeletal problems. Interventions utilized include education and exercises to improve posture.[8,14] This focus on posture and its relationship to neck pain can be found in the literature from the 1940s to the present in practice guidelines, case studies, and surveys of current practice.[15-23] In particular forward head posture (FHP) has been implicated as a contributor to neck pain. Forward head posture is a position of the head and neck where the ear is aligned anterior to the acromion process of the shoulder. This alignment creates flexion of the lower cervical spinal segments and extension of the upper cervical segments.

In addition to sitting posture, other factors also influence symptoms in computer users such as the physical set up of the workstation and psychosocial aspects including job satisfaction.[3,7,24,25] Ergonomic changes to the workstation have been utilized in an attempt to improve posture and reduce musculoskeletal symptoms and syndromes. A change in the physical set up of a workstation alone, however, does not ensure proper use and posture by the worker.[24] When individuals are educated regarding appropriate posture, work organization, and physical work habits, those with musculoskeletal symptoms have demonstrated significant decreases in pain intensity, duration, and frequency.[25] The influence of job satisfaction has been addressed by some researchers when studying neck pain.[7,24,25] The physical therapist may be able to modify some of these additional factors influencing neck symptoms (workstation set up) but not others (job satisfaction). The potential impact of these factors, however, should be considered when studying interventions addressing neck symptoms.

Statement of the Problem

Despite the use of postural correction clinically to address neck symptoms, there is not a clear connection identified in the literature between postural changes and symptoms. There also is little evidence that interventions focused on improving posture result in a change in posture or a change in symptoms or function. A need for further research in this area has been identified.[26] Some studies suggest that FHP may be a normal finding, unrelated to musculoskeletal dysfunction.[27,28] Other authors, however, have identified relationships between FHP and symptoms about the head and neck.[17,29-32] The relationship between posture and neck symptoms should be clearly defined within the literature if postural correction continues to be a focus of intervention by physical therapists.

In contrast to limited evidence for a relationship between posture and symptoms, there is moderate evidence supporting that neck strengthening and endurance exercises can result in improvement in reducing symptoms and disability for chronic neck complaints. Some studies have incorporated both exercise and manual techniques without attempting to discern differences in outcome between them,[33] while others have demonstrated no benefit of one over the other.[34] A 2005 Cochrane Database Systematic Review noted moderate evidence for neck exercises (stretching and strengthening) in reducing pain and disability in chronic mechanical neck disorders, and moderate evidence for strengthening exercises in those with neck disability with headache.[35] Exercise is recommended in the treatment of neck pain in current orthopaedic clinical practice guidelines for physical therapists,[20] and is used in current case reports and treatment review articles in physical therapy literature.[21-23] Though clearly of value, the benefit of exercise relative to other interventions for office workers has not been well defined in the literature.

Education as an intervention has support in the literature as an effective means of reducing pain/discomfort in office workers.[25,36,37] When education is provided by physical therapists in a one on one situation with the use of tactile cues for posture, there is greater activation of the deep cervical muscles as compared to verbal instruction alone.[38] If muscles which control neck posture can be activated through education and cueing of posture, perhaps specific neck exercise programs are not a necessary component in intervention programs for computer users. Specific neck exercises as a means of improving symptoms and reducing disability have not been directly compared to postural education to determine efficacy. In this study a comparison was made between education alone, education with specific exercise, and a control group with no intervention.

Many studies of neck pain and posture have been performed in laboratory or clinical settings and may not provide an adequate indication of postures assumed in the workplace. Studies which have been performed in the workplace used a small number of subjects,[31] or included only asymptomatic workers.[37] Studies utilizing standardized postures reflect the ability of the worker to assume a particular posture, however, may not reflect the posture used during work tasks.[29,39] This standardized positioning may create an artificial representation of an individual's posture during the workday. Examination of posture in the work setting using preferred positioning may better reflect the postures assumed by computer users on a daily basis, and provide a better understanding of the possible relationship between sub-clinical neck symptoms and posture. Within this current study measurements of head and neck posture were taken in the workplace at the subject's workstation using both preferred and standardized positions.

Studies on cervical posture have examined posture at a single point in time, with few studies looking at potential changes in posture over the workday.

In a study of postural change over 10 minutes while performing work at a computer Falla et al[29] found that individuals with low level neck symptoms demonstrated a significant increase in forward head posture. Asymptomatic controls did not demonstrate this same change. Szeto and colleagues[31] performed a field study examining posture of the upper body during computer work on symptomatic and asymptomatic female office workers, and reported a trend towards increased forward head posture in the symptomatic group; however, data analysis of change in head and neck posture over the period of a workday was not significant in either group. Little other research is available to determine if a change in posture occurs over time.

Purpose

The primary purpose of this study was to compare the effectiveness of eight weeks of specific exercises for the deep cervical flexors with education in posture as compared to education only, and a control group (no intervention), in computer users with sub-clinical neck symptoms. The impact of job-satisfaction and physical set up of the workstation from an ergonomic perspective was also explored. A second purpose was to determine differences in cervical posture in computer users with sub-clinical neck symptoms when seated at their own workstation in their preferred posture as compared to standardized sitting postures. The third purpose was to determine if there is an increase in forward head posture over the workday. To avoid influence of the eight week intervention program (the primary purpose of the study) on the other 2 aspects of the study the primary purpose was addressed as the third research question. The order of research questions will reflect the order of implementation within the study.

Relevance and Significance of the Study

Despite a popular clinical focus on addressing posture in the management of neck symptoms there is a lack of evidence of the relationship between posture and neck symptoms. Physical therapists utilize education and exercise directed at modifying posture in health and wellness programming provided for employees in the workplace. This clinical practice is supported by the American Physical Therapy Association's guidelines for occupational health.[40] Evidence exists for the use of exercise in decreasing symptoms and improving function in those with neck complaints; however, the levels of exercise intensity and types of exercise examined in the literature have varied. Some have utilized shoulder exercises[41] and others used neck flexor muscle strengthening.[29] At times exercises were not detailed, but simply described as strengthening and postural exercises.[14] Time frames for exercise programs range from 10-20 minutes per day[29] to 60 minutes.[14,33] Education in posture and ergonomics has also been demonstrated to result in decreased symptoms,[36] however, comparisons have not been made between exercise and educational interventions. This study explored differences between these 2 interventions.

Posture is a dynamic and complex concept which is influenced by many factors. Perhaps one reason for the lack of evidence between posture and symptoms is the assessment of posture using standardized positions. Falla and colleagues,[29] for example, utilized a position of 90 degrees of hip and knee flexion, feet flat on the floor, with a vertical pelvis. This standardized positioning may not accurately represent an individual's posture during the workday. Differences in cervical posture may exist between that assumed in a standardized position of the pelvis and legs used in many research studies, and the positions an individual may use at work. Posture measurement of computer users at their own workstation may provide a more valid measure of the postures assumed during work activities. This study assessed posture both in standardized and preferred positions as the relationship between symptoms and posture was explored, as well as measurements taken at an individual's own work station.

Because posture is a dynamic concept, posture measured at a single point in time may not be a valid indication of work postures assumed over the course of the work day. Falla et al[29] identified a change in posture (greater forward head) in a group of female office workers over a 10 minute period of computer activity that was not found in asymptomatic subjects. This current study expanded that time frame to determine if an increase in forward head posture occurs over an 8 hour workday.

Physical therapists working in occupational health settings will be able to utilize the findings of this study to assist them in the development of programming for office workers. Knowledge of the most effective intervention strategies with regard to education and exercise will result in improved provision of services for those at risk. The 2000-2010 Task Force on Neck Pain conceptual model includes individuals with non-specific neck pain who are at risk of developing recurrent and disabling symptoms.[5] Many of these individuals do not seek health care for their symptoms until they reach the disabling level. If interventions which address sub-clinical neck symptoms in the computer user can be identified, then longitudinal studies can be developed to determine if these interventions ultimately have a preventative effect and improve prognosis. The 2000-2010 Task Force on Neck Pain identified the study of workers who experience neck pain on the job as an area in urgent need of additional research.[3] In addition to addressing neck pain in the current working population, focus should also be placed on those who are entering the workforce currently because they have been exposed to even more frequent computer use at home and school. Computer use in schools and homes has increased exponentially over the past 20 years and is frequently utilized at the elementary and middle school level, resulting in earlier exposure to computer postures than seen in the past.

Although exercises have been demonstrated to be effective in the management of neck symptoms, the level of exercise utilized in some studies requires a significant time commitment from an individual employee. Low level exercises are likely to result in greater compliance as opposed to exercise programs requiring 30 to 60 minutes a day. If greater improvement in symptoms and disability are identified with the addition of exercise as opposed to education alone then more time and effort should be focused on exercise within an intervention program. If, however, postural education and awareness results in the same level of improvement in symptoms and disability as seen using exercise and education then perhaps the addition of exercise to occupational health workplace programming is not necessary. If neither intervention demonstrates improved outcomes over the control group then employer dollars would be better spent on alternative activities.

Information obtained from studying changes in cervical posture related to lower spine and lower extremity positioning, and changes over time will be helpful in designing further studies on the relationship between forward head posture and cervical symptoms. Researcher attention to the effect of time and the effect of standardized positioning may be important factors in teasing out the influence of cervical posture on the development of symptoms and disability in the cervical region.

Research Questions

Research Question 1

Is there a change in forward head posture of computer users (as measured by the craniovertebral angle) over an 8 hour work day when seated at a computer using preferred positioning of the worker at his/her own workstation?

Null Hypothesis 1

There is no difference in forward head posture of a computer user (as measured by craniovertebral angle) over an 8 hour workday when seated at a computer workstation using preferred positioning at the individual's own workstation in a subgroup of subjects (30%) who agree to additional participation as the videotape group (VG).

Research Hypothesis 1

There will be an increase in forward head posture over an 8 hour workday as measured using preferred posture at an individual's own workstation in a subgroup of subjects (30%) who agree to additional participation as the VG.

Research Question 2

Do computer users assume a different forward head posture when seated at their own workstation using preferred posture as compared to sitting with standardized positioning of the thoracolumbar spine and lower extremities?

Null Hypothesis 2

There is no difference in forward head posture (as measured by the CROM device) assumed at the computer user's workstation in a preferred posture as compared to a standardized position of the thoracolumbar spine and lower extremities in all subjects.

Research Hypothesis 2

There will be an increase in forward head posture assumed at a computer user's own workstation using preferred posture as compared to a standardized position of the thoracolumbar spine and lower extremities for all subjects.

Research Question 3

Is the addition of 8 weeks of exercise of the deep cervical flexor muscles more effective in reducing sub-clinical neck symptoms and disability, improving cervical sitting posture, and improving cervical muscle function than postural education alone or no treatment in computer users?

Null Hypothesis 3

There is no difference in change in symptoms (as measured with a visual analog scale), change in disability (as measured with the Neck Disability Index), cervical sitting posture (forward head position measured with the cervical range of motion device (CROM) [Performance Attainment Associates, Lindstrom, MN]), and cervical muscle function (as measured with the Craniocervical Flexion Test, and the Short Neck Flexor Endurance Test) between computer users who perform 8 weeks of exercise for the deep cervical flexor muscles in addition to education (EEG) when compared to those who receive education only (EOG), and a control group (CG) receiving no treatment.

Research Hypothesis 3

Both intervention groups will demonstrate decreased pain and disability (lower scores on the visual analog scale and Neck Disability Index), a decrease in forward head posture (lower reading on the CROM device) and increased cervical muscle function (higher scores on the Craniocervical Flexion Test and the Short Neck Flexor Endurance Test) relative to controls. Based on the literature demonstrating effectiveness of exercise, and less evidence for education in postural correction, the exercise group should demonstrate greater improvement.

Definition of Terms

Computer User – an individual who utilizes a computer workstation at least 4 hours a day as a component of an office job that is primarily sedentary (seated activities at a desk/workstation including computer use, paperwork and phone calls).

Disability – is defined in The Guide to Physical Therapist Practice[6] as the inability to engage in normal societal roles. The Bone and Joint 2000-2010 Task Force on Neck Pain classification system describes categories for individuals with neck pain in terms of "low", "moderate", and "high" disability, but specific survey tools or scales are not recommended. For the purposes of this study disability related to neck symptoms/pain will be described in terms of the score on the Neck Disability Index (NDI), a self-report outcome tool (Appendix B). In an attempt to capture activity limitations due to neck pain, this study defines low disability as a score of 1 to 14 and moderate disability as 15-24 on the NDI. This deviates from the scoring system proposed by the originator of the scale which considered 0-4 no disability, and 5-14 mild disability.[42] The NDI has test-retest validity of 0.89[42] and reported construct validity by Riddle and Stratford.[43]

Job-satisfaction – a self-report measure of job satisfaction (Appendix C) as measured on a 5 point Likert scale ranging from 1 (very dissatisfied) to 5 (very satisfied).

Preferred Posture/Position – the posture or position assumed by an individual when seated at their workstation without formal instruction.

Standardized Posture/Position – the posture or position assumed by an individual when seated at their workstation (Appendix D) with instruction to position their lower extremities and pelvis/low back in a particular manner (feet flat, hips and knees at a 90 degree angle, pelvis upright with lumbar lordosis, thoracic spine supported by the chair back).[29]

Sub-clinical Neck Symptoms – The classification scheme outlined by the Bone and Joint Decade 2000-2010 Task Force on Neck Pain will be utilized to define this level of symptoms. It will include symptoms of discomfort, pain, stiffness and/or tenderness in the region of the body between the superior nuchal line of the skull and the spine of the scapula posteriorly, and the superior border of the clavicle and suprasternal notch anteriorly, as identified through survey (Axis I), in individuals employed as computer users (Axis II). This excludes pain in this region attributed to serious local pathology or systemic disease. Individuals with this level of symptoms do not seek treatment for their symptoms, and generally report low disability/low pain intensity (Axis III - Grade I). These symptoms may be transitory, short or long duration (Axis IV), and may be single episode, recurrent or persistent overtime (Axis V). This level of symptoms is consistent with the larger classification of Non-Interfering Neck Pain as described by The Bone and Joint Decade 2000-2010 Task Force on Neck Pain.[5]

Workstation – a desk, office chair and video display terminal utilized by subjects to perform their work tasks. Workstations will be screened for ergonomic flaws prior to implementation of the study using the Video Display Terminal Workstation Checklist.[44]

Video Display Terminal Workstation Checklist – a screening tool developed by the Occupational Safety and Health Administration utilized in this study to assess workstations for minimal health and safety set-up.[44]

Control Group (CG) - subjects who meet inclusion criteria for the study but do not receive exercise or education intervention. Thirty subjects were planned to be recruited for this group.

Education/Exercise Group (EEG) - subjects who receive both education and exercise intervention. Thirty subjects were planned to be recruited for this group.

Education Only Group (EOG) - subjects who receive only education intervention. Thirty subjects were planned to be recruited for this group.

Videotaping Group (VG) – a sub-group of subjects from the CG, EOG and EEGs who agreed to being videotaped for two 15 minute periods during the first and eighth hours of their workday to address research question 3. Twenty-seven subjects (30% of the total pool) were planned to be recruited for this group.

Craniocervical Flexion Test (CCFT) – a test of performance of the deep cervical flexor muscles performed in the supine position using The Stabilizer™ [Chattanooga Group, Hixson, TN] pneumatic pressure device resulting in a pressure score in millimeters of mercury.[45] The unit has been demonstrated to have construct validity, and reliability with ICC reported between 0.81 and 0.93.[45] It is also known as the Cranial Cervical Flexion Test.[20]

Short Neck Flexor Endurance Test (SNFET) – a test of performance of the deep cervical flexor muscles performed in the supine position with a chin tuck/head raise maneuver resulting in a timed score in seconds. Validity has been demonstrated by Falla,[46] inter-rater reliability of 0.82 – 0.91.[12] Also known as the neck flexor muscle endurance test, the muscle endurance of short neck flexors, the deep cervical short muscle endurance or the cranial flexion endurance test.[12,20,47-49]

Visual Analog Scale (VAS) – a 10 centimeter line on which an individual makes a mark indicating their level of pain or discomfort intensity (Appendix E). This line is anchored with the descriptors "no pain/discomfort" and "worst you experience", and is measured in millimeters. Test/retest reliability ranges from 0.71-0.91, and convergent validity with the numeric pain scale and McGill Pain Questionnaire ranges from 0.30-0.95.[50]

Craniovertebral Angle – the angle formed between a line passing between the tragus of the ear and the C7 spinous process and a horizontal line passing through the C7 spinous process. These landmarks have been utilized in studies of head and neck posture.[17,27,29,34] Measurement of the craniovertebral angle has been found to correlate with radiographs (0.98), with reliability demonstrated by an ICC of 0.98.[51] This angle has also been described as the craniocervical angle, angle of neck flexion, or cranial angulation.[31,32]

Forward Head Posture (FHP)– a position of the head in which the ear is aligned anterior to a line passing through the line of gravity of the body. For this study FHP will be measured via the craniovertebral angle, for the VG, with a smaller angle indicating a more forward head posture. Based on limited current literature the average craniovertebral angle in asymptomatic subjects is 49 (SD 6) degrees with a range of 35-63 degrees .[52] For my study a craniovertebral angle less than

40 degrees (1.5 times less than the SD) will be considered forward head posture. For the CG, EOG, and EEG comparison forward head posture will be measured using the CROM [Performance Attainment Associates, Lindstrom, MN], with a larger value indicating a more forward head posture. Based on limited current literature the average measurement for head position using the CROM is 17 cm (SD 1.8).[53] For my study a CROM measurement greater than 19.7 cm (1.5 time greater than the SD) will be considered forward head posture. The CROM has a reported intra-tester reliability of 0.93.[53]

Summary

Given the prevalence of neck pain and sub-clinical symptoms in office workers utilizing computers, the focus on head and neck posture, and education and exercise in the management of these individuals, it is important that the relationships between these factors are clearly defined. A suggestion of a relationship has been demonstrated in some studies; however, limitation in design in regard to standardized techniques and single point in time measurements may have impacted the interpretation of these study results. Although improvements in decreasing pain and disability have been demonstrated using educational and exercise interventions, there has not been a comparison between the two as to effectiveness in the workplace. This study was designed to discern differences among an education alone group, education and exercise group, and a control group having no intervention with respect to symptoms, perceived disability and postural change. The influence of standardized positioning and time was explored as well. Information on job satisfaction and physical set up of the workstation from an ergonomic perspective was collected to examine potential confounding effects.

CHAPTER TWO

LITERATURE REVIEW

Introduction to the Chapter

This chapter will provide an analysis of the literature relevant to this study. An overview of the conceptual framework of neck pain utilized in the study will be presented first. The prevalence of neck pain in computer users will be reviewed, specifically sub-clinical neck pain as this was the focus of subjects for the study. Studies detailing the relationship of posture and symptoms about the head and neck will be presented. Interventions utilized for the management of neck pain in computer users will be discussed, with current evidence for effectiveness of exercise and educational methods. An argument will be made for consideration of actual work postures assumed by individuals at work and not standardized postures when studies are performed to assess the relationship of neck symptoms and posture. The impact on neck posture of sustained sitting over time will be discussed. An overview of measurement techniques for forward head posture (FHP) will be included. Information on validity and reliability of measures to be utilized in this study will be presented. A summary of the current findings in the literature related to neck symptoms, disability, education, exercise, and posture will be provided.

Conceptual Framework/ Models of Neck Pain

In 2008 a series of articles was published in *Spine* providing reports of The Bone and Joint Decade 2000-2010 Task Force on Neck Pain and It's Associated Disorders.[1-3,5] This interdisciplinary task force stemmed from an initiative from the United Nations and the World Health Organization, and produced reports based on a review of available evidence as well as the implementation of several original studies related to the epidemiology and treatment of neck pain. The Task Force provided a new conceptual model and classification system for neck pain which includes those with neck pain as well as those at risk of developing neck pain. The classification system was proposed as a means of bringing consistency in terminology for researchers, clinicians and policy makers, and to assist in the organization and interpretation of studies related to neck pain/disorders.[1] It was recommended that future studies on neck pain define the subjects used in terms of a 5-axis classification scheme to assist in the comparison of studies. This scheme includes; the source of subjects and data (Axis I), the setting (Axis II), the severity of symptoms (Axis III), duration of symptoms (Axis IV) and pattern of symptoms over time (Axis V).[5]

Other classification systems for physical therapist use include the Guide to Physical Therapist Practice,[6] and the Neck Pain Clinical Practice Guidelines put forth by the Orthopaedic Section of the American Physical Therapy Association.[20] The Bone and Joint Decade 2000-2010 Task Force model of neck pain grades symptom severity and provides a scheme which separates individuals with clinical and sub-clinical symptoms. These individuals with sub-clinical neck symptoms would be categorized as "clients" in the Guide to Physical Therapist Practice.[6] The classification system proposed by the Bone and Joint Decade Task Force was selected for this study based on the inclusion of individuals with sub-clinical neck symptoms, the application to both the research and clinical setting, and standardization of terminology.

This classification scheme includes five axes to describe individuals with neck pain for the research process as outlined in Table 1.[5] The first axis relates to how the symptoms are identified (via survey or questioning, by seeking healthcare, or via submission of an insurance claim). For this study I planned to utilize questioning/survey to describe neck pain in subjects (Appendix F). The second axis relates to setting and sampling of individuals and includes 3 categories of general population (which can be further detailed by employment or sport participation), healthcare settings, or insurance records. On the second axis the general adult working population was identified for use in my study, specifically those employed in office positions who utilize computer workstations. Axis three relates to severity of symptoms, and it was anticipated most subjects in my study would be at the Grade I level, which includes those with no signs of pathology, low disability and low intensity of symptoms, though Grade II (low disability with high intensity of symptoms) might also be present. The fourth axis relates to duration of symptoms ranging from transitory (less than 1 week), short duration (1 week to less than 3 months) and long duration (more than 3 months). The fifth axis relates to the pattern of symptoms including single episode, recurrent or persistent. Subjects in my study could fall into any category on the last 2 axes. My study was designed to identify the pattern and duration of symptoms once subjects entered the study, and report this information in the description of subjects.

Table 1. Classification of Case Definitions for Neck Pain and Associated Disorders Proposed by the Bone and Joint Decade2000-2010 Task Force on Neck Pain and Associated Disorders.

Axis I Source of Subjects	Axis II Setting and Sampling	Axis III Severity	Axis IV Duration	Axis V Pattern
Neck pain in surveys	General population, employed population, specific occupations, sporting events	Grade I, low disability/low intensity; Grade II, low disability/high intensity; Grade III, high disability/moderately limiting Grade IV, high disability/severely limiting	Transitory Short Duration Long Duration	Single episode Recurrent Persistent
Neck pain with Healthcare	Emergency room, primary ambulatory care, secondary care, tertiary care	Grade I, no signs of pathology, low disability Grade II, no signs of pathology, high disability Grade III, neck pain with neurological signs Grade IV, neck pain with signs of pathology	Transitory Short Duration Long Duration	Single episode Recurrent Persistent
Neck pain with claim	Health insurance Auto Insurance WCB Insurance Personal Injury	Care or equipment repair only, Wage replacement, Long-term disability, Disability, Pain and suffering	Transitory Short Duration Long Duration	Single episode Recurrent Persistent
Axes I-III can be established early, but axes IV and V can only be established after follow-up. Pathology indicates cancer, infection, fracture, spinal cord injury, or inflammatory rheumatic disease; Transitory less than 1 week; Short Duration one week or longer, but less than 3 months; Long Duration 3 months or longer; Single Episode, no pain before, self-reported recovery after; Recurrent, periods of self-reported recovery in between 2 or more episodes (minimum period of recovery varies with context, but ought to be explicitly defined); Persistent, no recovery				

(Reprinted with permission; Lippincott Williams & Wilkins from Guzman L, Hurwitz EL, Carroll L, et al. A new conceptual model of neck pain: linking onset, course and care: The Bone and Joint Decade 2000-2010 Task Force on Neck Pain and It's Associated Disorders. Spine.2008;33(4S):S14-S23).
WCB = Workers' Compensation Board

The task force also identified 2 broad levels of neck pain, interfering neck pain and non-interfering neck pain. With non-interfering neck pain symptoms are present, however, at a level at which the individual does not experience any impact at the levels of impairments, activities, participation, well-being or resource use. Interfering neck pain does impact one or more of these levels, however, the response of the individual may include no care, self-care, or professional healthcare. Subjects in my study are classified into the interfering neck pain group with a response of self-care or no care, and described as having sub-clinical neck symptoms. Those seeking healthcare as a result of their symptoms were excluded from my study. Use of this model of neck pain assists in the description of the population used for my study, and the classification of their neck symptoms relative to future clinical and epidemiologic studies.

Neck Symptoms in Computer Users

Computer users spend a significant amount of the day sitting, and the sitting position has been identified as a risk factor in the development of neck pain that is double that of other workers.[4] Cagnie et al[54] in 2007 found a 12 month survey of neck symptoms (defined as pain in the head and neck region) of the in a sample of 512 computer users in Belgium, from 10 different companies including employees in management/administration, education and engineering, to be 45.5%, with women twice as likely as men to develop neck symptoms. In a 2002 prospective study of computer users Gerr et al[7] found that over 50% of 538 asymptomatic new hires reported symptoms in the upper quarter within the first year, with an annual incidence of 58 cases/100 person-years for neck and shoulder symptoms. In comparison 10% of the 632 subjects who entered the study reported symptoms at the start of the study. Gerr et al[7] followed the employees, from a variety of sectors in the United State including education, healthcare, insurance and telecommunications, for 3 years, monitoring symptoms via survey, with confirmatory physical examinations following onset of musculoskeletal complaints. The Task Force on Neck Pain in a broader look at neck pain in a variety of workers (not limited to office workers), identified a 12 month prevalence of neck pain in the range of 12-71%, with 11-14% of workers limited in work activities due to pain.[1,2] This wide range of prevalence can be attributed to the complex relationship between personal and workplace risk factors as well as varied reporting mechanisms and healthcare monitoring systems across different countries. Differences in operational definitions of neck pain included new onset, recurrent, and chronic neck pain. Recruitment methods varied including identification of specific populations such as dentists, bank tellers, nursing home workers or general workers. Though these studies demonstrate a range of prevalence of neck pain in office workers/computer users it is clear that the risks of neck symptoms are greater than those in other work settings.

Sitting posture and specifically a forward or flexed head posture have been implicated in the prevalence of neck symptoms. Cagnie et al[54] in 2007 identified sitting and a flexed neck posture to be risk factors for the development of neck symptoms with positive odds ratios exceeding 2 . Ariëns et al[4] in 2001 reported a trend towards a positive association between neck pain and neck flexion while working. Their assessment involved timing individuals wearing a weighted (2.5 – 5 kg) helmet to determine the length of time an individual could maintain a 45 degree flexed neck position before reaching a pre-determined level of discomfort on a 10 point scale. This technique has questionable face validity in relation to typical activities and stresses of a normal workday.[4]

Although many individuals seek treatment for their neck symptoms there is an additional group who have symptoms and are not actively seeking care, those described as having sub-clinical symptoms.[10] This group is defined by the Bone and Joint Decade 2000-2010 Task Force on Neck Pain as those who are at risk of developing disabling neck pain.[1] There are many individuals in this category. Cote, Cassidy and Carroll[55] in a large population based survey in 1998 with 1,133 respondents from Saskatchewan, Canada found a lifetime prevalence of 66.7% for neck pain. Neck pain was defined as pain between the occiput and the third thoracic vertebra in this study, and the survey was conducted by mail.[55] This figure is higher than the 12 month prevalence noted by Cagnie et al[54], however, includes lifetime prevalence. The 12 month prevalence was not reported by Cote et al,[3] however, 6 month prevalence figures were more similar to the Cagnie study at 54.2%. The population of the Cote study included workers from a variety of settings as opposed to Cagnie's office workers. All participants in the study had access to medical services through the Canadian health system. Severity of symptoms and disability were examined utilizing the Chronic Pain Questionnaire It is significant that the majority of respondents (38.6%) in the Cote[55] study reported symptoms that were low level and low disabling, demonstrating that there are likely a number of individuals with neck pain not actively seeking medical care, who could be described as having sub-clinical symptoms.

A 2008 cross-sectional study of female office workers was performed to better describe cervical musculoskeletal findings in this population of office workers with sub-clinical neck symptoms. The authors recruited individuals with sub-clinical neck pain and grouped them by severity based on the Neck Disability Index (mean score of 16.6%, range of 2-40%). Half reported symptoms for less than 30 days, and the other half for greater than 30 days.[13] The authors compared these individuals to a control group of non-working women. They concluded that workers with sub-clinical neck pain had physical findings consistent with cervical disorder including cervical range of motion, the Craniocervical Flexion Test (CCFT), and muscle activity and symptom reproduction with a coordination task. A linear relationship was present between the self-reported symptoms and physical findings. The controls utilized for this study were non-working, non-computer users without neck symptoms, and were 6-8 years younger than those with sub-clinical neck pain.[13] This design makes it difficult to determine if group differences were due to age, work tasks, or other activity factors which differ between working and non-working individuals. The significance of this study is that individuals with sub-clinical neck symptoms have been found to have objective changes in cervical range of motion and muscle function.[13] My study was designed to examine neck symptoms as well as physical findings of muscle function and posture in computer users with sub-clinical neck symptoms. The relationship of posture and neck symptoms is described in the following section.

Posture and Neck Symptoms in Physical Therapy

A connection between symptoms in the neck region and their relationship to posture has been a common theme in physical therapy literature for many years. Kuhns[18] as far back as 1948, in *The Physical Therapy Review* argued that even mild changes in posture can result in weakness of the surrounding musculature and pain. He noted however that normal posture is difficult to define as variations exist in body build and ligamentous support. Treatment recommendations included postural correction as the primary focus, particularly in the early stages of symptom onset.[18] This theme of a relationship between posture and pain was echoed in the 1960's by Kendall and Kendall[15] who provided an description of good posture and argued for its importance in controlling pain. Specific to the neck, a forward head posture has been described, referring to a position of the head in which the ear is aligned anterior to a line passing through the line of gravity of the body.[15]

The focus on posture and a relationship to neck symptoms has been included in physical therapist education, and is evident in clinical practice. In a survey of physical therapist practice in 1986 Enwemeka et al[19] analyzed responses from 43 physical therapists with clinical experience treating patients with neck pain. Eighty-six percent of these therapists reported that postural correction was important in addressing neck symptoms, and utilized either a neutral or retracted position to correct forward head posture.[19] This focus on postural interventions for individuals with neck symptoms continues as a theme in more current literature. In case studies, research reports, editorials, clinical practice guidelines and classification schemes physical therapists continue to endorse a relationship between posture and neck symptoms. [16,17,20,21,26,56]

Despite the use of postural correction exercises in physical therapy treatment programs, and the attention to cervical forward head posture in the literature there has not been a clearly identified link between "poor" posture of the head and neck, and symptoms. In 2002 a need for further research in this area was identified.[26] Some authors argue that forward head posture may be a normal finding, unrelated to musculoskeletal dysfunction.[27,28] In 1994 Raine and Twomey[28] published an extensive review of literature on the relationship between posture and musculoskeletal dysfunction and pain. This publication reviewed 173 sources from 1894 through 1993. They explained the current and previous descriptions of "correct" posture as well as a variety of classification schemes for posture. Forward head posture was noted to be one of the frequently cited examples of incorrect posture with longstanding traditional opinion linking it to pain. The references specifically related to forward head posture and pain were secondary sources or expert opinion articles with the exception of one.[57] This study by Hanten[57] in 1991 found that there is a difference in resting head posture between men and women, with women maintaining a more forward head posture, however, did not address a relationship between posture and pain. Thus Raine and Twomey[28] argued that there was no demonstrable evidence to support a link between good posture and musculoskeletal symptoms, and that current thought linking the two was based solely on anecdotal evidence and belief. Since that time however a number of studies have attempted to explore a relationship between posture and musculoskeletal symptoms as outlined in Table 2 and described in further detail in the following narrative.[4,17,27,31,39,58]

Three studies performed in the 1990s utilized samples ranging from 60-88 participants, including individuals with and without symptoms of neck pain and/or headache.[27,30,58] Griegel-Morris et al [30] in 1992, and Watson and Trott[58] in 1993 both reported a relationship between forward head posture and symptoms. In contrast Harrison et al[27] (1996) reported no statistical difference in forward head posture (as measured by craniovertebral angle) in those with and without neck pain. The groups however were unequal with respect to gender, with 25% of the non-patient group, and only 10% of the patient group male. This is important as they identified a statistically significant difference in forward head posture between males and females in their sample, with males having more forward head posture.[27] Watson and Trott[58] utilized all female subjects, however Greigel-Morris et al[30] though starting with a 53% female subject pool did not report the genders once the groups had been divided into those with and without symptoms. Because differences in posture have been identified between genders it is important that studies on posture use groups with similar gender or gender proportions. My study was designed to equate males and females in the three comparison groups to accommodate this difference.

Table 2. Studies Relating Posture and Neck Symptoms

Author Date Size	Purpose	Outcome Measures	Methods	Conclusions
Griegel-Morris[30] 1992 N= 88	Assess relationship between posture and pain and incidence of abnormal posture	Numeric pain scale, pain descriptors, posture via plumb line	Assessed posture and symptoms in healthy volunteers	66% had FHP More severe postural change associated with increased incidence of pain
Watson[58] 1993 N=60	Determine prevalence of cervical abnormalities in those with and without headache	Craniovertebral angle with lateral photography, isometric strength and endurance	Measurements obtained prior to classification into headache/non groups	More FHP, less strength and endurance in those with cervical headache. FHP correlated with lower endurance
Harrison[27] 1996 N=15/51	Measurement reliability and comparison of FHP in pain and non-pain patients	Craniovertebral angle	15 subjects measured by 2 PTs 41 non-pain and 10 pain pts	No difference between pain and no pain groups Males had greater FHP
Ariëns[4] 2001 N=1,334	Determine relationship between neck pain and posture	Posture, pain, psychosocial and individual factors	Observational video analysis of work Multi-variant analysis of risk	Significant assoc of neck pain and sitting Positive trend between pain and neck flexion
Szeto[31] 2002 N= 16	Compare posture in those with and without neck pain	Discomfort/pain Neck and head posture	Video and motion analysis in work setting	More FHP in work posture versus relaxed Greater neck flexion in pain group
Fernandez-de-las-Penas[59] 2006 N=50	Determine relationship between trigger points, FHP and headache	Craniovertebral angle, presence of trigger points, symptoms	Matched headache and non-subjects	Those with active trigger points and headache had greater FHP
Fernandez-de-las-Penas[17] 2007 N=20	Determine differences in CCFT in those with/without headache	Headache diary, CCFT, cranio-vertebral angle	Matched controls and subjects for measurements	Those with HA had greater FHP in standing but not sitting and lower performance on CCFT
Grob[39] 2007 N=107	To determine a correlation between neck pain and posture	Angular measurements of neck position	Radiographic measurements in individuals with and without pain	No correlation between symptoms and posture

FHP = Forward Head Posture, PT = Physical Therapist, Assoc = association, HA = head-ache, CCFT = Craniocervical Flexion Test

Differences existed in the measurement techniques utilized in each study. Griegel-Morris et al[30] utilized a plumb line for assessment of posture. The examiners demonstrated good intra-rater reliability with Cohen's Kappa at 0.825

for their postural assessment technique; however inter-rater reliability was lower at 0.611. Watson and Trott [58] and Harrison et al[27] utilized the craniovertebral angle as defined in this current study with Watson and Trott reporting high reliability with Pearson's r = 0.973, while Harrison had a low reliability of r = 0.34. This difference could be due to Watson and Trott using a lateral photograph, while Harrison took the measurement live. I planned to utilize lateral photography for a portion of my study based on this difference. These three studies from the 1990s were cross-sectional in design, and were relatively small in comparison to a study by Ariëns et al[4] in 2001 which focused on neck pain and sitting posture.

Ariëns et al[4] published a large, longitudinal prospective cohort study in 2001 of the relationship between neck pain and neck flexion, including a 3 year follow up of 1,334 workers. Neck flexion was assessed by video however specific location of the markers was not described, so it cannot be determined how neck flexion was measured. The subjects for this study were part of a larger study in The Netherlands on musculoskeletal risk factors related to work activities. Regression and multivariate analysis were utilized to assess the relationship between neck pain and potential confounding factors including age, gender and physical exposure variables including working time with the neck in flexion. The researchers found a significant association between sitting and neck pain, a positive trend for association of neck pain and neck flexion, and an increased risk of neck pain in those working with the neck in flexion.[4] A large number of subjects in this study were lost to follow up (27%), and 74% of the subjects were males with occupations including metal work, construction and bricklaying, not positions associated with significant amounts of sitting. In addition there was no indication of reliability of the methods utilized to rate the subjects via review of videotapes. This study is supportive of a link between posture and neck symptoms as evidenced by the identified relative risk, and has strength in that it is one of the few prospective designs examining this topic, and includes a large number of subjects. Concerns include the lack of clarity in measurement technique and attention to reliability issues, the large number of subjects lost to follow up, and the genders and varied occupations of the subjects. My study addresses reliability of measurements utilized, and includes detailed descriptions of the measurement techniques utilized. In 2002 a study on posture and neck symptoms specifically focused on female subjects utilizing computer workstations.[31]

Szeto et al[31] in 2002 reported a trend towards a more flexed cervical posture when working at a computer workstation versus relaxed sitting in female workers, and found that those with neck complaints (pain/discomfort of 2/10 or higher, or a history of such complaints) had a greater degree of flexion. Although this study is supportive of a difference in cervical posture between subjects with and without neck symptoms it included only 8 subjects per group, therefore the ability to demonstrate statistical significance of group comparisons was limited. My study will expand upon this work by incorporating a larger sample, with a prospective design. As the Szeto study was cross-sectional in design it could not be determined whether the postural changes preceded the symptoms, or were a result of the symptoms. Szeto reported on symptoms in the head, neck and shoulder region, while others focused specifically on headache as it related to head and neck posture.[17,59]

Fernandez-de-las-Penas et al[59] in 2006 looked at the relationship of myofascial trigger points to a variety of factors including forward head posture in a blinded, controlled study of 50 subjects comparing those with and without tension-type headache. Forward head posture in sitting was greater in those with headache and active trigger points as compared to those with latent trigger points. More recently in 2007 Fernandez –de-las-Penas et al[17] studied subjects with tension type headaches using the craniovertebral angle measure of forward head posture and the Craniocervical Flexion Test to measure deep cervical muscle function. Utilizing lateral photography to measure the craniovertebral angle they identified greater forward head posture in those with headaches as compared to controls.[17] A limitation of this study was the small sample size (n=20), as well as the recruitment of patients for the "headache" group, and hospital staff for the "control" group, who may have had more awareness of posture, with no indication of occupation in either group. No indication was provided as to the position used for the forward head measurement with the exception of "1 in sitting and 1 in standing" (p. 35).[17] The rest of the procedures were well described, and blinding of the examiner was utilized while obtaining measurements. Findings included a more forward head in standing for the headache group, without a difference in sitting, in contrast to the findings of the 2006 study by the same primary author.[17] As with Watson and Trott[58] these studies support a relationship between headache and forward head posture,[17,59] though other authors reported no relationship.[39]

In a 2007 study Grob et al[39] concluded there was no relationship between symptoms and neck position, as measured by radiographic segmental measurements of C2 through C7. Several factors in the study design and data analysis may have affected these results. Measurements were of the angle of the posterior vertebral body relative to the adjacent level, and of the total angle from C2 through C7 using lateral radiographs with a standardized head on neck position. Chi square was utilized for multiple analyses and 42% of the cells had 5 subjects or less, likely impacting the results though not discussed by the authors. Subjects were classified as lordosis, kyphosis or a straight spine however of the 103 subjects, 96 were lordotic, 6 straight and only 1 subject in the kyphotic group.[39] This classification scheme is of questionable value given the lack of dispersion among the subjects. The standardized head position as well as the lack of a normal distribution of the data raise question regarding the authors conclusions that there is no relationship between posture of the cervical spine and pain.

Despite the history of expert opinion relating posture and pain[15,18] and the continued focus on interventions addressing posture for individuals with neck symptoms in descriptions of clinical practice and case studies[16,17,19-21,26,56] the evidence for this link is conflicting. Some studies have found a lack of relationship[27,39] while others report a more forward head posture in individuals with neck symptoms as compared to those without.[17,31,58,59] There is a clear relationship between seated work involving neck flexion and neck symptoms.[4,7] Posture and neck symptoms have been examined in a number of studies, however the inclusion of some measure of muscle function is less frequent. My study was designed to include 2 measurements of muscle function. I also intended to equalize gender across groups, provide specific description of measurement techniques, and expand the subject pool in number and occupation in an attempt to address some of the concerns noted in the studies described above.

Posture and Muscle Function

Four studies on neck pain and posture incorporated some measure of muscle function.[17,29,38,58] Watson and Trott[58] in 1993 found lower muscle strength and endurance in the cervical region in subjects with neck symptoms as compared to those without. Forward head posture also correlated with lower endurance, though not with isometric strength.[58] The measurement of strength and endurance reported by Watson and Trott however utilized a mechanism with strain gauges developed by the authors involving pressure measurement through the mandible, possibly allowing for additional muscle substitution via the hyoid muscles. More recent studies have incorporated the Craniocervical Flexion Test as a measure of neck muscle function.[17,29] In 2007 Fernandez–de-las-Penas et al[17] performed a descriptive pilot study to examine differences in individuals with and without headache on the Craniocervical Flexion Test and reported a decrease in holding capacity of the deep cervical flexors in those with tension-type headaches. In addition those with headache had a more forward head posture. This was a small study however, and did not include any interventions to improve muscle function.[17] Falla et al [29,38] however in that same year published 2 studies. One demonstrated that correction of posture in individuals with chronic neck pain resulted in increased activation of the deep cervical musculature as measured with electrodes placed on the posterior oropharyngeal wall through the nose.[38] The second demonstrated that a muscle strengthening program that targets the deep cervical flexors resulted in improved posture when using a computer workstation for at least a short period of time (10 minutes).[29] These studies demonstrate that there is a change in muscle function in those with head and neck symptoms, and that muscle function can be impacted through the use of postural exercise. I designed my study to examine muscle function of the deep cervical flexors, and potential changes following education and a combination of education and exercise using the Craniocervical Flexion Test and the Short Neck Flexor Endurance Test. Both of these tests are recommended examination techniques in current neck pain clinical practice guidelines for physical therapists.[20]

Interventions for Computer Users

Educational Intervention for Computer Users

Education has been utilized as an intervention for the management and prevention of neck symptoms by physical therapists for many years and continues to be recommended in current clinical treatment guidelines for neck pain and occupational health physical therapy.[20,40] Recent case studies in physical therapy journals demonstrating ergonomic intervention in additional to traditional physical therapy, and use of a treatment-based classification system emphasized the use of education in proper posture in treatment.[21,22] Educational interventions have been studied in research as a primary intervention, and at times as the “control” intervention.[14,41] Two studies demonstrating the effectiveness of education in reducing symptoms and two demonstrating a change in posture following education are reviewed in detail within this section and are summarized in Table 3.[25,36-38]

Table 3. Studies on the Effect of Education on Spine Symptoms and Posture

Author Date Size	Purpose	Outcome Measures	Methods	Conclusions
Bohr[36] 2000 N=154	Compare traditional and participatory education	Symptom report; Posture Workstation setup	Group educational sessions on posture, workstation modification, muscle physiology, health and wellness	Education reduced symptoms; no change in posture or workstation
Street [37] 2003 N=23	Evaluate effectiveness of educational session on general health work postures	Posture and Repetitive Risk Factor Index SF-36	60 min group session and 15 min individual session on work injuries/habits, ergonomic changes, posture, exercise	Posture and work risk improve with education
Greene[25] 2005 N= 87	Evaluate effectiveness of ergonomic education	Rapid Upper Limb Assessment; Self-efficacy scale; Ergonomics quiz; Msx symptoms; Outcome expectation scale	Group sessions on anatomy, biomechanics, posture, workstation design	Decreased intensity, duration and frequency of symptoms in individuals with baseline complaint Decreased risk exposure following exercise
Falla[38] 2007 N=10	Compare activation of postural mm with verbal education versus verbal education with tactile cueing	EMG recordings of deep cervical flexors	Individual education sessions with tactile cueing from a PT versus instruction to “sit up straight”	Postural correction with verbal and tactile cues facilitated deep cervical flexor muscle activity as opposed to verbal instruction alone

Msx = Muscusloskeletal; SF-36 = Short Form -36 (Outcome Tool); EMG = Electromyography; PT = Physical Therapist

Use of education for computer users/office workers has been demonstrated to decrease pain intensity, duration and frequency. Randomized controlled trials by Bohr[36] in 2000 and Greene et al[25] demonstrated a significant decrease in symptoms in those receiving education as compared to controls. Educational content included ideal posture, workstation modification, muscle physiology, and health and wellness instruction. Both studies utilized adult office workers and followed subjects for 12 months. Both had 80-86% female participants. Bohr[36] required at least 5 hours of computer use per day, and Greene et al [25] at least 10 hours per week. Greene et al [25] specifically excluded those receiving treatment of the neck or upper body by a health care provider; however this was not addressed by Bohr. [36] I planned to use a figure between these two, with at least 4 hours/day of computer use, and to exclude individuals receiving health care for their neck symptoms within the past year.

In the Greene et al[25] study when all participants were included in the statistical analysis no difference was found for pain intensity, frequency and duration, however when the subjects were grouped based on the presence of sub-clinical symptoms pre-intervention (69% had upper back/neck symptoms) significant improvements were identified. The authors concluded that those at risk of developing musculoskeletal disorders were most likely to benefit from the educational programming. [25] This study was well designed, with data analysis that was thorough, including screening for outliners and addressing of assumptions of linearity, normality and homoscedasticity. It provides support for the benefits of education in addressing neck symptoms in computer users.

Both studies provide support for the efficacy of educational interventions in reducing musculoskeletal symptoms; however neither adequately addresses posture of the head and neck. Bohr[36] utilized a check list including 3 items related to head and neck posture; if the neck was neutral with respect to flexion/extension, rotated, or flexed to hold a phone. Greene et al[25] utilized an observational tool, the Rapid Upper Limb Assessment which is a composite score of neck, back and upper extremity joint positions, frequencies and durations used to assess risk related to end range positions. Both of these postural assessments are qualitative in nature and it is difficult to determine a relationship to measured head and neck posture and a change in posture following intervention. I planned to incorporate physical measurement of head and neck posture utilizing the CROM device and lateral photography of the craniovertebral angle in my study to provide a quantitative measure as opposed to qualitative.

Studies by Street et al[37] and Falla[38] do provide an indication of change in posture as a result of education. Street et al[37] in 2003 studied office workers who utilized a computer at least 4 hours/day via blinded assessment of a 15 minute segment of video taken from a 30 minute recording. An observational tool for postural assessment, the Postural and Repetitive Risk Factor Index (PRRI) was utilized, which does have a quantification of neck flexion of at least 20 degrees included in the scoring. Following the educational session significant improvement was demonstrated in postural scores using the paired t-test, however no significant changes were seen in the Medical Outcomes Study 36-

Item Short-Form Health Survey (SF-36) scores. No long term follow up was included as this was a pilot study. This study demonstrates the ability to modify posture based on educational intervention.[37] The study did not have a control group, weakening the ability to determine if results were due to the intervention, or other factors. The SF-36 utilized for determination of health was too broad to detect changes in symptoms of the cervical region. The reliability coefficient noted for the PRRI tool was moderate at 0.75, and no indication was provided as to the individual researcher's reliability in utilizing the tool. A strength of the study included assessment of individuals at their own workstation.[37] For my study I planned to utilize a more focused educational content specific to spinal posture, a more direct measure of head and neck posture, and assesse change over an 8 week period as opposed to 5 weeks. In addition I planned to use a control group to strengthen the ability to detect change due to the intervention.

The studies on education detailed thus far utilized educational sessions ranging from 1-6 hours provided in a group format. While this is time effective for large groups, Falla et al[38] demonstrated in 2007 that individual attention with tactile cueing from the therapist resulted in greater activation of the deep cervical flexor muscles as compared to verbal instruction alone. A group of 10 subjects with chronic neck pain, ages 21-52 with an average numeric pain scale score of 4.5 ± 2.3 and an average score on the Neck Disability Index (NDI) of 10.5 ± 2.9 participated. Muscle activity was measured with surface electromyographic electrodes affixed to the posterior oropharyngeal wall overlying the deep cervical flexor muscle bellies via nasal wires. A significant increase in muscle activity was recorded when subjects were taught to sit in good posture via verbal and tactile cues from a therapist as opposed to verbal instruction to sit up straight. Drawbacks of this study are that the authors looked at immediate effects of the individual education only and not effect over time. A small group was tested, likely due to the invasive nature of the electrodes affixed to the oropharynx to measure the deep cervical flexor muscle activity. Pain and disability scores were collected only pre-test for descriptive purposes, and not assessed for change. This study demonstrates the benefit of individual education, and the value of having a physical therapist work one on one with an individual when attempting to modify posture. Falla et al[38] demonstrated a change in posture with education, as well as activation of the deep cervical flexor muscles. I designed my study to utilize one-on-one educational sessions with tactile cueing based on the results of Falla et al's[38] work.

The articles reviewed related to education, neck symptoms and posture suggest that educational interventions can result in decreases in intensity, frequency and duration of subjective complaints related to computer workstation activity.[25,36] While not specifically looking at symptoms, Street[37] found a reduction in the score on a postural risk index, and Falla et al[38] demonstrated that individual instruction resulted in greater activation of postural muscles, specifically the deep cervical flexors. None of these studies however utilized a direct measure to determine if education resulted in a change in neck posture. In a systematic review of risk factors for neck pain as part of the 2000-2010 Task Force on Neck Pain, the authors concluded that despite strong evidence that head and neck posture at a computer workstation is associated with an increased risk of neck pain, there has not been adequate evidence demonstrating that modifying posture in an individual will result in a positive effect on neck symptoms.[3] In addition none of these studies examined the effect of education on disability. Street attempted to do so by including the SF-36, however the authors noted the SF-36 may not have been specific enough to detect changes in the upper quadrant in relatively healthy individuals. Falla et al[38] utilized the NDI strictly as inclusion criteria, and did not assess change of this measure. I designed my study to bridge this gap by including measures of neck posture, disability and symptoms with interventions including both education and exercise to address these factors.

Exercise Intervention for Computer Users

Exercise has support as an intervention effective in reducing head and neck symptoms and disability, however as seen with education there is little evidence demonstrating a change in posture in conjunction with these improvements. A 2005 Cochrane Database Systematic Review noted moderate evidence for neck exercises in reducing pain and disability in chronic mechanical neck disorders, and moderate evidence for strengthening exercises in those with neck disability with headache.[35] A more recent article published in 2008 as part of the 2000-2010 Task Force on Neck Pain suggests that exercise (alone or in combination with manual techniques) is more effective than no or sham treatment.[60] Exercise is recommended in the prevention and treatment of neck pain in 2008 orthopaedic clinical practice guidelines for physical therapists[20], and is used in current case reports and review articles in physical therapy literature.[21-23,61] With a focus primarily on outcomes of pain and disability most studies do not include postural assessment when studying the effects of exercise. Nine articles are reviewed here, providing information related to exercise specific to office workers, or exercise specific to the deep cervical flexor muscles. Seven of these utilized a measure of pain/symptoms in the neck region as an outcome, 4 included a measure of posture and 3 some measure of disability. The types and parameters of the exercise programs varied, and those comparing different types of exercise found that all types of exercise resulted in improvements in pain, disability or posture. These studies are summarized in Tables 4 and 5.

A decrease in neck pain with exercise is consistently demonstrated in a number of studies in a variety of populations.[14,29,33,34,41,62,63] Waling et al[63] found that exercise significantly reduced pain in a group of female workers 45 years old and younger, who had at least a 1 year history of symptoms with associated trigger points in the trapezius muscle. The specific work setting was not described for these subjects. Jull et al[34] used a larger age range of 18-60, and included individuals with headache and related neck pain, and again the work setting of the participants was not indicated. This multi-site randomized clinical trial compared manipulation, exercise and a combination, finding statistical and clinical significance in symptom improvement for all 3 groups without interaction effects in the combination group.[34] Omer et al[14] reported decreased pain in computer users with a variety of neck and upper extremity complaints following an exercise program as compared to a control group. Ylinen et al[33,62] used a

Table 4. Studies on the Effect of Exercise on Neck Symptoms

Author Date Size	Purpose	Outcome Measures	Methods	Conclusions
Waling[63] 2000 N=126	Comparison of strength, endurance and coordination exercises	VAS for pain, Pain threshold (algometer), pain drawing	Strength group Endurance group, Coordination group Control group	All groups had decreased pain intensity. Type of exercise is not as important as participation in a program
Jull[34] 2002 N=200	Compare exercise for deep cervical flexors and manipulation	Northwick Park Neck Pain Questionnaire Symptom intensity and frequency Head Posture	Exercise group Manipulation group Combined group Control group	Intervention groups improved without interaction effects in combined group No change in posture
Omer[14] 2003/2004 N=50	Education versus education with exercise	Numeric Pain Scale Disability Scale	Education only Education and exercise group	Improvement in pain, disability and depression with exercise, no change with education only
Ylinen[33,62] 2003/2006 N= 180	2003 -Compare effect of strengthening and endurance exercise 2006- follow up report with focus on rate of change	Isometric neck strength; Repetition Max for UE & trunk; VAS for pain; NDI; modified neck and shoulder pain and disability index	Strengthening group Endurance group Control group All 3 groups did stretching and aerobic	All 3 groups had improvement in pain, disability, and strength; greater improvement in intervention group Greatest gains in the first 2 months
Falla[29] 2007 N=58	Compared ex. for deep cervical flexors to resistance/endurance ex of neck	NDI, Numeric Pain Scale, craniovertebral angle for cervical posture	Deep cervical flexor ex group Resistance neck ex. group Control group	Both ex groups had improvement in pain and NDI Deep cervical flexor group had improved cervical posture
Anderson[41] 2008 N=48	Comparison of strength training versus general fitness training	VAS for pain, VO_2 max Isometric arm strength	Strength group General fitness group, Control group	Both groups improved, with greater improvement in the strength group

VAS = Visual Analog Scale, Max = Maximum, UE = Upper Extremity, ex = exercise, NDI = Neck Disability Index, VO_2 max = maximal oxygen uptake

Table 5. Studies on the Effect of Exercise on Neck Posture

Author Date Size	Purpose	Outcome Measures	Methods	Conclusions
Pearson[64] 1995 N = 30	Investigate immediate effects of cervical retraction exercises	Resting head posture Protraction and retraction ROM	Repeated cervical retraction exercises (1 session)	No change in ROM, but improved resting head posture (less forward head)
Jull[34] 2002 N=200	Compare exercise for deep cervical flexors and manipulation	Northwick Park Neck Pain Questionnaire Symptom intensity and frequency Head Posture	Exercise group Manipulation group Combined group Control group	Intervention groups improved without interaction effects in combined group No change in posture
Harman[65] 2005 N=40	Efficacy of a 10 week exercise program on improving FHP	Craniovertebral angle Cervical ROM	Strengthening and stretching exercises compared to a control group	Improved posture in both groups, greater improvement in the exercise group
Falla[29] 2007 N=58	Compared ex. for deep cervical flexors to resistance ex of neck	NDI, Numeric Pain Scale, craniovertebral angle for cervical posture	Deep cervical flexor ex group Resistance neck ex. group Control group	Deep cervical flexor group had improved cervical posture

ROM = Range of motion, FHP = Forward head posture, NDI = Neck Disability Index

similar group of female office workers with chronic neck pain, however in addition to the exercise program participants received 4 physical therapy sessions which included manual therapy, relaxation training, behavioral support and education in ergonomics. This additional care was not provided to the control group, making it difficult to determine if the improvement in symptoms was related to the exercise, or the additional interventions.[33,62] Falla et al[29] in 2007 recruited females with chronic "non-severe" neck pain of at least 3 months who also presented with palpable cervical joint tenderness and poor performance on a test of cervical muscle function. Andersen et al[41] utilized female workers with chronic neck symptoms who like those in the Waling and Falla studies presented with additional clinical signs. They also noted that 79% of their subjects utilized a computer for at least 75% of the workday though work tasks varied from office to production jobs. Despite these differences in population the similarities included individuals with neck complaints, with the majority in an office setting utilizing a computer work station. All seven of the studies summarized in Table 4 reported improvement in neck symptoms following implementation of an exercise program, supporting the inclusion of exercise for management of chronic low-level cervical symptoms. Some, but not all of these studies included a measure of disability.

Disability was measured less frequently, however three studies did report statistically significant improvement in disability as measured with either the NDI or the Northwick Park Neck Pain Questionnaire.[29,33,34] Both Ylinen et al[33] and Falla et al[29] utilized the Neck Disability Index (NDI). Ylinen et al[33] reported initial scores in the range of 21-22 in all 3 groups, with significant improvement seen in both exercise groups post treatment with an 8-9 point drop. Falla et al[29] reported an average NDI score of 10 pre-exercise, dropping an average of 3 points in both of their exercise groups. Inclusion criteria for this study specified that the individual must have a NDI score less than or equal to 15/50, so the impact on those with higher levels of disability cannot be determined.[29] Falla et al's[29] findings are not within the minimal clinically important difference for the NDI as described below in the section detailing clinimetric properties of each measurement (p.57). Based on the literature reviewed I planned to utilized the Neck Disability Index as a measure of disability. The impact of education on disability scores had not been addressed in any of the literature reviewed to date however given the improvement in symptoms following education described in the previous section it was anticipated that improvement in disability would also be seen.

Although a number of studies suggest improvement in symptoms and function as a result of exercise for the neck region there is little indication that exercise can result in a change in posture. Of the 7 studies described in Table 4, only 2 measured posture as an outcome. Jull et al[34] found no change in forward head posture with exercise, while Falla et al[29] noted an improvement in with less forward head posture over time during sustained computer activity. Two additional studies have examined forward head posture in response to exercise as outlined in Table 5.[64,65] Pearson and Walmsley[64] in 1995 described an immediate change in head and neck posture with a single episode of cervical retraction exercises. Following 2 sets of 10 neck retraction exercises participants demonstrated a significant difference in resting head position with a decrease in forward head posture.[64] As the study was limited to just one measurement session it is not known if this change is maintained over time. Harman and colleagues[65] designed a randomized controlled trial in 2005 to examine the effects of exercise on forward head posture. Using pain-free adults 20 - 50 years of age with forward head posture, measurements were obtained in standing using a camera with computerized digital assessment of markers placed on the tragus of the ear and C7 spinous process (craniovertebral angle). Significant changes in neck angle were observed in both the exercise and the control group, with greater improvement in the exercise group. The authors attributed the improvement in controls to an increased awareness in posture due to their participation in the study.[65] An issue with the Harman study was a 27% attrition rate, the majority of those being in the experimental group. Although these studies suggest that posture can be modified via exercise, both Harman[65] and Pearson and Walmsley[64] utilized asymptomatic individuals and the changes seen in posture in the Harman[65] study cannot be attributed to the exercise alone given the changes seen in the control group. The Harman study results suggest that attention to posture (as may occur following education) can result in a measurable change. Three of the four studies relating posture and exercise are suggestive of improvement in posture with exercise.[29,34,64,65] My study was designed to determine if changes in head and neck posture could be observed in symptomatic individuals, using an exercise program for the deep cervical flexor muscles which incorporated cervical retraction as utilized by Pearson and Walmsley.[64]

The studies on exercise presented in Tables 4 and 5 varied considerably in the type of exercise utilized. Studies comparing different types of exercise such as endurance versus strengthening consistently found improvement in pain and/or disability in all groups without benefit of one type over another. [29,33,63,65] Anderson et al[41] did report a difference between types of exercise in a comparison of strengthening versus general fitness, however the exercise program for the fitness group involved only the lower extremities (stationary bike). This suggests that the type of exercise may not be important in reducing neck pain and disability however it needs to be specific to the neck/shoulder region. Some studies utilized equipment such as free weights, machines and/or bands for resistance,[33,41,63] while others focused on exercises which activated postural muscles and did not require additional equipment.[29,34,64] All 4 of the studies which examined improvement in posture with exercise utilized some form of cervical retraction, or activation of the deep cervical flexor musculature as a component of the program.[29,34,64,65] My study was designed to incorporate exercises thought to facilitate activation of the deep cervical muscles, without the need for additional equipment.

The studies also varied with respect to frequency and duration of the exercise program.[14,29,33,34,41,62-65] Some utilized 45-60 minute sessions[14,33,63] while others demonstrated improvement with 10-20 minute sessions.[29,34,41] Duration of exercise programs ranged from 6 weeks[29,34] to a year[33], with the majority in the 8-12 week range.[14,41,63,65] Ylinen et al[33] with the longest time frame of 1 year reported in a follow-up study that the majority of change occurred within the first 12 weeks, with minimal change or maintenance over the remainder of the year.[62] A study with the shortest time frame of 6 weeks of exercise demonstrated that the treatment effect was maintained up to 1 year via follow-up measurements.[34] An 8 week exercise period was selected for my study, consistent with the majority of other studies reviewed. Based on Pearson and Walmsley's[64] finding of a change in posture with a brief exercise episode, I selected 3 short episodes of exercise throughout the day. Acceptance of an exercise program by employers and employees is more likely to occur with a shorter time requirement. Assessment of the effects of education and exercise on neck pain, disability, posture, and muscle function was designed to answer the third research question posed in this study. The first and second research questions involved looking at the methodology utilized in studies on posture by examining the impact of standardized versus preferred positioning and the effect of time on sitting posture.

Standardized Positions in Postural Research

Research studies on cervical posture typically require subjects to assume a posture that is standardized in relation to the position of the legs and pelvis in an attempt to minimize variation. If a standardized position is not described there may be a standard workstation which is used when taking measurements on each subject in a laboratory setting. Several studies have assessed cervical posture in standing as opposed to the seated posture utilized while working.[27,30,39] These methods of looking at posture may not adequately reflect postures assumed by individuals at their own workstations. A few studies have been done in the field (at an individual's own work site), however with small size samples. [31,37] Szeto et al[31] in 2002 videotaped 16 subjects at their own workstations in a study assessing cervical and shoulder posture in symptomatic and asymptomatic office workers. Subjects were measured in a standardized posture with arms in their lap and back against the back of the chair; however this was for comparison purposed to their preferred working postures throughout the remainder of the day. Over the work day, 10 video segments of 10 seconds each, taken 1-2 hours apart, were analyzed to determine working posture. Results found a trend for more forward head posture in the symptomatic individuals (13% greater mean working posture and 16% greater mean reference posture in the case individuals compared to controls), however, these differences were not statistically significant, possibly due to low power. In a comparison between the initial standardized posture and the preferred working posture it was found that there was a greater forward head position in the working posture which was statistically significant.[31] This difference in posture between the standardized and preferred positions was an incidental finding in this study and not highlighted or discussed in detail by the authors as it was not identified as a purpose of the study; however, does support my contention that postures measured in standardized positions do not adequately represent postures used while working. Street's study[37] described previously (p.40) did examine individuals at their own workstation using their preferred posture and assessed a change following an ergonomics training program. Improved posture was identified using a postural risk index scoring system; however, there was not adequate measurement of subject symptoms in this study.[37]

In assessing posture, in sitting over time, Falla and colleagues[29] in 2007 utilized a larger subject pool of 68 subjects. A standardized posture of feet flat, knees at 90 degrees of flexion and the spine in thoracic kyphosis and lumbar lordosis was used when comparing the craniovertebral angle in symptomatic and asymptomatic individuals. Falla et al[29] sought to observe differences in posture over time and did identify significant changes; however, this prescribed position is likely not one utilized by individuals when working. Grob et al[39] in 2007 had an even larger sample of 102 subjects, and utilized a standardized head tilt with a

20 degree angle between the tragus of the ear and corner of the eye when assessing cervical posture. The purpose of their study was to determine if there was a correlation between cervical pain and lordosis of the cervical spine. By prescribing a specific head and neck posture for the radiographs on which their measurement were taken the authors ensured that there would be no differences in the measurements obtained.[39] These standing or standardized sitting postures likely do not reflect the postures assumed by individuals in the workplace. A relationship between posture and neck symptoms, or lack thereof should not be determined based on these studies if they are not representative of typical work postures. My study aimed to examine cervical posture in a standardized and preferred position to determine if differences exist that would suggest a change in methodology of postural assessment in future studies. In addition I sought to explore differences in posture over time (a typical 8 hour workday) to determine if significant changes would occur in individuals with sub-clinical neck symptoms.

Change in Posture over Time

Studies of posture typically measure posture at one point in time; only a few studies were identified that have examined change in posture over a period of time.[29,31,66] Szeto et al[31] in 2002 evaluated the effect of time working on postural change in office workers by periodic sampling of posture over a workday. A sample of 16 subjects was analyzed, with 8 having reports of pain over 2/10 compared to a control group of 8 with pain complaints equal to or under 2/10. A series of 5 measurements at least one hour apart were compared using analysis of variance. The authors found no significant difference in posture over time. Power was low, with a power calculation of 0.274 for the change in craniovertebral angle over time. A study by some of the same authors in 2005 utilized a similar subject pool with larger number of participants (21 with neck symptoms and 17 without).[66] Each subject was monitored at a standardized workstation for one hour while working at a computer, and 3 dimensional motion analyses was utilized to gather data. Findings included increased head on neck positioning in the case group as compared to the controls, though again failing to reach statistical significance. The motion analysis system utilized in by Szeto et al in 2005 resulted in a measure of cervical flexion[66], as opposed to the craniovertebral angle (forward head position) utilized by Szeto et al in 2002.[31]

Falla et al[29] in 2007 compared cervical posture in a group of 58 females with a mean age of 38 who had chronic neck symptoms to a group of 10 asymptomatic individuals. All subjects performed computer activity for 10 minutes, and lateral photography was utilized to assess the forward head posture using the craniovertebral angle. Subjects with neck symptoms were found to have a significant increase in forward head position over the 10 minute time period while those without symptoms had no significant change. The authors theorized this difference was due to reduced ability of the deep cervical flexor muscles to maintain posture over time. The study by Falla et al[29] utilized a standardized posture as noted above, which may have impacted results. In addition the 10 minute time frame does not provide indication of changes which might occur over an entire workday.[29]

Time constraints both on the part of the researchers and the subjects impact the ability to obtain information related to change in posture over time. To obtain valid measures of postures utilized while working the researcher must take measurements at the worksite, a technique which is logistically more difficult and time consuming and allows for more variability and less control of the physical set up. Employers may be unwilling to have disruption of work time, making it more difficult to obtain the data necessary to examine postural changes over time. Videotaping or lateral photography has been the method of choice in those studies[29,31] with videotaping allowing for capture of a longer time period, however resulting in larger amounts of data to be analyzed. I planned to utilize videotape assessment on a sub-group of the population in my study, in an attempt to explore the factor of change in posture over time.

Measurement Tools and Techniques

Job Satisfaction

Job satisfaction is a factor which has been identified as a risk factor for neck pain.[3] As such it needs to be considered as a potential confounding factor in any study of spinal symptoms and work tasks or postures. A global job satisfaction rating was studied by Scarpello and Campbell[67] in 1983, and was found to be a valid and reliable tool as compared to other more detailed measures of job satisfaction. Twenty separate facets of work were examined using the Minnesota Satisfaction Questionnaire and 21 facets of work were examined in an oral interview, with correlation coefficients provided for each facet. The overall correlation between the 3 tools ranged from 0.32 – 0.62. The authors noted that a measure of the whole is more complex and complete than scales involving specific details of various aspects of job satisfaction. This global job satisfaction rating asks the question "How satisfied are you with your job in general?", and responses are scored on a 5 point Likert scale ranging from 1 (very dissatisfied) to 5 (very satisfied). Use of global ratings has been supported in recent physical therapy literature as a quick and simple method of assessment which allows individuals the ability to consider factors important to them.[68] I planned to obtain a measure of job satisfaction (Appendix C) from all subjects for post primary analysis to explore possible impact on study results.

Video Display Terminal Workstation Checklist

Use of computer workstations has been identified as a risk factor for the development of neck pain, and it has been theorized that postures assumed while working at the computer result in this increased risk.[7-9] The Occupational Safety and Health Administration (OSHA) has put forth recommendations for computer workstations designed to assist in the development of safe and comfortable work settings in the form of a Video Display Terminal Workstation Checklist (Appendix A). This is a 2 page list of items to be assessed at a computer worksite. It is not considered to be a standard or guideline that is required, but rather a resource for those interested in creating safe and healthy worksites. It includes items related to desk and chair dimensions, monitor and keyboard positioning.[44] I planned to utilize this list with all subjects at intake with recommendations for modification for all identified concerns, to ensure that all subjects entering the study were utilizing workstations that would meet minimal ergonomic recommendations. This tool does not have reliability and validity testing reported, however of 16 different ergonomic assessment tools for work related musculoskeletal dysfunction reviewed in a 2008 publication it is the only observational tool specific to the physical computer station set up for office work.[69]

Visual Analog Scale

The Visual Analog Scale (VAS) is a self-report scale utilized to assess intensity of symptoms (Appendix E). It is an interval level scale which utilizes a 10 centimeter line on which an individual makes a mark indicating a level of pain intensity. This scale has been utilized in medical literature for over 30 years. It has test-retest reliability ranging from 0.71 – 0.99 and convergent validity with other pain indicators including the McGill Pain Questionnaire and the numeric pain scale (0.30 – 0.95).[50]

Neck Disability Index

The Neck Disability Index (NDI) (Appendix B) is a self-report outcome tool utilized for individuals with neck pain to identify baseline status and change over time in relation to pain, function and disability.[20] This tool first published in 1991 was developed by Vernon,[42] modeled after the Oswestry Disability Index for the low back. It has been utilized frequently in physical therapy literature, and is a recommended outcome tool in neck pain clinical practice guidelines from the Orthopaedic Section of the American Physical Therapy Association.[20]

Stratford et al[70] reported on the clinimetric properties of the NDI, noting a minimal detectible change (MDC) and minimal clinically important difference (MCID) of 5 points on the 50 point scale. Their findings were similar to Westaway et al[71] from 2 years prior. Cleland and colleagues[72] reported a level of 10 points for the MDC however this difference has been attributed to the use of a population of subjects with cervical radiculopathy as opposed to general neck pain. In a later study by several of the same authors, utilizing individuals with mechanical neck pain a higher figure was identified for MDC (9.5 points on the 50 point scale).[73] Vernon,[42] based on a review of studies on the NDI through 2008, reports a MDC of less than 2 and a MCID of 3-5 points. Variability of the MDC and MCID of a tool has been demonstrated to be dependent on an individual's baseline score.[74] Those showing higher levels of disability require more change to report meaningful improvement, and those with lower levels of disability reporting meaningful improvement with lower levels of change. Wang, Hart, Stratford and Mioduski[74] concluded that a MCID is not fixed for a particular outcome tool, but rather varies according to degree of involvement. The NDI has a reported test-retest reliability of 0.89 and internal consistency of 0.80 using Cronbach's alpha.[42]

The NDI was examined in comparison to the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) on construct validity and sensitivity to change by Riddle and Stratford[43] for individuals with disorders of the cervical spine. It was determined that the NDI measured both physical and mental health factors, and that there was significant overlap between the two assessment tools. The authors concluded that use of both tools is not necessary to obtain information on functional status of individuals with cervical spine involvement.

This tool was selected for this study as it is able to detect change in function specifically related to neck symptoms. It has adequate clinimetric properties and is a quick screen which subjects can complete with relative ease.

Craniocervical Flexion Test

The Craniocervical Flexion Test (CCFT) is designed to assess function of the deep cervical flexor muscles. Use of this test is recommended by the expert panel on neck pain from the Orthopaedic Section of the American Physical Therapy Association in guidelines published in 2008.[20] It was noted this recommendation was based on moderate grade evidence following a review of the literature through 2007, which was described as a single randomized controlled trial or multiple studies of a lower level of evidence.[20]   This test is performed with a pneumatic pressure biofeedback device, The Stabilizer™ [Chattanooga Group, Hixson, TN] as shown in Figure 1. An abnormal response to this test is determined as the inability to achieve at least a 6 mmHg increase in pressure, the inability to sustain that pressure for at least 10 seconds, or substitution with superficial neck flexor, or the neck extensor muscles. Monitoring for substitution requires observation and/or palpation by the

Figure 1 - The Stabilizer^{TM}

examininer.[20] It has been reported that asymptomatic individuals achieve a mean score of 8 mmHg, while those with neck dysfunction achieve mean scores of 4 mmHg.[45] The CCFT has been well described by Jull et al[45] and the construct validity as a measure of deep cervical flexor muscles has been demonstrated, as well as reliability with ICC reported between 0.81 and 0.93. The validity of the cervical endurance test as a measure of deep cervical flexor muscle function is based on the finding of Falla et al.[46] Using electromyography with surface electrodes on the posterior oropharyngeal wall, passed through the nasopharyngeal cavity, they were able to demonstrate activity of the deep cervical flexor muscles during progressive flexion of the head on the neck in a retraction/chin tuck maneuver.[46]

Short Neck Flexor Endurance Test

The Short Neck Flexor Endurance Test has been determined to be an appropriate test of muscle function for subjects with non-specific neck pain.[47] This test was first described by Grimmer[48] in 1994 and has been utilized in numerous research studies since that time, though the name utilized varies depending on the author.[12,20,47-49] It is included as a recommended examination procedure in the clinical practice guidelines for neck pain from the Orthopaedic Section of the APTA.[20] As with the CCFT, it was recommended based on a moderate level of evidence. In 2008 deKoning et al[47] included this test in a systematic review of clinimetric properties of tests of muscle function for the neck. The authors rated the test as "recommended" based on their review.[47] Scores for this test have been reported on asymptomatic and symptomatic individuals. These scores have varied with a large range of 19 to 142 seconds.[49] Harris et al[12] reported mean scores of 39 seconds (SD 26) for asymptomatic and 24 seconds (SD 13) for individuals with neck symptoms, though details on the subjects were not reported with the exception of age (low to middle 30s). Edmondston et al[49] found higher figures in a group of symptomatic individuals with similar ages, reporting a mean of 47 seconds (SD 23). Both of these studies utilized samples of 20 subjects, and did not include scores separated by gender.[49] A larger study by Grimmer and Trott[75], using over 400 subjects in Australia, reported lower mean scores of 14 seconds (SD 5) for females, and 18 seconds (SD 5) for males. The subjects used by Grimmer and Trott[75] were described as "non-injured"; however, they did not appear to be screened for current neck symptoms.

Harris et al[12] identified an intra-rater reliability of good to excellent (ICC[3,1] .82-.91) for individuals without neck pain. Inter-rater reliability for those with neck pain was moderate to good (ICC [2,1] .67-.78) for those without neck pain and good (ICC [2,1] .67) for those with neck pain. Intra-rater reliability was not calculated for those with neck pain. The level of neck pain of the subjects involved was not indicated.[12] Intra-rater reliability in a sample of individuals with postural neck pain was found to be excellent [ICC = .93] in a more recent study by Edmondston et al,[49] and it was noted that the test was limited in the majority of cases by muscle fatigue and not increased pain levels, indicating there is little risk of aggravating symptoms with the test.

Measurement of Posture

Numerous methods of postural assessment of the head and neck have been demonstrated in the literature, some incorporating use of technology while others utilize basic measurement techniques. Technological methods have included computer assisted digitization, use of still photography and use of videography.[52,76-79] Other methods such as observation with a plumb line, goniometry, the cervical range of motion devices (CROM) and linear measurements using a ruler have also been recommended with the advantage of ease of clinical use highlighted.[27,30,53,57]

Physical therapists Braun and Amundson[76] in 1989 used computer assisted digitization of lateral photographs of the head and neck to describe quantification of head and neck posture by measurement of the angle formed between a horizontal line through the spinous process of the 7th cervical vertebrae and a line from the C7 vertebrae to the tragus of the ear (later termed the craniovertebral angle).[76] A lateral slide photograph was taken and projected onto a screen. A probe connected to a computer provided digital localization of points after being pressed over the landmarks, and the information was entered into a software program which computed the angle of head and neck position.[76] The authors reported a mean of 52 degrees (SD 6 degrees) in a pool of 20 young male subjects. Measurements were obtained following a maximum protraction, maximum retraction, then relaxation to a resting position while subjects were strapped to a chair at the pelvic and scapular regions. Although the authors concluded this method could be easily incorporated into the clinical setting it involves a significant degree of set up, cost and software and hardware needs.

During the same time period others reported more basic measurement methods. Hanten et al[57] in 1991 developed a linear measurement of forward head position and motion, using a ruler and masking tape to measure a horizontal line from a reference point behind the subject to the angle of the eye. Although more simplistic in set up and measurement tools this technique could be affected by anthropometric factors such as head and trunk size/depth or thoracic kyphosis, factors not considered by the authors. Griegle-Morris et al[30] in 1992 assessed posture with a plumb line and clinical estimates of normal, moderate and severe forward head posture. They reported adequate reliability for this method; however it involves subjectivity in the clinical estimate.[30] Harrison and colleagues[27] devised a method in 1996 with a tri-square and goniometer using the landmarks of C7, tragus of the ear and a horizontal line which Braun and Admunson[76] had reported previously. This technique accommodated for anthropometric differences in head and trunk size by measuring position of the tragus of the ear, a point distal to the acromial angle and the lateral malleolus relative to a plumb line and a fixed point on a wall.

Use of lateral photography with the craniovertebral angle measurement was reported by Raine and Twomey[52] in 1997 and has been utilized by a number of researchers.[17,29,34,80] Most of the researchers utilize the landmarks described by Braun and Admunson[76] in 1989 including the spinous process of C7, the tragus of the ear and a horizontal line, with a lower angle indicating a more forward head posture. The craniovertebral angle measurement was examined in 2008 for validity and reliability by van Niekerk et al[51] with comparison for validation using radiography as the gold standard. The researchers utilized a sample of 40 high school students sitting in relaxed, upright and slouched postures. A digital camera set 2 meters from the subject was used with reflective markers on the C7 spinous process and the tragus of the ear to measure what the researchers termed the "cervical angle" (craniovertebral angle). Five images were taken in each of the 3 postures and a radiographic image was taken for validation of the external markers to the underlying bony structures. The angle of forward head position was determined using each method. Pearson's r correlation of 0.89 was found for the comparison between lateral photography measures and radiographic measures, with a range of 0.79-0.89 for the 3 postures. Reliability measures identified an ICC = 0.98, and a standard error of measurement of 8.06 degrees. The researchers concluded that the lateral photography method is a valid and appropriate measure to use, and that a single image is sufficient for determination of posture. Although this study was performed on adolescents it should be generalizable to adults based on musculoskeletal maturity.[51]

Measurements for head and neck posture using lateral photography have been reported by several authors with varied subject pools.[17,34,51,52] The largest group, 200 subjects with headache, studied by Jull et al,[34] had craniovertebral angles in a range of 47-50 degrees. A pool of 160 asymptomatic subjects assessed by Raine and Twomey[52] had an average craniovertebral angle of 49 degrees, with no difference noted in gender. The interpretation of this measurement has been complicated by the authors measuring the complementary angle of the craniovertebral angle, formed by a line between the spinous process of C7 and a vertical line.[52] The numbers reported by Raine andTwomey[52] have been transposed to reflect the craniovertebral angle as defined in my study for consistency. Fernandez-De-Las-Penas et al[17] found a more forward head posture (lower craniovertebral angle), in a 10 subjects with headache symptoms, as compared to 10 subjects without headache, with scores of 39 degrees (SD 9) and 43 degrees (SD 9) respectively.

I planned to utilize lateral photography in my study to assess posture in the sub-group over time as it provides a valid and reliable measure of head and neck posture that can be obtained via videotaping/lateral still photography (Figure 2). For the primary purpose of this study with the entire pool of subjects a faster and more simplistic technique (the CROM device) which does not require photography was selected.

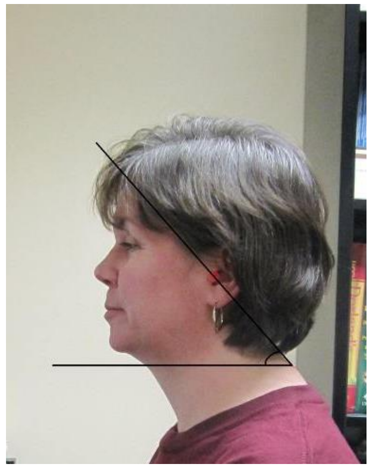


Figure 2 – Lateral photograph demonstrating landmarks for craniovertebral angle measurements

The cervical range of motion device (CROM) [Performance Attainment Associates, Lindstrom, MN] has been used in the clinical and research settings. It is most frequently used to measure range of motion, however also has the ability to measure position of the head in the sagittal plane, or forward head posture. The CROM consists of a plastic frame similar to eyeglasses to which 3 inclinometers have been affixed (Figure 3). These inclinometers are utilized for measuring flexion, extension, lateral flexion and rotation. The device also has an optional attachment for the measurement of forward head position (CROM Deluxe), which includes a horizontal bar with a centimeter ruler, and a vertical arm or locator with a bubble leveling device that is placed over the spinous process of the seventh cervical vertebra. Forward head posture can be measured relative to the C7 spinous process to the nearest 0.5 centimeter.

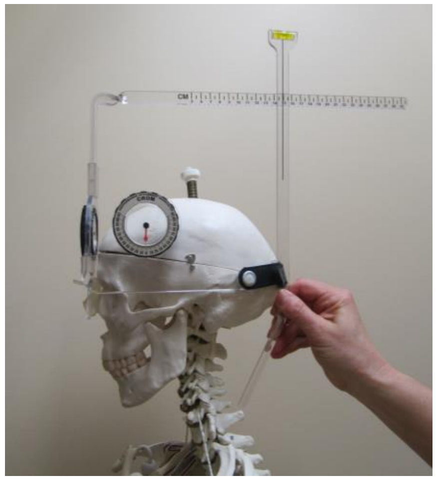


Figure 3 - CROM Deluxe device with vertebral locator and horizontal ruler

Clinimetric properties for the measurement of forward head posture have been studied on the CROM in subjects with neck pain with good reliability reported.[52] Garrett and colleagues[52] in 1993 demonstrated high intra-tester reliability (ICC = 0.93), and good reliability for inter-tester measurements (ICC = 0.83) as assessed by 7 physical therapists using 40 individuals between 24 and 77 years of age with cervical or shoulder involvement. In this sample a mean measurement of 17 cm was reported, with a range of 13.5-20.5 cm (SD 1.8) for measurements taken in a position standardized by the authors. This included feet flat on the floor, spine upright against a chair back, with the measurement taken after the subjects performed a protraction/retraction followed by relaxation to a “natural resting head position”.[53 (p158)] The authors did not discuss whether the amount of forward head posture measured was considered to be in a normal or abnormal range. No other studies providing normative values for forward head posture using the CROM have been identified. Garrett and colleagues[53] recommend the addition of millimeter increments on the horizontal arm which is marked in 0.5 cm increments by the manufacturer. This suggestion was incorporated in my study. This instrument provides a quick and reliable method of measuring forward head posture.

Summary of Current Knowledge

Neck pain is a problem in workers worldwide, particularly for those in positions involving sitting and computer use,[4] and women are more likely than men to be affected.[54] Flexed positions of the cervical spine are linked to increased risk of development of neck symptoms.[54] There are a number of individuals in the working population who experience sub-clinical neck symptoms[54] and those with symptoms have been found to have positive physical finding as well.[13] There is a strong tradition in the field of physical therapy addressing posture and postural exercise in the management of individuals with neck symptoms.[15-21,26,56] Physical therapists, working in occupational health, use postural exercises and education in proper posture when developing worksite programs for computer users. This relationship of posture, pain and disability and the impact of interventions utilized by physical therapists has not been clearly described in the literature; some argue there is no relationship,[27,28,39] however, the methodologies utilized in some of the studies are problematic.[39] In addition the standardization of positioning during assessment of posture may influence outcomes of these studies.

It has been demonstrated that postural changes can be seen with use of exercise as well as with attention to posture.[64] It has also been determined that head and neck posture in those individuals with head and neck pain is different than that assumed by individuals without neck pain,[13,17,30,31,58] and that these changes are more pronounced over time while using computer workstations.[29]

There is evidence that the use of exercise can result in positive changes in pain and disability in those with neck pain, and a variety of types of exercise can be utilized,[29,33,60,62] though aerobic exercise focused on lower body muscle activity such as a stationary bike does not have this same effect.[41] Specifically deep cervical flexor muscle strengthening can result in a decrease in pain and disability related to the neck.[29,34] The positive effects of exercise on neck pain and disability can be seen within the first 8 weeks of an exercise program and can be maintained over time.[62] There is also evidence that education can result in decreased duration, intensity and frequency of pain complaints,[36] and result in postural change.[37,38] Deep cervical flexor muscles which provide support to the cervical spine can be activated by individuals following instruction and cueing to improve posture.[38]

A variety of methods have been utilized to measure head and neck posture including technological methods and basic linear or angular measurements using tools found in most PT departments. Those techniques using technology have not been demonstrated to be superior in reliability of measurements.[77] Considerations in the measurement of head and neck posture in workers include the position utilized while taking the measurements, the type of chair utilized for measurements in sitting, and the timing of the measurements relative to the workday.

There is not clear evidence that posture can be improved via exercise and/or education or that modification of posture will result in positive effects in symptoms and disability. Standardization of positioning during assessment of posture may impact findings examining the relationship between forward head posture and neck symptoms. Time as a factor in postural assessment has been explored only minimally. One study suggests there is a change in forward head posture over time while performing computer work[29] while others have not identified a statistically significant difference.[31,66] My study was designed to explore the factors of time at task and standardized positioning versus non-standardized positioning in addition to determining the effects of education alone or education and exercise combined in the management of sub-clinical neck symptoms in computer users.

CHAPTER THREE

METHODOLOGY

Introduction to the Chapter

This chapter details the methodology utilized in this study. Implementation and results of a preliminary reliability study for 4 of the measurements utilized in the study is described. Study design is discussed along with research questions and hypotheses. Assumptions and limitations for the study are outlined. The procedures of the study are provided along with a time schedule for each step. Testing instruments are described including validity and reliability issues related to the use of these instruments. Format for reporting of results and data analysis procedures are included. Three research questions are addressed in this study including:

1. Is there a change in forward head posture of computer users (as measured by the craniovertebral angle) over an 8 hour work day when seated at a computer using preferred positioning of the worker at his/her own workstation?
2. Do computer users assume a different forward head posture when seated at their own workstation using preferred posture as compared to sitting with standardized positioning of the thoracolumbar spine and lower extremities?
3. Is the addition of 8 weeks of exercise of the deep cervical flexor muscles more effective in reducing sub-clinical neck symptoms and disability, improving cervical sitting posture, and improving cervical muscle function than postural education alone or no treatment in computer users?

Preliminary Reliability Study of Measurements

Purpose

Prior to implementation of the primary study a preliminary study was performed on four of the physical measures utilized in the study to determine the primary researcher's reliability with the physical measurements. These included the Craniocervical Flexion Test (CCFT), the Short Neck Flexor Endurance Test (SNFET), measurement of forward head position utilizing the Cervical Range of Motion (CROM) Device [Performance Attainment Associates, Lindstrom, MN], and measurement of the craniovertebral angle using lateral photography. Only the primary researcher performed measurements for the study, so inter-rater reliability was not a concern.

Methods

A convenience sample consisting of twelve individuals who fit the primary study criteria were recruited to participate in this portion of the study. A separate informed consent was developed and approved by the Gannon University and Nova Southeastern University IRB committees for this activity. These subjects were measured twice on each of the physical tests, using the methods described for the primary study, in random order to assess intra-tester reliability.

Results

The Intra-class Correlation Coefficients (ICC) for the CCFT, the SNFET, measurement of forward head position with the CROM, and the measurement of craniovertebral angle using lateral photography are listed in Table 6. ICCs ranged from 0.92 to 0.99, indicating good reliability for these measurements.

Table 6. Pilot Study Intra-rater Reliability Statistics

(n = 12)

Test	Trial I (Mean/SD)	Trial 2 (Mean/SD)	$ICC_{(3,1)}$	95% CI for ICC	SEM
Craniocervical Flexion Test	28/3 mmHg	29/3 mmHg	0.92	0.73 – 0.98	0.76 mmHg
Short Neck Flexor Endurance Test	100/56 sec	94/54 sec	0.94	0.80 – 0.99	13.2 sec
CROM Forward Head Measurement	194 mm/15mm	194 mm/15mm	0.98	0.94 – 0.99	2.1 mm
Craniovertebral Angle	38°/10°	38°/10°	0.99	0.96 – 0.99	1°

Abbreviations: $ICC_{(3,1)}$, Intra-class Correlation Coefficient, Model 3,1; CI, Confidence Interval; SEM, Standard Error of Measurement; sec, seconds; mmHg, millimeters of mercury; mm, millimeters

Study Design

The design of this study varied for the three research questions that were explored. Each question utilized subjects who fit the inclusion/exclusion criteria, however grouping of subjects differed for each question. The following paragraphs describe the groupings, anticipated numbers, variables, blinding and randomization for each of the research questions.

The first question was addressed with a smaller sub-group of the entire sample, referred to as the videotape group (VG). All subjects entered into the study were asked if they would agree to the additional time commitment of two 15 minute videotaping sessions at the start and end of a single workday. The videotaping was performed prior to the baseline measurements for question 3, and prior to the measurements for question 2. For the first 27 subjects who agreed the craniovertebral angle was measured via still lateral photography from each videotape session. The independent variable was time of day, and the dependent variable was change in posture measured via the craniovertebral angle, creating ratio level data. Subjects could not be blinded to the videotaping; however the examiner measuring the still photographs was blinded to the timing of the measurement (beginning or end of the workday). Thirty percent (n = 27) of the originally planned number of subjects (n = 90) participated in videotaping for a quasi-experimental repeated measures design.

For the second question, determination of cervical posture in preferred versus standardized sitting positions, every subject was assessed in the 2 sitting positions during baseline measurements, prior to randomization into the 3 groups for question 3. The independent variable was sitting position (standardized/preferred); the dependent variable was the measurement of forward head position using the CROM. This measurement tool was utilized with the larger subject pool to address the second and third research questions as it is a faster and easier means of obtaining a measure of forward head position without the need for photography. The CROM produced ratio data in millimeters. Blinding could not be incorporated into these measurements; however the preferred sitting position was assessed first, to eliminate impact of the standardized position on the preferred position. All subjects entered into the study were compared for a quasi-experimental repeated measures design.

For the third question, comparing the education and exercise group (EEG), exercise only group (EOG), and control group (CG), a three group experimental pre-test post-test design over an 8 week period was utilized. Random assignment was incorporated for subjects presenting with neck symptoms into EEG, EOG, or CG, resulting in 17 control subjects, 19 in the Education and

Exercise group, and 23 in the Education Only group. The independent variable was the type of intervention. The dependent variables included:

1.) pain using the visual analog scale (VAS) measured in millimeters,
2.) disability using the Neck Disability Index (NDI), measured on a 0-50 point scale,
3.) forward head posture using the Cervical Range of Motion Device (CROM), measured in millimeters,
4.) muscle function assessed via the CCFT measured in millimeters of mercury (ranging from 20-30 in increments of 2), and
5.) muscle function assessed via the SNFET measured in seconds.

Blinding of subjects was not possible; however the examiner taking measurements was blinded to group assignment. Possible confounding variables were assessed including job satisfaction, age, hours of computer work/day, length of time on the job, and duration and pattern of neck symptoms.

Population and Sample

Population

The target population for this study included adults ages 18-65, who utilize a computer workstation for at least 4 hours of their workday, and who have sub-clinical neck symptoms. Sub-clinical neck symptoms include symptoms of discomfort, pain, stiffness, and/or tenderness in the region of the body between the superior nuchal line of the skull and the spine of the scapula posteriorly, and the superior border of the clavicle and suprasternal notch anteriorly. Consistent with the definition put forth by The Bone and Joint 2000-2010 Task Force on Neck Pain for mechanical, soft tissue or non-specific neck pain, this definition excludes pain in this region attributed to serious local pathology or systemic disease.[5] It includes that level of symptoms referred to by the Task Force as "non-interfering" indicating that the individual has not sought health care for their complaints, or "interfering" neck pain where the response of the individual has been no care or self-care. These symptoms can be detected through survey.[5] An intake survey form was developed for this study (Appendix F) utilizing the terminology recommended by the task force. Based on previous research it is estimated that 46% of computer users will have neck symptoms and 39% of those will be sub-clinical symptoms. As a result it was anticipated that around 18% of computer users would fit the criteria for this study.

Sample

The sample for this study was a sample of convenience drawn from businesses within the Erie, Pennsylvania region that agreed to allow the researcher to recruit volunteer subjects, and allowed the subjects to be examined and potentially provided with educational training, or educational training and exercise instruction during work hours. Businesses included higher education, insurance, accountant and medical offices, surveyors, media, governmental agencies, community, and religious agencies. A goal of 90 subjects was utilized. This would allow a sub-group of 27 (30%) to address the first research question, all 90 subjects to address the second research question, and 30 subjects per group to address the third research question (comparing the EEG, EOG, and CG). For a moderate effect size of 0.3 and an alpha level of .05 the sample size of 90, with 3 groups of 30 would have resulted in a power level of .75.

Inclusion Criteria

a. Work includes at least 4 hours/day of computer use

b No treatment from a health care provider (medical or osteopathic physician, nurse practitioner, physician assistant, physical therapist, or chiropractor) related to neck symptoms over the past year

c. Eighteen to sixty-five years of age

d. Self-report of one or more episodes of neck pain within the past 3 months

Exclusion Criteria

a. History of neck surgery or traumatic injury to the neck requiring medical treatment

b. History of fibromyalgia, rheumatoid arthritis, or other neuromuscular disorders

Subject Recruitment

Potential worksites for subject recruiting were contacted via letter (Appendix G), phone call or email beginning with the human resources department, or office manager. The purpose and procedures of the study were presented, and permission sought to recruit subjects from the employees of the worksites. Letters of intent to participate (Appendix H) were obtained from Gannon University, Logistics Inc., Zurn Industries, Hamot Hospital, and the law firm Knox, McLaughlin, Gornall & Sennett, collectively employing 2,700 individuals who utilized a computer workstation at least 4 hours per day. A recruitment flyer (Appendix I) was provided to each employer who agreed to allow employees to participate in the study.

Group Assignment

Videotaping (for those subjects who agreed to be part of the 30% sub-group) occurred prior to baseline measurements and group assignment/intervention to avoid influence of these activities on the videotaped activities. Measurements of cervical posture in preferred and standardized positions (to address the second research question) occurred prior to the exercise/education interventions to avoid influence of group assignment on this portion of the study. Following videotaping (for those subjects who agreed to be part of the 30% sub-group) and baseline measurements the subjects were randomly assigned to one of three groups; education and exercise group (EEG), education only group (EOG), or control group (CG) by a research assistant. Co-workers in close proximity were assigned to the same group to avoid contamination between groups, and gender was monitored in an attempt to have equal proportions within each group.

Subject Protection

The Institutional Review Boards of Nova Southeastern University and Gannon University approved the study proposal. All subjects signed an informed consent prior to their participation in the study (Appendix J). Forms utilized in the study were coded so no individual names appear on the forms. Only one copy of the names and linked codes was developed. During the data collection phase the list of codes and group assignment was accessed by the research assistant for group assignment. The list and the signed consents are maintained in the primary researcher's office in a locked cabinet at Gannon University. Video files are maintained on an external hard drive kept in a locked cabinet in the primary researcher's office. Names linked to the codes, and the informed consent forms will be shredded 5 years after completion of the study, and all video files will be destroyed.

Community Service Benefits

The author of this study is a faculty member of Gannon University in Erie, Pennsylvania, and inherent in the mission and strategic plan of the University is the forging of relationships within the local community, and service to the community. In structuring this study subjects were provided with an assessment of their workstation utilizing recommendations from a computer workstation checklist from the Occupational Safety and Health Administration.[44] Subjects were also provided with educational programming in posture and exercise (Appendices L and M) to address sub-clinical neck symptoms. Following completion of the study participants in the CG and EOG were offered the educational and exercise instruction, and all of the subjects took advantage of this offer. This provided service to the community, and a forging of community partnerships consistent with the University mission and strategic plan.

Instrumentation

Intake Form

A form (Appendix F) generated by the researcher was utilized to collect individual information from the subject. This form was coded for names, and included age, worksite, previous history of cervical symptoms using definitions developed by the Neck Pain Task Force for duration (transitory ≤ 7 days, short duration 7 days to 3 months, long duration ≥ 3 months), and pattern of symptoms (single episode with full recovery, recurrent = 2+ with full recovery between, persistent = no periods of full recovery). Past medical history related to previous neck surgery/injury and other chronic conditions, and the subject's estimate of hours utilizing computer per workday were also included on the form.

Job Satisfaction Form

A global rating of job satisfaction was utilized with each subject as part of the intake information (Appendix C). This rating asked the question "How satisfied are you with your job in general?" and responses were scored on a 5 point Likert scale ranging from 1 (very dissatisfied) to 5 (very satisfied). This information was considered post primary analysis to explore possible impact of job satisfaction on study results.

Video Display Terminal Workstation Checklist

The Video Display Terminal Checklist (Appendix A) developed by the Occupational Safety and Health Administration (OSHA) is a 2 page list of items to be assessed at a computer worksite.[44] It is not considered to be a standard or guideline that is required, but rather a resource for those interested in creating safe and healthy worksites. It included items related to desk and chair dimensions, monitor and keyboard positioning. This list was utilized as part of the intake for all subjects, and recommendations for modification were provided to the individual subject.

Video Camera and Tripod for Measurement of Craniovertebral Angle

Two video cameras (Sony Handycam DCR-TRV380/TRV 480 Hi8, 8 millimeter cameras, with 290,000 pixel resolution) and tripods were borrowed from the Center for Excellence in Teaching and Learning, a department which provides technological equipment at Gannon University. Video taken with the cameras was converted to electronic format and saved to a hard drive and a secured network drive through which the research assistant could access the videos and obtain still photographs utilizing Windows Movie Maker [Microsoft Corporation]. These still photographs were provided to the primary researcher in a coded format so that measurements of the craniovertebral angle for morning and afternoon could be obtained in a blinded manner. Validity and reliability of lateral photography for the measurement of spinal posture, of subjects sitting at a computer workstation, were demonstrated by van Niekerk et al.[51] Validity was determined relative to a gold standard of radiography, with a Pearson's r of 0.89, and reliability scores of ICC = 0.98 were found.

Visual Analog Scale

The Visual Analog Scale (VAS) is a self-report scale utilized to assess intensity of symptoms (Appendix E). It consists of a 10 centimeter line on which an individual makes a mark indicating a level of pain intensity.[50] The line was anchored on either end by descriptors of “no pain” and “worst you experience”. The VAS has a test-retest reliability ranging from 0.71- 0.99.[50]

Neck Disability Index

The Neck Disability Index (NDI) (Appendix B) is a self-report outcome tool that is recommended for use for individuals with neck pain to identify baseline status and change over time in relation to pain, function and disability.[20] It has a reported test-retest reliability of 0.89 and internal consistency of 0.80 using Cronbach’s alpha.[42] The tool consists of 10 items, each with 6 possible answers ranked from 0 to 5 on a point scale (lower scores indicating better function), for a total of 50 possible points. Seven of the items relate to functional activities including personal care, reading, lifting, work, driving, sleeping and recreation while the remaining three items address pain intensity, headache and concentration. The scoring interpretation put forth by the originator of the tool for disability is noted below.

0-4 points = none

5-14 points = mild

15-24 points = moderate

25-34 points = severe

Greater than 34 points = complete

This scale has been modified by other researchers.[42] For my study scores of 1-14 are considered to reflect low disability. Relevant change scores for individuals with clinical levels of pain have been identified in the range of 3-9.5 depending on the patient population utilized.[42,70-72] Stratford et al[70] reported that the magnitude of an important change will vary depending on the initial level of the NDI score. For this study the lower value of the minimally important clinical difference were utilized as disability levels were anticipated to be low in the subject pool.

CROM Measurement Device

The Cervical Range of Motion (CROM) Device [Performance Attainment Associates, Lindstrom, MN] consists of a plastic frame similar to eyeglasses to which 3 inclinometers have been affixed. These inclinometers are utilized for measuring flexion, extension, lateral flexion and rotation. The device has an optional attachment for the measurement of forward head position (CROM Deluxe), which includes a horizontal bar with a bubble leveling device, and a vertical arm or locator that is placed over the spinous process of the seventh cervical vertebra as seen in Figure 4. Forward head posture can be measured relative to the C7 spinous process to the nearest 0.5 cm. It has been demonstrated to have an intra-tester reliability of 0.93 (ICC) and inter-tester reliability of 0.83 (ICC).[53] Garrett, Youdas, and Madson[53] recommend the addition of millimeter increments on the horizontal arm which is marked in 0.5 cm increments by the manufacturer. This suggestion was incorporated into the present study. Intra-rater reliability was calculated following repeated measures on forward head posture using the CROM with 12 pilot subjects, demonstrating an ICC of 0.98 for the examiner in this present study.

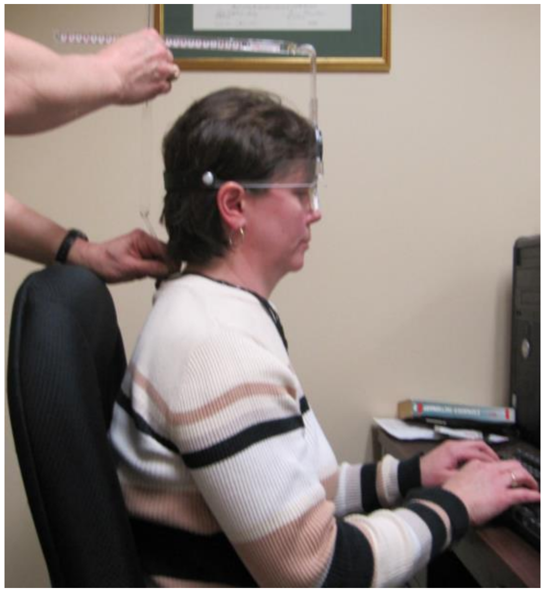


Figure 4 - Measurement of posture using the CROM Deluxe

The Stabilizer (For Craniocervical Flexion Test)

The Stabilizer™ (Chattanooga Group, Hixson, TN) is a pneumatic pressure biofeedback device utilized for the CCFT. The unit includes a bladder attached by tubing to a pressure gauge with an analog scale ranging from 0-200 mmHg in increments of 2. It can be utilized for a variety of body parts to monitor muscle activation and resultant changes in pressure due to movement. The unit has been demonstrated to have construct validity, and reliability with ICC reported between 0.81 and 0.93.[45] Calibration of the unit is not described by the manufacturer in the operating instructions, however if the unit is out of calibration this would be apparent on the pressure gauge where the needle should be at 0. Use of The Stabilizer™ has been described by Jull et al[45] for assessment of the deep cervical flexor muscles. The subject lies supine on a plinth without a pillow, and the device is placed behind the neck and inflated to 20 mmHg as shown in Figure 5. As the test is performed readings are taken from the force gauge in the range of 20-30 mmHg. The test is scored at the highest level the individual can achieve and hold for three 10 second holds while maintaining the pressure and without substitution.[45]

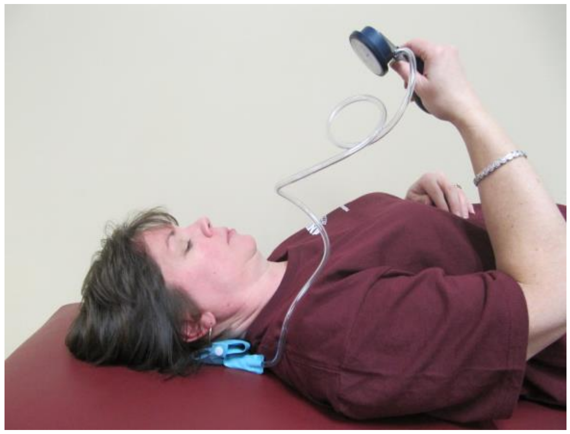


Figure 5 - Craniocervical Flexion Test

Stopwatch

A digital stopwatch was utilized to record time for the Short Neck Flexor Endurance Test to the nearest tenth of a second.

2.5 cm Measurement Device

A stack of 8.5X11 paper measured to a thickness of 2.5 centimeters was used to maintain the subjects head at least 2.5 cm from the table during the Short Neck Flexor Endurance Test by the examiner ensuring free movement under the head during testing (Figure 6). The subject was also asked to monitor and avoid any sensation of the paper stack touching their head during the testing. The Short Neck Flexor Endurance Test has been demonstrated to have inter-rater reliability of 0.67 – 0.78,[12] and intra-rater reliability of 0.93.[49]

Figure 6. Short Neck Flexor Endurance Test using 2.5 cm paper stack to ensure proper head position

Procedures

Study Implementation

Subjects were entered into the study on a rolling basis from January to December of 2012. Each subject was followed for a 9 week period which included the optional videotape sessions for question 1, baseline measurements for questions 2 and 3, group assignment, intervention and follow-up measurements for question 3. The timing and flow for the study is indicated in Figure 7. Once recruited, potential subjects were scheduled a date and time to meet with the primary researcher to review, read and sign the informed consent (Appendix J) at their worksite. At this time an intake form (Appendix F), which included age, previous history of cervical symptoms using definitions developed by the Neck Pain Task Force for duration, pattern of symptoms, past medical history related to previous neck surgery/injury and other chronic conditions, and the subject's estimation of hours utilizing a computer per workday, was completed by the subject. A global measure of job satisfaction (Appendix C) was also completed.

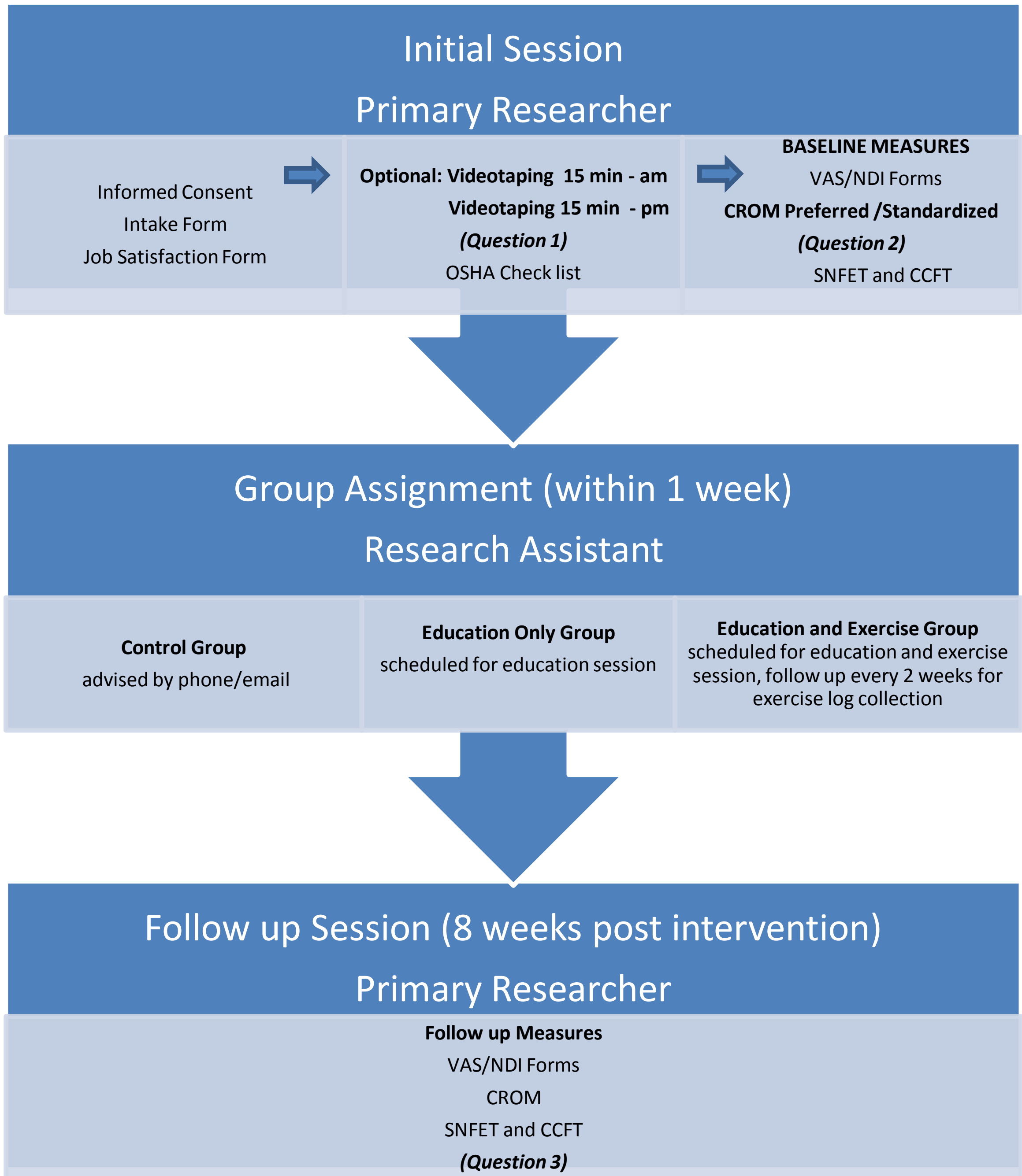


Figure 7. Flow chart of study implementation

The videotaping aspect of the study to address the first research question related to change in posture over time was implemented first for those subjects who were agreeable to this portion of the study. This was done to avoid possible influence of the education and exercise interventions on this aspect of the study. Subjects were scheduled so that those who were willing could be videotaped at their own workstation during the first hour of their workday, with the remainder of the baseline measurements occurring after the pm videotape session. The primary researcher placed an adhesive dot marker on the spinous process of C7 and the tragus of the ear. The camera was located with the lens 5 feet from the subject at a right angle at the height of the C7 marker. The camera was positioned perpendicular to the ground and parallel to the plane in which the subject was facing. Subjects were videotaped for a 15 minute period during the first hour and last hour of their workday, with the camera unattended during this time period to minimize testing impact. They were asked to perform their normal work activities at the computer during the taping, and to avoid leaving their desk if possible. The 15 minute segment was reviewed by the research assistant to obtain a lateral view still photograph for measurement of the forward head posture using a still photograph taken during the middle 5 minute segment, representing the subject's typical posture, with the least amount of out of plane movement in a manner similar to Szeto et al.[31] The still photographs were assessed for measurement of the craniovertebral angle by the primary research with blinding as to whether the photo is the first or last photo to avoid biasing the measurement. A change score was calculated for each subject with a positive score indicating a more forward head position and a negative score indicating a decrease in the forward head position over time.

The OSHA Video Display Terminal (VDT) Workstation Checklist form (Appendix A) was utilized to assess the workstations of subjects from an ergonomic perspective.[44] Employees with identified concerns were educated on recommended changes. Many of these employees required education in proper adjustment of their existing equipment, and adjustments were made if needed. This ensured that all subjects were working from an appropriate physical set-up of their workstations before implantation of the proposed intervention. Employers were offered a report of findings following completion of the study.

Baseline Measurements

Prior to initiation of the intervention phase of the study all subjects were tested for baseline measurements on the VAS (Appendix E) and NDI (Appendix B), and the measurements of cervical posture via the CROM device to address the second purpose of comparison of standardized positioning versus preferred positioning (Figure 8) at their individual workstation. These measurements of cervical posture in standardized and preferred positions were taken by the primary researcher.

The baseline measurements of pain/discomfort on the VAS were obtained for the past 24 hours and highest level over the previous week. The subject then completed the NDI. Baseline measurements of resting head position using the CROM Deluxe device were taken first in the subject's preferred position in their office chair (Figure 4).

Figure 8. Preferred and standardized postures in an office chair

The 7th cervical spinous process was palpated for placement of the foot of the vertebra locator using palpation of C6/C7 region with cervical extension to determine the spinous process which translates anteriorly as C6 and that which does not as C7. The bubble gauge on the locator was used to maintain the locator in a vertical position, and the subject's head was aligned so that the sagittal plane meter was positioned at 0 degrees. The subjects were encouraged to assume their preferred position at their workstation with their hands in position on their keyboard, and a level forward gaze. A measurement was taken of the resting head position which represents the horizontal distance from the bridge of the nose to the C7 spinous process. The examiner then asked the subject to assume a standardized position in their chair with the sacrum against the back of the chair, spine erect with a lumbar lordosis, feet flat on the floor with hips and knees in 90 degrees of flexion, and hands on the keyboard. Adjustments in seat height and back support were made as needed to achieve this position. A second measurement of forward head position was taken of resting head position with a level forward gaze using the standardized sitting position (Appendix D). The difference between these 2 measurements was calculated as a change score.

Baseline measure of the Short Neck Flexor Endurance Test was taken using the technique described by Harris et al.[12] The test is performed in supine without use of a pillow. The head is lifted by the patient 2.5 centimeters from the plinth while maintaining retraction of the head with use of verbal commands "tuck your chin" and "hold your head up". In a modification of Grimmer's[48] original technique the therapist held a stack of 8.5 X 11 inch paper in a stack 2.5 cm thick beneath the subject's occiput to monitor the head position. The subjects were instructed that they should not feel their head resting on the paper stack and the examiner should be able to freely move the paper stack during the test (Figure 6). The time from the start of the test until the individual was no longer able to maintain test position (head drops or chin thrusts) with verbal cues was measured in seconds using a digital stop watch.[49]

Baseline measure of the CCFT were performed using the technique described by Jull et al using The Stabilizer™ (Chattanooga Group, Chattanooga, TN).[45] Implementation of the test is pictured in Figure 5. It was performed with the subject supine on a plinth without a pillow. The face and neck were in the horizontal plane, towel rolls were utilized behind the occiput to achieve this position when necessary. The Stabilizer™ was placed behind the neck and inflated to 20 mmHg, a level which fills the space behind the neck but does not push the neck into lordosis. The subject was instructed to nod the head without lifting the occiput from the table, as if indicating "yes" by activation of the deep cervical flexor muscles, and permitted to practice this movement until they understood the relationship between the output on the gauge and their action. This movement was then performed in 5 increments with the goal of generating 22, 24, 26, 28, and 30 mmHg on the force gauge with a 10 second hold at each level and a return to the start position between each stage, with a 10 second rest. The highest level attained was repeated for a total of 3 sets of 10 seconds. If the subject was unable to perform 3 sets of 10 seconds at that level the next lower level was tested at 3 sets of 10 seconds. The examiner palpated and observed the neck during testing to ensure proper technique, looking for a visible increase in head on neck rotation and no substitution by the superficial neck muscles (sternocleidomastoid and anterior scalene). Additionally the individual being tested was instructed to keep the tongue on the roof of the mouth, lips together but teeth apart to avoid substitution by the platysma and hyoid muscles. The test was scored at the highest level the individual could achieve and hold for three 10 second holds while maintaining the pressure and without substitution.[45]

A rest period of at least 2 minutes was provided between to the two cervical muscle tests to minimize effects of fatigue. A portable treatment plinth was used either in the subject's work area or in a nearby conference/work-room for both of the muscle tests.

Intervention

Each subject in the EEG and EOG was scheduled for a one-on-one session by a research assistant who provided the exercise (Appendix K) and education instruction (Appendix L). The primary researcher performing baseline and follow-up measurements was blinded to group assignment. These sessions occurred at each worksite during regular work hours.

Exercise/education (EEG) – each group member was instructed in a daily exercise program for the deep cervical flexor muscles (3-5 minutes 3/day) to be performed over an 8-week period (Appendix K). Instruction in the exercise program was provided in a 10-minute session of individual instruction, review of written instructions, and demonstration by the subject with correction in technique as necessary. The education program included 10-15 minutes of individual instruction in the same manner as that received by the EOG as outlined in Appendix L. Written exercise logs were provided and collected every 2 weeks during the study by the research assistant to encourage compliance.

Education Only (EOG) – included 10-15 minutes of individual instruction with each subject in proper posture with verbal and tactile cues, and the provision of a visual reminder (card with the word “Posture”) posted by their computer screen. An outline of the educational programming is provided in Appendix L.

Control (CG) – group received no further intervention following baseline measurements.

Follow-up Measurements

Follow up measurements were taken on each subject after 8 weeks including, the Short Neck Flexor Endurance Test, CCFT, and resting head posture using the CROM device. Subjects completed the VAS for the past 24 hours and over the previous week as well as the NDI questionnaire. Measurements were taken during work hours at the subject's worksite within a 2 hour window of the original time of day that the baseline measurements were obtained if possible. These measurements were performed by the primary researcher, blinded to the intervention grouping. When scheduling the appointment for the follow-up measurements subjects were asked to remove the "Posture" reminder card and any logs which would indicate their grouping from their desk area so the researcher could remain blinded to group assignment.

Data Analysis

Data Screening

Data was visually screened for missing items, and spot checked for accuracy against data intake forms prior to analysis. Two missing items were identified, and the original data sheets were reviewed. When the missing items were not found mean values were utilized in their place.

Descriptive Statistics

Descriptive statistics were utilized to provide an overview of the sample characteristics of subjects for each of the research questions including gender, age, estimated hours per day utilizing a computer, and years performing computer work. Percentiles were calculated for gender. Mean, standard deviation and range were reported for the ratio data, and presented in table format. Medians and interquartile ranges were used to describe ordinal data. VDT Workstation Checklists were reviewed to ensure that all subjects had acceptable scores.

For the first research question, addressing change in head and neck posture over an 8 hour work day, the means, standard deviations, and ranges of craniovertebral angle were reported in narrative format. For the second research question, addressing change in head and neck posture in preferred versus standardized position, mean scores of CROM measurements were calculated with standard deviation and range. The mean change scores and 95% confidence intervals were calculated.

For the third research question age, average hours utilizing a computer per day, and years of computer work were shown in table format for the total pool and for the EEG, EOG, and CG. Percentages were utilized to describe gender, job satisfaction, and symptom duration/symptom pattern (Axis IV and Axis V from the Task Force on Neck Pain classification scheme) in table format. Percentages were also utilized to describe exercise compliance in the EEG, presented in narrative format. Percentages were calculated for Job Satisfaction scores of 1 or 2 (dissatisfied and very dissatisfied) in each group. Baseline and post intervention median scores with interquartile range were calculated for the dependent variables of VAS and NDI. Means were utilized for the dependent variables of forward head posture (FHP), CCFT, and SNFET, including range and standard deviations.

Inferential Statistics

Wilcoxon Signed Rank Test for related samples was utilized to test the measurement data of forward head posture for the first hypotheses comparing 2 measurements of paired data with a small *n* (27). A paired t-test was used to analyze data for the second research question comparing forward head position in preferred and standardized postures, with an *n* of 66. The 5 measures utilized to answer the third research question included pre and post scores on the VAS (numeric scores in millimeters 0-100), pre and post scores on the NDI (numeric score on 0-50 scale), numeric scores in millimeters of forward head posture (positive scores indicating increased FHP and negative scores indicating a decrease in FHP), pre and post scores on the Craniocervical Flexion Test (mmHg ranging from 20 to 30 in increments of 2), and pre and post scores on the Short Neck Flexor Endurance Test (in seconds). The VAS and NDI were treated as ordinal data; remaining variables were interval/ratio data. The Kruskal-Wallis was utilized to compare the three groups on demographic data including age, hours using a computer per day, and years of computer use, presented in table format. Chi square was used to determine if there were significant group differences at baseline in gender, symptom episode and symptom duration. Kruskal-Wallis tests were utilized to compare the EEG, EOG and CG on dependent variables of VAS and NDI medians at baseline to determine if differences were present pre-intervention. The Kruskal-Wallis tests were also used to compare groups at baseline and post-intervention on FHP, CCFT and SNFET, and to compare gain scores on each of the 5 variables. Post hoc pairwise comparisons using Dunn's procedure with a Bonferroni adjustment were performed for between group gain scores differences reaching significance.

The alpha level was set at 0.05 for all analyses. SPSS 20.0 software (SPSS Inc., Chicago, IL) was utilized for statistical analysis.

Summary

In summary, this chapter outlined the methods utilized to examine the effect of education and 8 weeks of exercise for deep cervical flexor muscles on sub-clinical neck symptoms, disability, posture and muscle function as compared to education only, and no intervention in office workers who utilize computers. Methods to examine forward head posture in standardized and preferred positions of the lower body (spine and lower extremities), and to examine change in forward head posture of computer users over an 8 hour work day were also described. A preliminary reliability study for measurements utilized in the study was also described.

CHAPTER FOUR

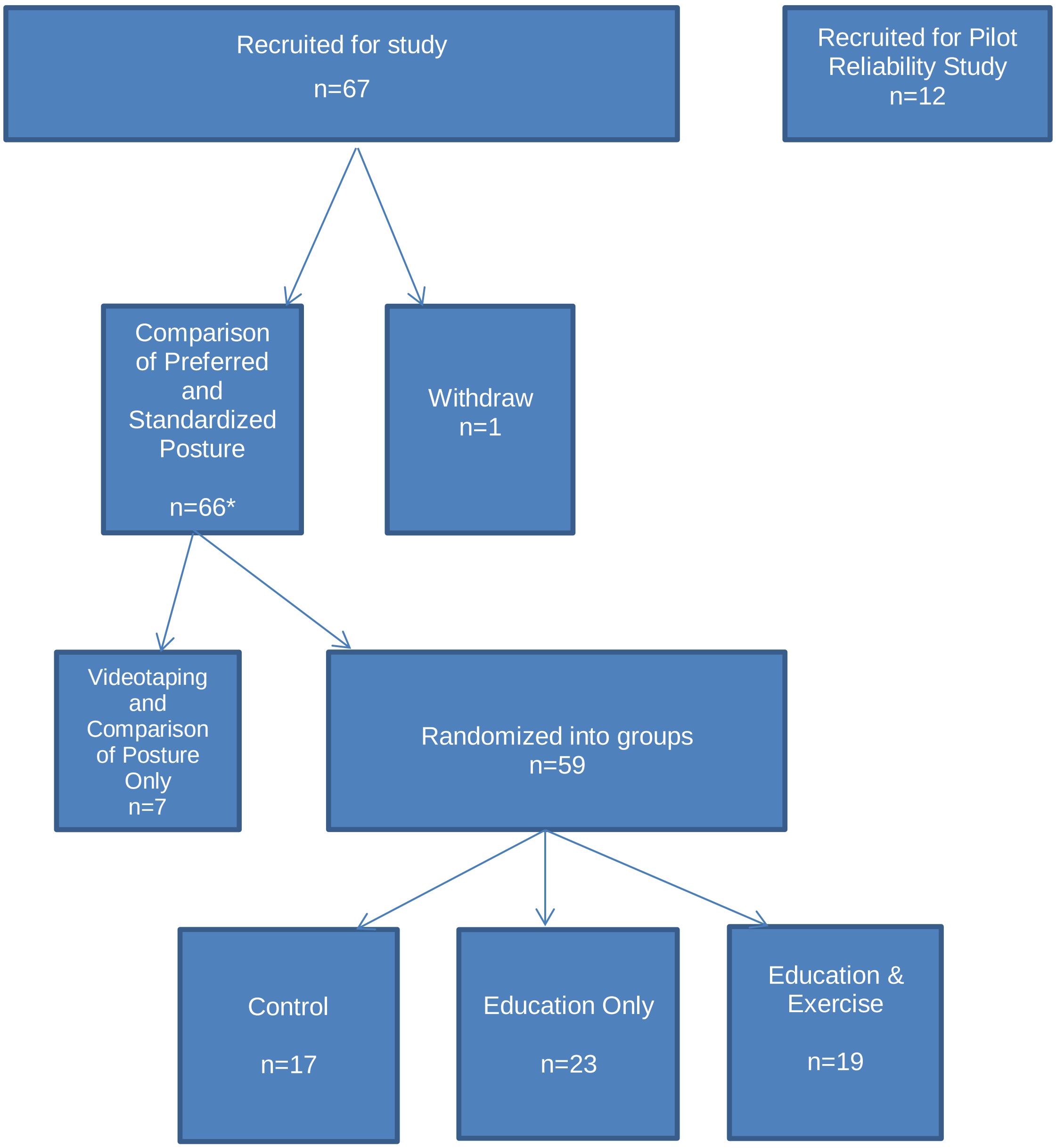
RESULTS

Introduction to the Chapter

This chapter provides an overview of the analysis of the data collected. Participants obtained will be described for the three research questions. An overview of the ergonomic assessment of workstations is provided. Results will be divided into sections corresponding with the three research questions proposed in Chapter One. For each research question descriptive statistics will be presented for the subjects involved, followed by the inferential statistical analysis. A summary at the end of this chapter will highlight important results of the study.

Participants

Sixty-seven subjects were recruited, with 51% of them coming from the same employer (Gannon University), and a range of 1 to 4 subjects from each of the remaining 14 companies and institutions. One subject withdrew after intake testing due to a flare of neck symptoms, leaving 66 participants. Seven of the subjects had been recruited a second time after participating in the preliminary reliability study and were utilized for the videotaping and comparison of posture portions of the study. This resulted in a pool of 27 for the videotaping sub-group comparison of postural change over an 8 hour workday (question 1), 66 for the comparison of standardized and preferred posture (question 2), and 59 subjects for the primary study (question 3). Subject numbers are detailed in a study flow chart (Figure 9).



* includes 27 subject sub-group utilized for videotaping

Figure 9. Study flow chart

Ergonomic Workstation Reviews

The principle investigator performed ergonomic workstation reviews utilizing the Occupational Safety and Health Administration (OSHA) Video Display Terminal Workstation Checklist form (Appendix A) during the initial session. Forty-eight percent of the workstations were found to have concerns, however, all but one of these were correctable to an acceptable level by modifying the monitor height or position, repositioning the mouse and/or keyboard, or modifying the height of the chair. One subject had a workstation outside acceptable guidelines, with a chair that was not adjustable, and too low for the desk. Through consultation with the employer the chair was replaced to meet acceptable guidelines. Other recommendations included obtaining wrist rests or phone rests, moving materials from under desks to provide leg room, or closing blinds to avoid glare on the monitor screen. As all subject workstations were able to meet acceptable OSHA guidelines it was determined that physical set up of the workstations would not influence between group study results.

Comparison of Change in Posture over a Workday

Twenty-seven subjects were utilized for this portion of the study as planned. Twenty subjects were participants in the primary study who had agreed to the additional videotape sessions. Seven additional subjects were recruited from the pool of pilot study subjects to meet the anticipated number. Twenty-two of these subjects were female (81%). Characteristics of this group are detailed in Table 7. Data was analyzed on all subjects. The mean craniovertebral angle for the start of the workday was 33.93° ± 6.59° (range 23-50), and for the end of the workday was 35.74° ± 8.02° (range 20-53), with a mean difference of –1.82° (95% CI = -4.52, .89). Wilcoxon Signed Rank Test for related samples revealed no significant difference between the morning and afternoon measurements ($p = .210$), therefore the null hypothesis is not rejected. With the sample of 27, an alpha level of .05, and the small effect size the power obtained was .13.

Table 7. Characteristics of Subjects Used to Compare Craniovertebral Angle Over the Workday (n=27)

Characteristics	
Age (years)	48.10 ± 8.80 (32-61)
Sex (men/women)	5/22
Average Hours of Computer Use/Day	6.00 ± 1.50 (4-10)
Years Performing Computer Work	16.20 ± 9.00 (3-40)

Data are reported as mean ± Standard Deviation (range) for continuous variables and counts for dichotomous variables

Comparison of Preferred and Standardized Posture

Sixty-six of the 67 subjects were utilized for this portion of the study. One subject withdrew following intake measurements due to a flare of neck symptoms which resolved after 1 week. Seventy-six percent of subjects utilized for this aspect were female. Additional characteristics are shown in Table 8. Data screening identified 2 subjects with missing values, addressed by substituting mean values.

Preferred neck position during assessment resulted in greater forward head posture of 200.23 ± 14.73 mm with a range of 160-225 mm. The standardized position resulted in a head posture of 192.64 ± 13.76 mm with a range of 149-219 mm. The mean difference was 7.59 mm (95% CI = 6.27 – 8.92). A two tailed paired *t*-test demonstrated significance $t(65)=11.44$, $p<.001$, therefore the null hypothesis was rejected. There is a significant difference in head posture between the 2 testing conditions, with preferred neck position resulting in a more forward head posture. The effect size of r=.82, resulted in a power of .99.

Table 8. Characteristics of Subjects Used to Compare Preferred and Standardized Posture (n = 66)

Characteristic	
Age (years)	49.60 ± 9.00 (27-67)
Sex (men/women)	16/50
Average Hours of Computer Use/Day	6.50 ± 1.80 (4-12)
Years Performing Computer Work	16.60 ± 9.20 (2-40)

Data are reported as mean ± Standard Deviation (range) for continuous variables and counts for dichotomous variables

Comparison of Education Only, Education and Exercise and Control Group

Subject Characteristics

Fifty-nine subjects completed the primary portion of the study addressing the third research question, with 17 assigned to the Control Group (CG), 23 to Education Only (EOG), and 19 in Education and Exercise (EEG). Two subjects had incomplete data, addressed by substituting mean values. Subject characteristics are shown in Table 9.

Table 9. Group Demographics

Variable	All Subjects (n=59)	Control (n=17)	Education Only (n-23)	Education and Exercise (n=19)	P
Age (years)	49.60 ± 9.40 (27-67)	49.50 ± 9.90 (32-65)	50.80 ± 8.80 (34-67)	48.30 ± 10.00 (27-61)	.802[a]
Avg. Computer Use/day (hours)	6.60 ± 1.80 (4-12)	6.38 ± 1.96 (4-10)	6.96 ± 1.99 (4-12)	6.32 ± 1.51 (4-9)	.542[a]
Years of Computer Work	16.60 ± 9.50 (2-40)	17.53 ± 9.31 (7-40)	16.17 ± 10.54 (2-36)	16.37 ± 8.69 (3-30)	.830[a]
Not Satisfied		5.9%	13%	10.50%	N/A
Female	74.58%	76.50%	65.20%	84.20%	.363[b]
Symptom Episodes					.838[b]
Constant	44%	47%	47%	41%	
2 or More	47%	41%	42%	53%	
1 or less	9%	11%	11%	6%	
Symptom Duration					.876[b]
> 3 months	34%	35%	42%	29%	
7 days to 3 mo	15%	12%	16%	18%	
< 7 days	51%	53%	42%	53%	

Scores are presented as mean ± SD (range) for interval data; a=Kruskal-Wallis; b= Chi Square
SD = Standard Deviation, Avg = Average, > = greater than, < = less than, mo = months

Group Characteristics

Groups were compared with the Kruskal-Wallis for demographic information including age, years working at a computer-use desk job, and hours using a computer per day. No significant differences were identified between groups at intake as detailed in Table 9. Additionally job satisfaction and symptom characteristics were compared between groups. Three of the 59 subjects were dissatisfied with their job (5.1%), two in the EEG and one in the EOG. Five subjects reported neutral (8.5%) and the remainder satisfied or very satisfied. Based on the low percentage of subjects reporting that they were not satisfied with their job (6-13% per group) this factor was not explored further in data analysis. Symptom characteristics were also explored for each group, and no significant differences were evident. Most individuals had either constant symptoms (44.1%) or at least 2 episodes of neck symptoms in the prior 3 months (47.5%), while less than 9% had only 1 episode. The most common response was that episodes lasted less than 7 days, though between 26 and 35% in each group reported ongoing or chronic symptoms.

Baseline Measurements of Dependent Variables by Group

Dependent variables for the research question comparing the EOG, EEG and CG included pain measured with the Visual Analog Scale (VAS) in millimeters, disability measured with the Neck Disability Index (NDI), forward head posture (FHP) as measured with the CROM Device [Performance Attainment Associates, Lindstrom, MN] in millimeters, and muscle function. Muscle function was assessed using two methods, the Craniocervical Flexion

Test (CCFT) as a measure of deep cervical muscle activation, utilizing The Stabilizer™ [Chattanooga Group, Hixson, TN], and the Short Neck Flexor Endurance Test (SNFET) as a measure of overall neck musculature endurance. The CCFT is measured in millimeters of mercury, ranging from 20-30 in increments of 2, and the SNFET is measured in seconds.

A comparison of baseline measurements between the three groups is detailed in Table 10. No significant differences were noted between groups for each of the dependent variables at baseline.

Table 10. Baseline Dependent Measurements by Group

Variable	Control (n = 17)	Education Only (n=23)	Education and Exercise (n=19)	P Value
VAS (mm)	20.00 (5.50 – 29.00)	29.00 (8.00 – 54.00)	23.00 (13.00 – 64.00)	.413[a]
NDI	7.00 (3.50 – 13.00)	8.00 (5.00 – 12.00)	6.00 (4.00 – 11.00)	.798[a]
FHP (mm)	203.53 ± 15.36 (180-225)	199.43 ± 16.26 (161-222)	196.84 ± 15.26 (160-223)	.527[b]
CCFT (mmHg)	26.94 ± 3.17 (22-30)	26.78 ± 2.61 (22-30)	26.32 ± 2.43 (22-30)	.662[b]
SNFET (sec)	78.65 ± 54.08 (12-194)	86.39 ± 110.34 (11-480)	65.16 ± 47.35 (21-171)	.603[b]

Scores are presented as mean ± SD (range) for interval data, and median (interquartile range) for ordinal data
a= Kruskal-Wallis (comparison of median); b = Kruskal-Wallis Test (comparison of distribution)
SD = standard deviation, VAS = Visual analog scale, NDI = Neck Disability Index, FHP = Forward head posture, CCFT = Craniocervical Flexion Test, SNFET = Short Neck Flexor Endurance Test; mm = millimeters, mmHg = millimeters of mercury, sec = seconds

Exercise Compliance

Participants in the EEG were asked to complete logs to track their compliance with the exercise program. Of the 19 subjects in this group 17 completed the logs. Over half (53%) indicated that they completed at least 50% of the requested exercise sessions (120 sessions over 8 weeks), and an additional 21% indicated they completed at least 25% of the requested sessions. About one quarter of the group (26%) reported performing less than 25% of the exercise session, some noting illness, vacation time, meetings, or not being at their desk as reasons why they did not complete the exercises. Four individuals (21%) indicated performing the exercises on weekends as well as workdays, exceeding the requested number of exercise sessions.

Comparison of Post-intervention Dependent Variables by Group

Eight weeks following the intervention of education or education and exercise follow-up measurements were obtained on the 5 dependent variables from the intervention and control group participants. Results are presented by group in Table 11 including medians and interquartile ranges for the Visual Analog Scale and Neck Disability Index scores, and means, standard deviation and ranges for the remaining interval data. All three groups demonstrated lower post-intervention scores on the VAS and NDI. The control group had a decrease from 20 to 11 mm (45%), the EOG from 29 to 13 (55%), and the EEG from 23 to 9 mm (61%) in median pain score on the VAS. On the NDI the median score for the CG decreased from 7 to 5 (28.6%), the EOG from 8 to 7 (12.5%) and the EEG from 6 to 2 (66.67%). For forward head posture the CG had an increased mean forward head position of 0.23 mm, the EOG an increase of 2.48 mm, and the EEG had a decrease of 3.58 mm, indicating less of a forward head position. Scores for muscle function improved in all 3 groups by 2 mm of mercury on the Craniocervical Flexion Test, while the CG and EOG showed decreases in mean time for the Short Neck Flexor Endurance Test of 13 and 6 seconds respectively while the EEG demonstrated an improved mean by 12 seconds.

Table 11. Post-intervention Dependent Measurements by Group

Variable	Control (n = 17)	Education Only (n=23)	Education and Exercise (n=19)	P Value*
VAS (mm)	11.00 (4.50-18.50)	13.00 (2.00-33.00)	9.00 (.00-30.00)	.574
NDI	5.00 (3.00-9.00)	7.00 (4.00-8.00)	2.00 (1.00-4.00)	.012
FHP (mm)	203.76 ± 15.07 (177-226)	201.91 ± 17.62 (160-222)	193.26 ± 14.67 (165-217)	.100
CCFT (mmHg)	28.47 ± 2.60 (22-30)	28.70 ± 2.23 (24-30)	28.74 ± 2.23 (22-30)	.980
SNFET (sec)	66.00 ± 40.05 (12-158)	80.52 ± 128.16 (12-582)	76.89 ± 60.52 (26-256)	.140

*Scores are presented as mean ± SD (range) for interval data, and median (interquartile range) for ordinal data. *=Kruskal-Wallis (comparison of distribution), SD = standard deviation, VAS = Visual analog scale, NDI = Neck Disability Index, FHP = Forward head posture, CCFT = Craniocervical Flexion Test, SNFET = Short Neck Flexor Endurance Test; mm = millimeters, mmHg = millimeters of mercury, sec = seconds*

A Kruskal Wallis test was performed comparing the post-intervention dependent measure scores to determine if there were differences between the CG, EOG and EEG. The distribution of scores was not similar for all groups as assessed by visual inspection of box plots. Significance was demonstrated for the NDI; the remaining variables did not reach significance. The mean ranks of the NDI scores were statistically significantly different between groups, $X^2(2) = 8.783$, p=.012. Pairwise comparisons were made using Dunn's procedure with a Bonferroni correction for multiple comparisons. Adjusted p values are reported. Post hoc analysis demonstrated statistically significant differences in NDI scores between the EEG (20.45) and the CG (34.47), p=.042, and between the EEG and the EOG (34.59), p=.023.

Gain scores were calculated for the 5 dependent variables by group, and this data was screened for normality using the Kolmogorov-Smirnov test, and for homogeneity of variance using Levene's test. The Kolmogorov-Smirnov test for normality demonstrated non-significance for the 5 variables with the exceptions of the EO group for the SNFET, D(23) = .22, $p < .01$, and the CG for the CCFT, D(17) = .25, $p < .01$. Levene's test based on the median for VAS and NDI demonstrated equal variance, $F(2,56) = .98 – 1.27$, $p > .05$. Levene's test for the posture, CCFT, and SNFET based on the mean demonstrated equal variance, $F(2,56) = .13-.87$, $p > .05$.

A Kruskal-Wallis test was performed on the gain scores for each of the five dependent variables to determine if there were differences between the CG, EOG and EEG. Significance was demonstrated for the SNFET; the remaining variables did not reach significance as indicated in Table 12. Distributions of scores on the SNFET were not similar for all three groups as determined by visual inspection of boxplots, shown in Figure 10. The mean ranks of the SNFET gain scores were statistically significantly different between groups, $X^2(2) = 6.526$, p=.038.

Table 12. Dependent Measure Median Gain Scores by Group

	Control (n=17)	Education Only (n = 23)	Education and Exercise (n = 19)	P Value*
VAS (mm)	-7.00	-17.00	-13.00	.548
NDI	-1.00	-2.00	-4.00	.100
FHP (mm)	1.00	2.00	-4.00	.203
CCFT (mmHg)	2.00	2.00	2.00	.543
SNFET (sec)	-2.00	-6.00	8.00	.038

* *Kruskal-Wallis (comparison of distribution). VAS = Visual analog scale, NDI = Neck Disability Index, FHP = Forward head posture, CCFT = Craniocervical Flexion Test, SNFET = Short Neck Flexor Endurance Test;*

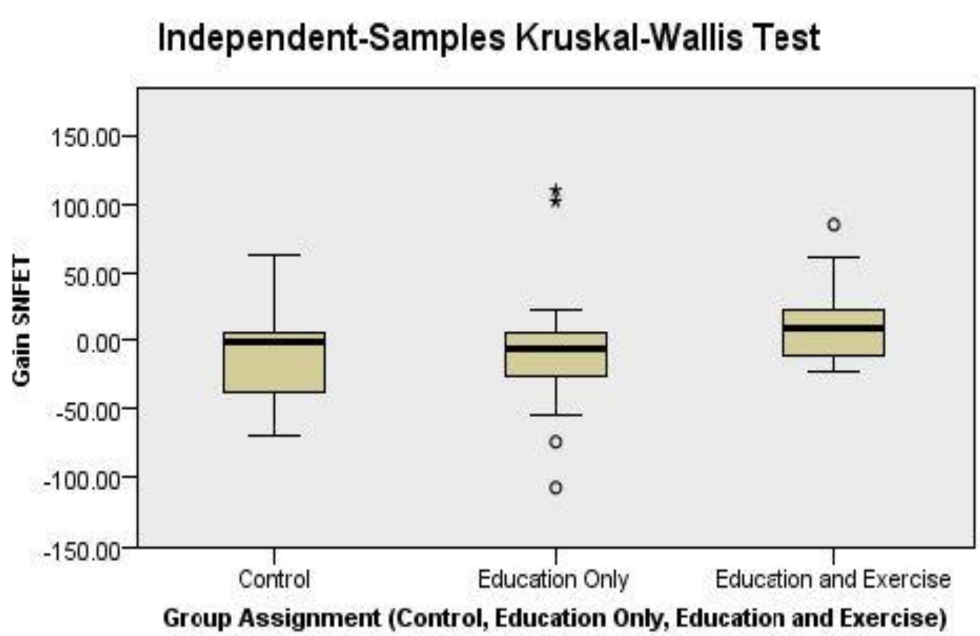


Figure 10. Box plots for group comparison of gain of the Short Neck Flexor Endurance Test

Post hoc testing in SPSS of pairwise comparisons using Dunn's procedure with a Bonferroni adjustment for multiple comparisons found no statistically significant differences in the SNFET scores between the three groups. The average ranks were lowest for the CG (25.24), slightly higher for the EOG (26.72), and highest for the EEG (38.24). Average rank differences, significance values, and adjusted significance values are detailed in Table 13 for the SNFET.

Table 13. Pairwise Comparisons between Groups for Short Neck Flexor Endurance Test

Comparison	Average Rank Difference (Test Statistic)	Significance	Adjusted Significance
Control – Education Only	-1.482	.787	1.000
Control – Education and Exercise	-13.002	.023	.070
Education Only – Education and Exercise	-11.519	.030	.091

Summary

This study encompassed volunteer subjects recruited from 16 different employers in the Erie, Pennsylvania area following contact with 48 employers, and additional recruiting from 2 health fairs. Subjects reported using a computer workstation on average over 16 years, with an estimate of at least 6 hours/day. Over three-quarters of the subjects were female (76%). The subjects presented with sub-clinical level neck symptoms which had been present in a range of less than a week to more than 3 months. Some reported only 1-2 episodes of these symptoms, while others reported ongoing symptoms. These subjects were not seeking medical care for their low level symptoms, self-reported using the VAS and the NDI. Almost half of the subjects were found to have workstation set-up concerns which were easily modifiable with changes in monitor, keyboard and chair positions. Job satisfaction was high with over 75% of subjects reporting being satisfied with their job, and less than 6% dissatisfied, so this factor was not considered to impact study results. Compliance with the exercise program was good with at least 74% of subjects reporting they completed at least ¼ of the planned exercise sessions, and 53% reporting completing at least ½ of the sessions. Preliminary testing demonstrated good reliability of the measurements utilized in the study.

Forward head posture was not found to change over an 8 hour work day in a sub-group of 27 subjects, in contrast to the expected finding for the first research question. Differences in forward head posture between preferred and standardized posture were found to be significant, supporting the second research question. Analysis for the third and primary research question found all three groups demonstrated improvement in median scores for pain and disability, with the EEG showing more improvement than the EOG and CG. The EEG had improved mean scores on the 3 additional dependent measures of forward head posture, cervical flexor muscle activation, and endurance. The CG and EOG had mean scores that were slightly worse for forward head posture and cervical flexor muscle endurance, and slight improvement on cervical flexor muscle activation. The Short Neck Flexor Endurance Test was found to have the largest variability between subjects with range from 11 seconds to 582 seconds. This measure identified 4 subjects with scores exceeding 200 seconds. Non-parametric testing found significance for 1 of the 5 dependent variable gain scores (SNFET) however post hoc pairwise comparisons failed to show statistical significance between the individual groups. Post intervention group NDI scores were significantly different in the EEG compared to the EOG and the CG. The research hypothesis related to group differences in gain scores between exercise only, exercise and education and control groups was not supported.

CHAPTER FIVE

DISCUSSION

Introduction to the Chapter

Our society's use of technology continues to expand, and computer use by office workers is increasing. Given the identified increase in risk of neck pain by office workers[4] particularly those utilizing computers[7] there is a need to manage this risk. Physical therapists consulting in occupational health settings and in the clinical setting utilize education and exercise interventions with a focus on improving neck posture, however the literature to date has not clearly linked changes in posture to changes in neck symptoms or function. The primary aim of this study was to determine the effectiveness of eight weeks of specific postural exercises and education, compared to education alone, and a control group (no intervention) in reducing symptoms of pain and disability, modifying neck posture, and improving neck muscle performance. Secondary aims were to determine differences in neck posture when measured using preferred and standardized positioning of the lower spine and lower extremities, and to explore possible changes in neck posture over an 8 hour workday.

This chapter will examine the current study findings in relation to research studies utilized in the development of the study. Subject characteristics will be discussed relative to the classification system put forth by the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders.[5] This will enable results to be interpreted using standardized terminology for comparison to other research, and for framing of additional research questions.

The results of the workstations assessments will be reviewed as this provides a snapshot of the current status of a typical office setting from an ergonomic perspective. The three research questions will be discussed relative to the results presented in Chapter Four, and alternative explanations will be considered. Strengths and weaknesses of the study as implemented will be reviewed. Limitations and delimitations will be examined, and implications for clinical practice put forth, along with suggestions for future research based on study results and challenges experienced.

Subject Characteristics

The subject pool in this study was 67% female, and over 90% of all subjects reported persistent or recurrent symptoms. This percentage of females was consistent with Cagnie et al's[54] findings specific to office workers of a 2 to 1 ratio of female office workers to males reporting neck pain in a cross-sectional study of risk factors for neck pain. In an overview of the course and prognosis of neck pain in workers Carroll et al[2] reported that females were more likely than males to have neck pain and in the majority of cases symptoms were persistent or recurrent. Cagnie et al[54] did not provide an explanation for the gender difference, however Carroll et al[2] noted that this pattern is seen in most types of body pain, with women reporting more symptoms than men.

The mean age of subjects in this study was 49.6 years (SD 9.40), with a range of 27-67 years. This is consistent with Cagnie et al's[54] findings that those between the ages of 40-49 had the highest likelihood of reporting neck pain, and that those over 30 years of age had a 2.61 greater chance of having neck pain as compared with those younger than 30. Côte' et al[3] looking at the burden of neck pain reported that incidence of neck pain increased with age, peaking in the 30-50 year age range, consistent with this current study's findings.

Subjects reported spending an average of 6.50 ± 1.80 hours with a range of 4-12 hours per day performing computer work. This is similar to the sample utilized by Grant et al[9] in their study of computer users in 1995. They had sought individuals who utilized a computer workstation for at least 4 hours/day as in the current study. They had excluded individuals with prior treatment for neck or arm pain/trauma, however they found that 80% of their subjects reported some degree of upper quarter symptoms for which they had not sought treatment, similar to the "sub-clinical" individuals recruited for this current study. Over 50% of their subject pool reported neck pain or headache symptoms.[9]

Subject selection for the current study was described in terms of the classification system of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. This classification system, described in greater detail on pages 22-23 includes the following five axes:

Axis I – Source of Subjects/Data

Axis II – Setting/Sampling Frame

Axis III – Severity of Symptoms

Axis IV – Duration of Symptoms

Axis V – Pattern of Symptoms

The first 3 Axes were pre-determined by the study design to be Axis I, Via Survey; Axis II, Employed Individuals; Axis III, Low Pain/Low Disability. The average pain score on the Visual Analog Scale (VAS) was 24 mm (range = 38 mm), and the average score on the Neck Disability Index (NDI) was 7 (range = 8). The level of pain and disability in the current study is consistent with the Task Force Grade I, which is described as a level that is not suggestive of major structural pathology, and no, or minor interference with activities of daily living.[5]

Prior studies on individuals with sub-clinical neck symptoms vary in methods of measuring pain and disability, and in some cases lack measurement of these factors. Lee et al[10] one of the first groups to discuss and study low level neck pain found that 35% of a group of "normal, healthy adults", with a mean age of 28 (19-42) reported recurrent neck symptoms. Subjects in that study, while not specifically identified as "office workers", were obtained from a university setting, similar to many subjects in the current study. Although they identified impairment differences between subjects with sub-clinical symptoms and those without, Lee et al[10] did not report a measure of symptom intensity or disability. Falla et al[29] had a subject pool with slightly higher levels of pain (VAS average 41 mm) and disability (NDI average 9.9/50) as compared to the findings of this current study. This was likely a result of their inclusion criteria which sought individuals with objective cervical dysfunction in addition to reported pain/disability. Szeto et al[31] reported discomfort scores of 4.2 ± 1.8 on a 10 point numeric scale in their symptomatic group of office workers. The higher pain level for their symptomatic group as compared to the current study was likely due to their classification system which placed those with 1/10 pain levels in the asymptomatic group. Szeto et al[31] did not include a measure of disability. Johnston et al[13] used a group of office workers divided into groups with and without neck pain, but did not measure/quantify the level of pain. They did quantify disability using the NDI, reporting scores of 8.3/50, similar to the level identified in the current study.[13] A larger randomized control trial of exercise to manage chronic neck symptoms in 180 female office workers in Finland sought individuals with "constantly or frequently occurring neck pain for more than 6 months". [(33 p. 2510)] That study reported average pain on the VAS at 58 mm, with average NDI scores of 11/50. Those levels are slightly higher than those utilized in the current study, likely a result of recruitment occurring through physician recommendation from occupational health facilities. Subjects in the current study were found to have sub-clinical or low level pain and disability that were similar to other studies of computer users.

On Axis IV Duration of Symptoms, the highest number (50%) of subjects in the current study reported transitory symptoms of 7 days or less, with 32% reporting long duration symptoms of more than 3 months. For Axis V Pattern of Symptoms 6% of subjects described their neck symptoms occurring as a single episode, over 90% described recurrent or persistent symptoms. This recurrent pattern was identified as the most common in publications of the Neck Pain Task Force.[2,5] Ylinen et al[33] and Lee et al[10] also identified recurrent low level symptoms in their subject pools. Their findings, consistent with findings of the current study suggest that many individuals in the workforce experience sub-clinical neck pain on an ongoing basis.

In describing symptoms about the neck area the current study did not specifically address headache symptoms, though a number of other studies focus on cervicogenic headaches with neck pain.[17,32,34,58,59] The NDI does incorporate a question related to headache, indirectly including this, however answers to individual questions on the NDI were not analyzed in this current study. Neck symptoms were self-reported in the current study via the VAS and NDI, while other studies incorporated physical examination techniques to determine presence of a musculoskeletal dysfunction, or specific pathologic condition.[7,17,29]

The participants in the current study represent adult office workers who utilize computer workstations on a routine basis, and experience sub-clinical symptoms of pain and disability. These individuals do not seek healthcare for treatment for their low level symptoms. Grant et al[9] theorized that economic concerns and employment status may limit their complaints, or that perhaps individuals expect to experience musculoskeletal aches and pains with work, and consider them to be a normal response. These workers could benefit from occupational health physical therapy services.

Workstation Ergonomic Assessment

Each subject in the current study received a review of their workstation prior to study measurements to ensure that all workstations met the basic ergonomic standards recommended by the Occupational Safety and Health Administration (OSHA) of the United States. A checklist for computer workstations was utilized by the primary researcher to assess each work area.[44] Of the 67 workstations reviewed 48% had concerns, of which all but 2% involved simple adjustments of positions for monitors, keyboards, and chairs. Adjustments were related to participants' lack of knowledge or attention to appropriate set up. This is consistent with the findings of Gerr et al[24] who identified a lack of attention to monitor height in a field study of 379 office computer workstations, and suggested that this may be related to neck disorders. Bringing all workstations into compliance with basic ergonomic recommendations for the current study enabled physical ergonomic factors to be eliminated as a potential cause of differences between groups. The workstation ergonomic adjustments may account for the small improvements found in the Control Group (CG) in pain and disability and a portion of the improvements noted in the Education Only Group (EOG) and Education and Exercise Group (EEG). The lack of knowledge or attention to workstation set up supports the continued need for education as an intervention by physical therapists when providing services for computer users.

Comparison of Change in Posture over a Workday

The comparison of neck posture as measured by the craniovertebral angle using lateral photography obtained from video found no difference over an 8 hour workday. The mean craviovertebral angle was 33.93° ± 6.59° (range 23-50°) in the morning, and 35.74° ± 8.02° (range 20-53°) at the end of the workday. This reflects a slightly less forward head mean in the afternoon as compared to morning. Based on the definition presented in Chapter 1 of forward head posture (FHP) considered a craniovertebral angle less than 40˚ all but three of the subjects used in this study had a measurement consistent with FHP. One subject had a.m. measurement, and 7 different subjects had p.m. measurements equal to or greater than 40˚, however each of these subjects had at least one measurement low enough to meet the criteria for forward head posture (FHP).

This portion of the study was exploratory with a small portion of the subject pool (30%) used to examine potential change in posture over time. As a result of the small pool and variability of the measurement the power was low, estimated to be .13, resulting in the strong possibility of a Type II error. A number of challenges were seen with this aspect of the study, including use of a single lateral photograph as a reflection of posture, and the disruption to work flow created by the measurement process. Although a significant difference in head and neck posture over the workday was not identified in this portion of the study the findings of craniovertebral angle in contrast to other studies are interesting as they demonstrate significantly more forward head positioning in this sample than reported by others.

Lateral photography has been utilized in a number of past studies[17,29,34,52] but only one of these examined changes in posture over time.[29] Falla et al[29] examined 5 lateral photographs taken every 2 minutes to assess change in posture during 10 minutes of computer use. Fernandez-de-las-Penas et al[17] found a significant difference in FHP in standing but not sitting, which they attributed to their small sample size of 2 groups of 10. Jull et al[34] reported no change in posture when providing manipulation and exercise in the management of patients with cervicogenic headache following 7 weeks of treatment. Raine and Twomey's[52] study was descriptive, documenting postural measurements in asymptomatic individuals.

Others used digitized measurements from video clips as opposed to a single photograph measurement. Szeto[31] in 2002 digitized two 10 second video clips over 5 trials throughout a single workday of workers at their computer. Their findings were similar to the current study, identifying a change in posture relative to a relaxed sitting posture, however no significant change in posture over a single workday. Three years later several of the same researchers used motion analysis video capture to assess head and neck posture in female computer users with and without neck symptoms.[66] A Vicon 370 motion analysis system was utilized, and 5 sessions of 60 seconds each were analyzed over a 1 hour time frame. Those measurements were taken at a single workstation, not at the individual's workstation, in an attempt to minimize any differences due to ergonomic differences in set-up. Data was not reported as a craniovertebral angle, and it was not clear how the angular measurements were defined. Findings did not reach statistical significance, however the authors argued that that the 4° differences found between symptomatic and asymptomatic individuals might be clinically significant. They further divided their symptomatic group into a Low Discomfort and High Discomfort group based on results of the modified

Standardized Nordic Questionnaire, finding greater differences (8˚) of neck flexion with greater flexion (more forward head posture) in the High Discomfort group.[66]

Falla et al[29] reported a 4.4° increase in forward head posture over a 10 minute time period of sustained computer work in individuals with low level neck pain, as compared to 2.2° in those without, which they attributed to decreased endurance of the cervical postural muscles. Absolute scores were not reported. Falla et al[29] suggested that, in light of the results of their study and the study by Szeto et al,[31] these small changes in working posture over time may be important in the development of neck pain in computer users.

Of nine studies which reported craniovertebral angles[17,27,29,31,34,51,52,58,76] eight provided mean or median scores of their data. Those scores are presented in Table 14 with the findings of the current study, and notations of methodology. Falla et al[29] provided change scores instead of absolute values, therefore is not included in this table. Although the research hypothesis of an increase in forward head posture over an 8 hour workday was not supported in the current study, it is interesting to note the differences between the craniovertebral measurements obtained from these office workers with sub-clinical neck symptoms and those reported in other studies. Measurement of forward head posture in the current study are most similar to those reported by Szeto et al[31] in their study of office workers with measurements taken at the workers own station via video. Office workers in both the Falla and Szeto[31] studies demonstrate a more pronounced

Table 14. Mean Scores of Craniovertebral Angle

Authors/Year	Subjects	Reported values	Notes
Braun, Amundson[76] 1989	20 asymptomatic	51.97° ± 5.77°	Comfortable sitting, standardized leg position, thorax and pelvis strapped to chair. Lateral photograph
Watson, Trott[58] 1993	30 headache/upper cervical pain 30 asymptomatic	44.5° ± 5.5° 49.1° ± 2.9°	Seated, measured after performing "self-balancing" flexion-extension exercises to attain "natural head posture"
Harrison[27] 1996	10 neck pain patients 41 asymptomatic, mix of office workers and PT students	49.4° ± 4.2° 49.3° ± 7.0°	Standing by a wall feet apart, comfortable position
Raine, Twomey[52] 1997	160 asymptomatic	48.9°	Converted data (supplementary angles reported). In comfortable, erect standing. Lateral photograph
Jull et al[34] 2002	200 cervicogenic Headache	47-50°	No description of position used Lateral photograph
Szeto, Straker, Raine[31] 2002	8 office workers with neck/UE symptoms 8 office workers with 1/10 or no neck/UE symptoms	30.7° 37.5°	Working posture at own workstation Lateral photo from video
Fernandez-Des-Las-Penas[17] 2007	10 tension type headache 10 asymptomatic	39° ± 8.9° 42.8° ± 8.9°	Relaxed sitting Lateral photograph
Van Niekerk et al[51] 2008	39 asymptomatic high school students	47.66° ± 9.75°	Asked to sit "normally" at a simulated computer workstation Non-adjustable chair Lateral photograph
Current study	27 office workers with sub-clinical neck symptoms	am 33.93° ± 6.59° (range 23-50°) pm 35.74° ± 8.02° (range 20-53°)	Working posture at own workstation Lateral photo from video

forward head posture than found in any of the other studies, with the exception of the subjects with tension type headache in the study by Fernandez-de-las-Penas,[17] performed in a relaxed sitting position. The measurements in the current study demonstrate more forward head positioning than all of the other studies with the exception of 1 group in the Szeto study. Potentially these similarities are due to the relaxed or normal sitting positions at a workstation measured in these studies and the current study, as opposed to the standardized or standing positions utilized in the other studies. In addition those studies demonstrating higher craniovertebral angles (less FHP) were generally those performed on asymptomatic individuals[27,51,52,58,76] while those studies reporting more FHP were performed on symptomatic individuals[17,31] similar to this current study.

Methodological Considerations

Videotaping was used in the current study in an attempt to minimize subject awareness of being measured via photograph and potentially modifying their posture. A fifteen minute videotape session was utilized, however possibly the interruption to their workday to set up the camera for the second session affected the subject's posture. Typically subjects would stand/walk when greeting the researcher, taking them away from their workstation for several minutes while the video camera and tripod were being set up. Subjects were aware of being videotaped, which may have caused an alteration in their posture. It was hoped that this would have less of an effect than the techniques used by other researchers, however may have still impacted the results.

A videotape session that lasts all day could minimize awareness of being observed by avoiding the interruption of work tasks with arrival of the researcher to set up the video camera as occurred in the present study design. Realistically, however, individuals are less likely to agree to participate in a study which would involve 8 hours of videotaping while working. Employers are less likely to be agreeable to that amount of videotaping due to potential confidential phone calls or conversations with co-workers that may occur. Eight hour video files would be extremely large, creating file maintenance issues, and videotaping equipment would be a physical hazard in some subject offices due to space limitations. All subjects in the current study were shown how to turn the camera off and back on in the event of a confidentiality issue with their work tasks, and were asked to remain at their desk if possible for the 15 minute videotape session. This was intended to created minimal disruption to their work activities. Only 20 of the 60 subjects recruited originally for the study were agreeable to the additional videotape portion of the study. To meet the anticipated number of 27 subjects 7 had to be recruited from the pilot portion of the study. Many subjects verbalized that they preferred not to be videotaped; others did not want to have the additional interruption to their workday.

Repeating a similar study with a more appropriate number of subjects, and improved methodology may demonstrate whether changes in work posture of the head and neck occur over the workday in computer users with sub-clinical neck symptoms. Advances in technology for motion analysis such as Dartfish (Dartfish USA, Inc, Alpharetta, GA) or similar software programs, could be utilized to analyze specific segments of video to obtain multiple measures of neck position over time. This could provide quantitative data of craniovertebral angles over a 5 or 10 minute segment as opposed to a single still photo. Gerr et al[24] argued that the single photo was sufficient based on a lack of significant change over 6 repeated measurements with still lateral photography in their study, however it would be interesting to see if a difference would exist, and to capture a range of positioning of the head and neck computer users maintain while working.

Comparison of Preferred and Standardized Posture

In the comparison of preferred and standardized posture the CROM device (Performance Attainment Associates, Lindstrom, MN) was utilized instead of lateral photography of craniovertebral angle as a measure of forward head posture as the measurement could be obtained more quickly and easily. The preferred neck position of 200.23 ± 14.73 mm with a range of 160-225 mm demonstrated a significantly greater FHP than the standardized position of 192.64 ± 13.76 mm, with a range of 149-219 mm. The use of the entire subject pool with paired data from each subject and low variability within the measurements resulted in a very high power of .99 for this portion of the study, and low probability of a Type II error. As noted with the question of change in posture over time the findings of FHP measurement in this sample are interesting in comparison to those from other studies.

Two other studies reported data for CROM measurements of FHP.[10,53] Lee et al[10] examined an "upright sit" to a "comfortable sit" position, measuring FHP in addition to other motion and endurance measures. Subjects were asymptomatic, 19-42 years old with a mean age of 28, recruited from a university setting including students and employees. They found CROM FHP to be 199.6 ±16.2 mm in comfortable sitting and 186.9 ± 13.4mm in the upright position. Both of these positions utilized a prescribed position of "feet flat on the floor", no mention was made of spine position. The authors did not perform statistical analysis between these 2 measurements. The preferred position of the current study and "comfortable" position of the Lee study resulted in similar measures of head and neck posture. The "upright" position of the Lee study was 5-6 mm less than the standardized position in the current study, indication a more FHP in the current group of subjects. Lee et al[10] did not report the type of work performed by the subjects, or the number of students versus employees in their subject pool, so it is difficult to determine a reason for this difference.

Garrett et al[53] in looking at the reliability of measuring FHP using the CROM reported measurements from 40 individuals with orthopaedic disorders, 30% of whom had cervical disorders. The mean age and range were similar to the current study at 50 years (24-77). Those researchers utilized a standardized position of the extremities and spine, in a metal folding chair. They found a mean score of 170 ± 18 mm with a range of 135-205 mm. In comparison the current study utilized each subject's own desk chair, adjusted to meet ergonomic guidelines, and each subject was instructed to sit at their desk in the manner they typically used when working at their computer for the preferred position measurement. As noted with the Lee study[10] the results of the current study demonstrate a more forward head posture in the standardized position as compared to Garret et al's[53] findings. Garrett et al[53] did not report on relaxed sitting posture. No indication was provided as to type of work performed by the subjects in that study. It is interesting that despite the similar age ranges the subjects in the current study demonstrated a more FHP even when the position of the lower extremities and spine were standardized. This perhaps indicates a more FHP in those with sub-clinical symptoms who perform computer work.

A comparison of results from both of the other studies providing data on FHP measured with the CROM suggest that the office workers with sub-clinical neck symptoms demonstrate a more FHP in comparison to the limited data available in symptomatic and asymptomatic individuals.[10,53] That is consistent with Szeto et al's[31] findings that individuals with neck or upper extremity pain demonstrated a more FHP as measured by the craniovertebral angle compared to those without symptoms. They reported a 4-8° difference in craniovertebral angle between subjects with and without neck symptoms, which approached but did not meet statistical significance. Similar to the current study their measurements were performed in the work setting using subject's own work stations, with measurements obtained from video analysis.

The differences of FHP identified in the current study between standardized positioning of the lower spine and extremities and the subject's preferred posture suggests that studies utilizing standardized positioning are obtaining an inaccurate measurement of head and neck posture of their subjects. Harrison et al[27] may have obtained different results in their comparison of FHP in symptomatic and asymptomatic subjects if they had utilized a preferred position as opposed to a standardized position. Other studies which found a suggestion of a relationship between neck posture and symptoms may have been able to demonstrate a stronger relationship if they had utilized preferred sitting postures.[29-32] Standardized positions are used by researchers in an attempt to improve the reproducibility of a measurement and subsequently the research study. That can impact the validity of the measurement, resulting in a measurement of the position an individual is able to achieve as opposed to the position they typically maintain.

Education Only, Education and Exercise and Control Group Comparisons

Potential Confounding Variables

Job satisfaction and ergonomic physical set up of each subject's workstation were assessed in the current study to avoid confounding variables affecting results. Neither factor was determined to have impacted the outcomes of the group comparisons. Results of the ergonomic assessments have been discussed previously. Only 5% of subjects were dissatisfied with their job, the majority were satisfied or very satisfied. The subjects in the current study did not demonstrate low job satisfaction, a factor which has been linked to increased risk of developing, or poor prognosis for recovery from neck pain.[2,3]

Baseline Measurements of Dependent Variables by Group

Baseline measurements of pain, disability, and the CROM measure of FHP were discussed previously in relation to scores for the current subjects relative to other similar studies. The two additional measures of neck muscle function assessed were the Craniocervical Flexion Test (CCFT) and the Short Neck Flexor Endurance Test (SNFET). Baseline scores for the CCFT ranged from 22-30 mmHg, with mean scores just above 26 mmHg in each group. For the SNFET baseline scores range from 11-489 seconds with mean scores of 79 seconds for the CG, 86 seconds for the EOG, and 65 seconds for the EEG. Baseline scores on all measures were not statistically significant between groups.

Based on test design scores for the CCFT can range from 20-30 mmHg in 2 mmHg increments. Normal values are reported to be 26-30 mmHg and abnormal scores 24 or below.[20,45] These abnormal scores of 24 or below have been noted to occur as a result of varied neck disorders.[45] The current study baseline scores are consistent with Fernandez de las Penas et al's[17] findings of a mean score of 25.8 ± 3.6 mmHg in a sample of 10 individuals with tension type headache. They identified a slightly higher mean score of 28.4 ±1.8 mmHg in 10 individuals without headache. Both Fernandez de las Penas et al[17] and the current study found those with head and neck symptoms to be in the low range of normal on the CCFT. Other researchers who utilized the CCFT either didn't report the scores,[13] or utilized a cut point of 24 mmHg or less as an inclusion criterion to target individuals with deep cervical flexor muscle weakness.[29]

Scores for the SNFET reported in the literature have varied. Grimmer[48] who first described the test in 1994, with a follow up in 1998 reported differences from male to female, with female scores averaging 14 (SD 5) seconds and males 18 (SD 4.9) seconds. Harris et al[12] compared asymptomatic and symptomatic individuals, combining males and females, and reported a mean of 39 (SD 26) seconds for asymptomatic and 24 (SD 13) seconds for symptomatic subjects, with a range of 7-126 seconds. Edmonston et al[49] reported the highest mean of 47 (SD 23) seconds in a group of 21 individuals with chronic neck pain (4.5/10 on VAS), with a range of 19-142 seconds. Means of the SNFET in the current study were higher, likely related to the lower pain levels in this group as compared to Edmonston. It is not clear why Grimmer's number were so much lower in both of her studies.[48,75] Perhaps her method of palpating the chin during the test resulted in earlier termination of the test by the examiner based on an earlier tactile sensation of chin thrust as compared to the visual assessment utilized by Edmonston et al,[49] Harris et al,[12] and the current researcher. Childs et al[20] in the Neck Pain Clinical Practice Guidelines of the Orthopaedic Section of the American Physical Therapy Association utilized the data from Harris et al[12] for expected scores on this test (24-39 seconds). Harris et al[12] did not provide a measure of neck pain in their subject pool, and did not describe how they were recruited for the study. Subjects were described as having neck pain, with additional exclusion criteria which would eliminate disc or nerve root impingement patients or very acute patients (those having difficulty sleeping). Likely their subjects represented patients with clinical level neck pain as opposed to the sub-clinical subject pool recruited for the current study. This may account for the higher baseline scores on the SNFET in the current study.

Exercise Compliance

Compliance with independently performed exercise programs is difficult to assess in field type research studies. More rigidly controlled studies performed in a laboratory or clinical setting are able to more accurately measure completion of exercises, as in the study by Jull et al[34] where exercises were performed by participants during supervised physical therapy visits. In Jull's study 50% of participants were reported to have made all visits (12 over a 6 week period), and 96.5% attended at least 2/3 of all sessions.[34] Anderson et al[41] also utilized supervised exercise session, and reported 83-90% attendance of scheduled sessions. Some researchers applied tighter control of their participants in regard to exercise compliance. Waling et al[63] eliminated any subjects from their study who did not attend at least 80% of their scheduled exercise sessions. Omer et al[14] performed a field study on the effectiveness of exercise and education with computer users from a governmental office in Turkey. The researchers reported that "a physician made the patients perform the exercises in the workplace three days a week during an approximately one-hour long session at lunchtime".[14 p.10] These levels of control would be difficult to provide in most private employment settings, and was not implemented in the current study.

Logs or exercise diaries are one means of attempting to obtain exercise compliance information, but these are dependent on participant attention to completion, and honesty. In the current study over half of the exercise group reported completing at least 50% of the exercise sessions. Falla et al,[29] and Harman et al[65] reported compliance tracked via logs of 91%, while Ylinen,[33] found 57-67% compliance with independent exercise programs. The compliance reported in the current study is lower than seen in other studies, likely because the sessions were scheduled 3 times a day, a much higher frequency than the 2-4 times a week utilized by many of the other researchers.[14,29,33,41,63,65]

The frequency of exercise selected for the current study was purposely higher than the other studies reviewed. The focus of the exercise program was to activate the deep cervical flexor muscles (longus colli and longus capitus) without the need for special equipment, or position changes. Exercises to promote postural muscle activation are typically active exercises without additional resistance applied. These types of exercise do not require an "off day" for recovery, unlike heavier resistance programs designed for strengthening, and can be performed multiple times a day. The exercise program could be performed at the individual's desk and was designed to take 3-5 minutes or less per session.

Specific exercise parameters have not been clearly defined for the treatment of neck pain and disability. In the Cochran Review on exercise for mechanical neck pain by Kay et al[35] and its most recent update by Gross et al[83] it was noted that benefits of specific types of exercise need to be determined. Regarding dosage of exercise it was acknowledged that there is limited evidence for optimal requirements.[83] The Neck Pain Guidelines put forth by the Orthopaedic Section of the American Physical Therapy Association recommend use of exercise in the management of neck pain based on strong evidence, but do not provide any recommendation related to dosage.

Post Intervention Dependent Measures

Overview

Median scores were assessed statistically for the VAS and NDI due to the ordinal nature of the measurements. Mean scores were reported for the FHP, CCFT and SNFET however median scores were assessed statistically due to concerns with normality of the data. All three groups demonstrated improvement in median scores on the VAS and NDI compared to pre intervention scores. Differences between groups on post intervention scores were not statistically significant for the VAS, but were significant for the NDI, between the EEG and EOG and between the EEG and CG. In contrast differences between groups for change scores of the VAS and NDI were not statistically significant. For FHP mean scores for the CG and EOG demonstrated a slight increase in FHP, the EEG mean demonstrated less (improved) FHP. On the CCFT all groups improved at a similar level and on the SNFET the CG and EOG mean was lower, while the EEG showed improvement. Statistical comparison of post intervention raw scores and change scores found that only the SNFET change score reached statistical significance. This statistical significance was not maintained in post hoc testing using adjusted significance levels for multiple group comparisons.

Interpretation of analysis of pain and disability scores has several issues of concern. As pain described by a VAS, and disability as described by the NDI are relative to an individual's perception of their status comparisons of absolute values are difficult to make. Comparison of change scores can provide indication of improvement in status. Use of change scores can inflate measurement error, so must be interpreted with caution. The NDI and VAS are both self-report measures, and are a reflection of an individual's perception of their status. Interventions such as exercise and education by their nature cannot be "blinded" from the participant, and subject's awareness of participating in the interventions as compared to being a control group member could have influenced their reporting.

Improvements seen in the CG and intervention groups could have several possible explanations. The modifications made to all of the workstations to bring them into compliance with OSHA recommendations for workstation set up could have had a positive effect on participant's perception of their status resulting in decreases in reporting of pain and disability. There also could have been true improvements in pain and disability due to the physical changes in the workstation set up. These changes would be expected to be at a similar level across the three groups; however, this was not the case.

Pain and Disability Results

The EOG group had the largest drop in median pain score on the VAS at 17 mm, however this group had the highest pre-intervention level and the CG had the lowest. The EEG decreased 13 mm and the CG 7 mm. In a comparison of post intervention mean scores the EEG had the lowest post-intervention pain levels on the VAS at 9 mm. In a study of clinically significant changes on a VAS Bird and Dickson[85] concluded that clinically significant changes in pain levels depend on the initial pain score. Those with higher initial scores require a larger change to be considered clinically significant and those with a lower initial score a smaller change. Based on Bird and Dickson's findings a recent research report on effects of exercise on neck pain utilized a minimal clinically important difference (MCID) of 9-11 mm on the VAS.[86] Based on that number both of the intervention groups in this current study would have a MCID in pain scores post intervention. On the NDI the EEG had the largest drop in NDI score of 4/50, with the EOG decreasing 2 points, and the CG 1 point. Only the change in the EEG reached the lowest level of change that is considered to be a minimal clinical important difference.[42] This difference is at the lowest end of a MCID, reflective of the low scores which were anticipated for this sub-clinical symptom population.

Changes in Pain and Disability in the Control Group

Other studies have found improvement in pain and disability in control groups. Perhaps, due to a Hawthorne type effect, individuals who volunteered for the current study had a change in their perception of pain and disability. The activities of responding to the flyers, signing the consent form, interacting with the primary researcher, and having their workstation assessed for ergonomic set-up may have resulted in an improved sense of self-efficacy, or belief in their ability to control their neck symptoms by participants in the study. All participants were told from the outset, via the informed consent, that regardless of their random group assignment, they would be provided with the education and exercises if desired following completion of the study. This could have provided a sense of action, and modified their outlook and expectations related to their neck pain and disability. Direct interaction with the researcher/physical therapist may also have impacted their perception of symptoms similar to the “therapeutic alliance” concept recently studied by Fuentes et al.[84] This therapeutic alliance, or a sense of social rapport/working relationship between the physical therapist was thought to be responsible for improvement in pain intensity and disability measured with self-report scales in a population of individuals with mild to moderate chronic low back pain.[84]

Changes in Pain and Disability in the Intervention Groups

The intervention groups had decreased pain scores of 13-17 mm, and decreased NDI scores of 2-4/50. The low baseline pain and disability levels in the current study resulted from the design which intentionally sought those with sub-clinical symptoms. This may have caused ceiling effects for the VAS and NDI measures, impacting the ability to demonstrate a larger improvement from baseline. Other studies demonstrating larger drops in pain scores had subjects with clinical level pain,[33,34] or minimum required pain scores.[41] Jull et al[34] reported decreases in VAS scores of 14-37mm in their control and intervention groups in a RCT comparing manipulation to exercise for the treatment of headache and neck pain. Andersen et al[41] reported a decrease in VAS pain scores of 34mm over 10 weeks in a group of female office and assembly line workers with chronic neck pain that performed specific strengthening exercises. Their control group demonstrated an 8 mm decrease and a group that performed aerobic exercises a 5 mm decrease. The magnitude of improvement in this current study was greater for both intervention groups (EEG and EOG) than

Andersen's control and aerobic groups, however not as great as their strengthening group, perhaps due to the difference in time frames (8 versus 10 weeks), or the intensity of the exercise programs. Waling et al[63] in 2000 reported decreases in mean group pain scores ranged from 10-13 mm while the control group decrease was 5 mm. Those decreases were similar to the median pain score decreases of the current study. No significance was found on pain score changes between their 4 groups, which ranged in size from 21-29 subjects, likely due to limited statistical power.[63]

Two studies had decreases in VAS and NDI that were comparable to the current study, with similar subject pools. Ylinen et al[33] measured change in VAS and the NDI in 2 exercise groups and a control group over 12 months in female office workers with chronic neck pain. Their subjects were referred by physician, but otherwise were similar to the subjects in this current study. Median baseline pain levels ranged from 57-58 mm in each of their groups, and improvement was 16 mm in the control group and 35-40 mm in the exercise groups. NDI median group scores ranged from 10.5-11 at baseline and improvement was 1.5/50 in their control group, and 4-4.5 in the exercise groups. Ylinen et al[33] had 59-60 subjects per group, and reported significant differences between the 2 exercise groups and the control group for pain and disability. Pain levels were higher in the Ylinen subjects likely related to their clinical recruitment as compared to the sub-clinical subjects in this current study. Their change scores were more than double those seen in the current study, but as a percentage of initial pain scores their exercise groups dropped 61 and 69%, similar to the 67% drop in the EEG of the current study. Ylinen et al's[33] control group drop in pain on the VAS was 28%, similar to the 29% drop seen in the current study. Ylinen et al's[33] baseline pain scores on the NDI were higher than those of the current study, however change scores for their exercise and control groups were similar to those of the current study. Falla et al[29] in a study of two types of neck exercises included the VAS and NDI measures in subjects with chronic low level neck pain. Their initial pain and disability levels were slightly higher than this current study (mean VAS 41 mm, and NDI 9.9/50). Their post intervention VAS scores decreased 9-11 mm, and NDI scores decreased from 2.8 - 3.5/50 over 6 weeks, similar to the results for this current study. Falla et al[29] also reported measurements of posture and muscle function that will be discussed in those sections of this report.

The post intervention differences between groups were not significant for pain, however did show significance for the NDI scores for the EOG as compared to the CG and the EEG. This significant difference between groups was not found in the analysis of change scores, perhaps related to the low power of this analysis. Based on percent change from baseline scores the EEG scores demonstrated the highest change from pre to post intervention on both measures. Considering a MCID of 9-11 mm on the VAS[85,86] and 3-5 on the NDI[42] the EEG would have reached this level for the VAS and NDI, and the EOG for just the VAS.

Changes in Posture

The EEG demonstrated less FHP by a mean of 4 mm while the CG and EOG had mean scores of 1-2 mm more FHP. The preferred posture was utilized in the pre and post intervention measurements for this variable. Few studies have measured a change in FHP following intervention, and none of those utilized the CROM device. Pearson and Wamsley[64] using motion capture found an immediate and statistically significant change in FHP following 3 sets of 10 neck retraction exercises in 30 asymptomatic subjects. It is interesting that the 4 mm change observed by Pearson and Wamsley[64] was the same as that found in the EEG following 6 weeks of exercises (which included neck retraction as an exercise) in the current study. Although the measurement techniques were different both reflect linear change in anterior/posterior position of the head in the horizontal plane.

Falla et al[29] reported improvement in ability to sustain upright posture during a ten minute computer task in a group of subjects with neck pain following 6 weeks of deep cervical flexor strengthening using the Stabilizer™. A second group that performed general neck exercises did not have the same level of improvement. The craniovertebral angle improved 4.4° in the deep cervical flexor group. The craniovertebral angle and a linear measurement with the CROM are not identical though they are both measurements of FHP. The relationship between the craniovertebral angle and FHP as measured with the CROM has not been studied. Results of Falla et al[29] and the current study suggest improvement in FHP following strengthening exercises of the deep cervical flexors. The exercises performed in the current study did not utilize the Stabilizer™ as Falla et al did,[29] but were designed to engage the deep cervical flexors without the need for specialized equipment.

While Falla et al,[29] and Pearson and Wamsley[64] demonstrated improvement in cervical posture with exercise, as seen in this current study, Jull et al[34] reported no change in cervical posture, in a group of individuals with cervicogenic headache with neck pain, following a similar exercise program using the Stabilizer™. Jull et al[34] did not describe how their measurements were obtained beyond stating they used lateral photography and the craniovertebral angle. If they utilized a standardized position that was unrelated to work posture that may explain the lack of consistency of their findings with this current study, and lend support for the argument for use of preferred positioning when studying FHP change with intervention.

A 4 mm linear or 4 degree angular improvement in FHP can occur by engaging the deep cervical flexors. This may reflect a change in the preferred position of the head and neck towards a position that more closely aligns with that assumed in a standardized position of the spine. This is typically the goal of physical therapists who utilize postural exercises in the management of individuals with cervical symptoms. Research study protocols which utilize a standardized position when measuring head and neck posture may be creating a false representation of an individual's baseline posture. This may in turn result in a lack of change in posture over time, or following an intervention that is being studied. This may account for the lack of improvement in posture noted in studies such as Jull et al.[34]

Changes in Muscle Performance

Muscle performance of the cervical flexors was assessed with the CCFT and the SNFET at baseline and at 8 weeks. All 3 groups had a 2 mmHg increase in median scores for the CCFT. On the SNFET the EEG demonstrated an improvement of 8 seconds; the remaining 2 groups had median scores that were 2-6 seconds worse than baseline. Mean score differences were similar, with the EEG demonstrating improvement in both measures of muscle performance, while the CG and EOG demonstrated the same level of improvement on the CCFT, and worsening scores on the SNFET.

Of studies that utilized the CCFT[13,17,29,34] only one reported change scores following an intervention.[34] Johnston et al[13] utilized the test while obtaining electromyographic measurements, but did not report the CCFT results. Fernandez-de-las-Penas et al[17] performed a descriptive study that did not assess change over time. Falla et al[29] performed an experimental study looking at change over time following exercise, however utilized the CCFT as an exercise technique not as an outcome measure. Jull et al[34] in a randomized controlled trial comparing exercise and manual therapy for subjects with neck pain did examine change in the CCFT over 7 weeks. They reported baseline means of 24 mmHg, with change scores ranging from 0.47-0.76 in the control and manual therapy groups, with change scores of 2.55-2.96 mmHg in the exercise and exercise with manual therapy groups. Their exercise program included use of the Stabilizer™, seated postural exercises, and isometrics. Statistical analysis on their 200 subjects using Wilcoxon Rank Sum found significance for the exercise and exercise with manual therapy groups as compared to the control and manual therapy only groups.[34] The increase of 2 mmHg found in the current study in all 3 groups is slightly lower than the increase found in Jull's exercise groups. Perhaps the lower baseline values in Jull's sample allowed for greater improvement with intervention. Jull's sample size provided for more power with their statistical analysis. The specific methods used for assessment of the CCFT were not detailed in that publication, however as it was published in 2002 it likely was similar to the methodology utilized in the Falla and Jull et al[46] study and, similar to the methodology of this current study.

The similar level of improvement seen in the CCFT for all 3 groups of the present study, including the control group brings into question the clinical significance of these findings. Improvement in all 3 groups could indicate an increase due to chance, or due to increased familiarity with the testing procedure, as opposed to improvement related to the interventions. Because the scoring of this test relies on the observational and palpatory skills of the examiner in determining the end point of the test, a difference of 2 mmHg may not reflect a clinically significant difference despite the statistical significance found with the larger subject pool as reported by Jull et al.[34] Jull, O'Leary and Falla acknowledged, in a 2008 review article on the CCFT, that individuals with neck pain utilize various alternative strategies when asked to perform the CCFT due to weakness of their deep cervical flexor muscles.[45] The changes in muscle strategy include increased use of superficial neck flexors and reverse action of neck extensors.

Interestingly a difference of 2 mmHg on the CCFT was found in a comparison of individuals with headache/neck pain and a group of asymptomatic controls.[17] Fernandez-de-las-Penas et al[17] reported an average score of 25.8 ± 3.6 mmHg in a group of symptomatic individuals, and 28.4 ± 1.8 in a group of asymptomatic individuals. Those levels are similar to the pre and post scores obtained in the current study. Fernandez-de-las-Penas et al[17] noted that pain was a limiting factor in testing of the symptomatic individuals in their study, with reproduction of symptoms during the CCFT. The lower pain and disability scores reported by all individuals in the post testing of the current study may have resulted in improved tolerance to the CCFT, resulting in the higher scores. Symptoms were not specifically monitored during the muscle performance testing in the current study. Subjects were advised to perform within their comfort level (they could terminate the testing based on their tolerance). The test could be terminated based on a change in subject form/muscle substitution as palpated or observed by the examiner. Pain complaints were not common during the testing procedures, and subjects did not appear to be uncomfortable during the testing. All subjects were advised that they might experience some post testing muscle soreness, however only one subject (who subsequently withdrew) reported any significant post-test symptoms. Edmondston et al[49] in a reliability study of neck muscle performance tests including the CCFT reported pain limiting the SNFET in some of their subjects, but noted that most of the tests were limited by muscle endurance not pain.

In the current study it was anticipated that the SNFET might be less well tolerated by subjects as it is a maximal hold test against the weight of the head as compared to the CCFT which has a predetermined time and force end point of 30 mmHg. Some subjects did offer comments during post testing that they had experienced soreness following the pre-test measurements, and they were going to be more conservative in their approach to the post testing session. The decreases in SNFET hold time for the CG (-2 seconds median, -12.65 seconds mean) and EOG (-6 seconds median, - 5.87 seconds mean) may reflect this more cautious approach to post testing by the subjects despite their lower pain levels. The group who had undergone the 6 week exercise program demonstrated improvement in hold time on the SNFET (+8 seconds median, +11.73 seconds mean). This finding met statistical significance via Kruskal-Wallis testing, however with post hoc testing using Bonferroni adjustment for multiple comparisons significance between groups was not identified. The largest average rank differences were found between the EEG and the CG and the EEG and the EOG. These findings suggest that exercise is an important component in improvement in muscle function. Though postural correction has been demonstrated to cause activation of the deep cervical flexor muscles[36], the EOG in this current study did not demonstrate improvement in muscle performance on the SNFET, and improvement on the CCFT was similar in all 3 groups.

Although the SNFET has had several studies of its clinimetric properties,[12,47,49] and is a recommended examination technique for physical therapists[20] and researchers,[47] no other studies were identified which reported change scores on this test following intervention. The current study found improvement in the SNFET following 6 weeks of low level exercise performed at work for brief periods (3-5 minutes), without equipment. The improvement in muscle function in the EEG was accompanied by improvement in reported pain levels, disability levels and forward head posture though statistical significance was limited.

Summary of CG, EOG and EEG Comparisons

The factors of job satisfaction and physical ergonomic set up of subject workstations were not found to influence results of the group comparisons. Exercise compliance in the EEG was lower than other studies which used tighter controls.[34,41,63] The absence of tight control of exercise performance was by design to reflect what is encountered in a real world occupational health setting. Overall compliance was fair with over 50% of the subjects reporting performance of at least ½ of the exercise sessions.

Baseline scores for all 3 groups on the VAS and NDI were lower than most other studies; however this was intentional by design, to target those with subclinical neck symptoms. The FHP of all subjects was more pronounced than that found in studies that utilized asymptomatic subjects measured in standardized positions[27,52,58,76] but similar to studies that utilized subjects measured at a workstation or in a relaxed posture.[17,31] Scores for the CCFT at

26-27 mmHg were at the low end of normal (26-30 mmHg) and similar to findings for those with head and neck pain.[17] The CFET demonstrated a wide range of scores (11-480 seconds), and means were higher than those noted in most other studies[12,48,75] however similar to Edmonston et al's[49] results from individuals with postural neck pain which ranged from 19-142 seconds. Two individuals in the current study were high outliers on this measure. Both were highly competitive, one an insurance agent who participated in body building, and one a university employee in the Reserve Officers' Training Corps.

Post intervention scores improved in all 3 groups on the VAS and NDI, with both intervention groups reaching a MCID on the pain score, and only the EEG on the disability score. Improvements in all 3 groups on these measures could be related to changes made to the workstations of all subjects, changes in perception of pain and disability based on participation in the study and/or interaction with the researcher. For FHP and the CFET only the EEG demonstrated improvement. On the CCFT all 3 groups improved slightly by a mean of 2 mmHg.

Statistical analysis for the three group comparison of this current study was limited to non-parametric Kruskal Wallis analysis due to the limited number of participants and the non-normal distributions of the dependent variables. Large variability was found in some measures (SNFET) while other measures had very limited variability (CCFT) based on design of the test. This resulted in low power for analysis of the primary question. Of the 5 variables statistical significance was limited to posttest differences between groups on the NDI at a level that just meets an important difference for those with sub-clinical symptoms. Despite the low power several comparisons approached significance on between group posttest dependent measures including the FHP at p=.1, and SNFET at p =.140. For change scores the NDI approached significance at p =.1 and the SNFET reached significance, but did not maintain significance with adjusted score comparisons between the 3 groups. Several of the variables (SNFET, CCFT, and FHP) lacked clear MCID scores in the literature despite being either commonly addressed or recommended measurements for the management of individuals with neck pain. Comparison to what has been demonstrated in the literature regarding these measurements has been provided.

The addition of a relatively low dose exercise program to an education session resulted in improvement in all 5 variables examined in this study in the EEG. The CG and EOG members demonstrated improvement in reported pain and disability; however no improvement in posture or in the two measures of muscle function. Change score comparisons between groups did not meet statistical significance likely related to the low power achieved and use of non-parametric analysis. The null hypothesis could not be rejected. The research hypothesis that both intervention groups would demonstrate improvement on all 5 measures was not supported.

Findings suggest that that the combination of exercise and education can result in improvement in the 5 variables assessed in computer users with subclinical neck symptoms. Posture was modified through the use of low level exercises in the workplace targeting the deep cervical flexor muscles, and this change in posture was associated with improvement in perceived subclinical neck pain and disability. Physical therapists working in occupational health settings should continue to use both education and exercise interventions as suggested in guidelines of the American Physical Therapy Association.[40] Results of the current study demonstrate that changes in neck posture and muscle function can be obtained with exercises that can be performed at an individual's workstation for just a few minutes a day. Education alone does not appear to provide the same level of improvement.

With increases in computer use in our society, and the clear relationship between seated work and neck symptoms interventions which can improve pain, disability, posture and muscle function should be studied in greater detail. Prognosis is poorer for those with prior episodes of neck pain, so interventions that can modify neck symptoms are important to minimize the burden and frequency of neck disorders related to seated computer activity.[2] Longitudinal studies are needed to determine if programs of this nature can modify the progression of neck pain from subclinical to clinical neck pain.

Strengths of the Study

This study is one of a few studies to examine workers with sub-clinical neck symptoms, and to do so in their own work environment.[4,8,14,31] Studies performed in a laboratory or clinical setting, though easier to standardize and control measurements, create an artificial environment which may unintentionally impact results. In the current study subjects were assessed at their own workstations, providing a more realistic representation of their function in the real world. The current study protocol utilized techniques that can easily be implemented by physical therapists working in occupational health settings, lending itself to translation into current practice. Multiple outcomes were assessed including pain, disability, posture, and muscle function, utilizing measurements techniques that are currently recommended for physical therapist assessment of neck pain.[20] Based on the findings that preferred positioning of the trunk and lower extremities results in a significantly different measure of cervical posture, the current study is one of the few to examine preferred posture that individuals use in the work setting, not an artificially modified posture created by standardized positioning. Use of the five axis case description classification system put forth by the Bone and Joint Decade 2000-2010 Task Force allows results of this study to be compared to other research studies that follow this system, and provides a clear description for application of study findings to practice.[5]

Weaknesses of the Study

The primary weakness of this study was the limited number of subjects obtained for the intervention aspect of the study. Given the ease of obtaining five large employer letters of intent for the proposed study it was anticipated that the planned number of 90 subjects would be feasible. However following 10 months of data collection including obtaining consent from 16 of 43 additional employers contacted subject recruitment was terminated at only 67 subjects, with 59 available for the intervention portion. Three of the five large employers who had initially agreed to participate backed out at the start of data collection, and the fourth provided only 1 subject. Other employers contacted voiced concern that calling attention to neck symptoms in their employees might increase worker's compensation claims, or were not interested in employees taking time from their workday to participate in the study. This resulted in randomized groups of 17-23, limiting power for statistical analysis.

The VAS and NDI though used routinely for assessment of clinical level neck symptoms may not have been the most appropriate tools to assess sub-clinical neck symptoms. Most scores were at the low end of each scale, potentially resulting in ceiling effects with little room for improvement in scores. On the CCFT, with limited variability of scores the majority of subjects were at the high end of the functional assessment (28/30) at the start of the study, with little room left for improvement.

A single lateral photograph from a 15 minute segment of videotape may not be representative of an individual's posture over an 8 hour workday. This method has been utilized previously in the literature. Gerr et al[24] suggested that there is low variability in worker cervical posture at their desk based on 6 repeated measures over a day. Longer videotaping periods would have increased the disruption of the employee's workday, and it was anticipated that this would further limit participant recruiting. Of the 67 participants only 20 were agreeable to being videotaped, the additional 7 videotape participants were obtained from the pilot study participants. Video motion analysis technology may be have been a better method of analyzing the two 15 minute video segments, however was not available to the researcher during development of the study methodology.

Delimitations

Delimitations are items under researcher control which may impact study results. For the current study, delimitations included subject selection, standardization of terminology, standardization of processes, blinding of the researcher performing measurements to group assignment, types of measurements obtained, timing of data collection, and individual subject differences. The following details how each of these factors were addressed.

Subject selection included office workers who utilize computers in the course of their employment, and report sub-clinical neck symptoms. All subjects volunteered for the study. Volunteers may have more interest in managing their symptoms, and may be more likely to be compliant with educational instruction and exercise programs than a typical employee. Generalization of results to all office computers users may be affected as a result.

Subject selection was performed based on the presence of sub-clinical neck symptoms, and not based on the presence of FHP, or other objective findings. Selection of only those with FHP may have resulted in more marked changes in head and neck posture with the exercise program. In comparison to other studies however the subject pool in this study did present with lower craniovertebral angles, consistent with a more FHP. Subjects were not divided into neck pain with headache and neck pain without headache, though other studies have done so[17,34,59] while others have grouped neck and upper extremity pain.[37,63,66] Pain localized to the region between the superior nuchal line to the spine of the scapula and in the supraclavicular area was considered neck pain for this study.

The types of measurement tools utilized in the current study have been described, and consideration given to the reliability and validity of each method. This was balanced with the need to utilize instruments and procedures which are feasible for current practice from a time and cost perspective so that study results can be applied to a real-world situation. Measurements included pain, disability, cervical posture and deep cervical flexor muscle function. Measurements did not include thoracic posture, cervical range of motion, or cervical extensor muscles function and comparisons to studies examining these factors cannot be made.

Standardization of terminology was implemented within the framework of the Classification of Case Definitions recommended by the Task Force of Neck Pain and Associated Disorders. This will improve comparisons between results of this study with other studies that follow these terminology recommendations. As noted in Chapter One, several of the measurement techniques utilized in this study had multiple names, or as with the CCFT and SNFET had evolved over time and were performed in slightly different ways in other studies. These variations make comparisons between studies challenging. Standard processes were implemented as described in the procedures section in an attempt to provide each subject with similar education sessions and exercise instruction, and to enable study replication.

Blinding of the researcher performing measurements of impairments was implemented. This blinding was compromised with several of the subjects who discussed their exercise or education program with the researcher during follow-up measurement sessions. Despite instructions to participants to remove items from their work area such as the "Posture" reminder card and exercise logs to avoid impacting researcher blinding, not all participants complied with this request. Strict controls of research processes are more difficult in field type research as compared to laboratory research, as subjects are in their own work setting, and not as focused on the specifics of the research process as they would be if attending a special laboratory session specifically for research study participation. Time of day was considered in obtaining measurements; however minimizing interruption of the employee workday had to be taken into account to limit disruption in the work setting.

Individual subject differences such as gender can impact study results. It has been demonstrated that differences in resting head posture and range of motion exist between male and female subjects.[57] The majority of studies on posture, neck symptoms and disability have utilized female subjects, or when both genders are included a higher percentage of females. Blocking of gender in group assignment and the use of change scores for measurements of forward head posture was used to minimize the effect of gender on study results. The percent of females in each group ranged from 65.2-84.2%. The gender difference between groups was not found to be statistically significant.

Limitations/Assumptions

Potential limitations of this study included the use of self-report measures, subject truthfulness, inability to blind subjects to the measurements, the inability to demonstrate 100% validity and reliability of the measurements utilized, subject attrition due to employment changes, injury or illness, subject compliance with interventions, and group diffusion due to subject interaction. Attempts were made in design to address these factors; however, they could not be controlled completely.

It is recognized that self-reporting has limited reliability, however patient/client-centered care process with an emphasis on enablement and disablement requires that researchers utilize methods of assessment which have real-world meaning to individuals with whom we work. Self-report via survey is a recognized method of data collection by the Neck Pain Task Force,[5] and by the Clinical Practice Guidelines for Neck Pain of the Orthopaedic Section of the American Physical Therapy Association. All self-report instruments utilized were assessed for clinimetric properties; however, study results are limited by the reliability and validity of the instruments utilized as no test or measure is 100% valid and reliable. Study results may be limited by subject truthfulness and proper consideration to answers on all forms completed for the study; however, it was assumed that subjects used good faith efforts in their responses. It was assumed that neck symptoms reported by the subjects were non-specific mechanical neck symptoms, and not related to more serious undiagnosed underlying pathology.

Blinding of subjects to the observation and measurement of their posture was not possible. Reaction to the data collection methods could not be eliminated as subjects were aware of being observed, photographed or videotaped. In addition unobtrusive methods such as one-way mirrors were not feasible for a study performed in the workplace. It was not possible to ensure that the posture displayed by the worker was reflective of their typical work posture however there is a greater likelihood that the postures assumed at the individual's own workstation is more reflective of their typical work posture as compared to those obtained during standardized positioning in previous studies performed in a laboratory setting.

Study results may also be limited by the reliability and validity of the instruments utilized to collect data on deep neck cervical flexor muscle function. Reliability of each instrument utilized in the current study has been reported in the literature review, and the pilot reliability study was utilized to determine the researcher's reliability in performing the CCFT, the SNFET, measurement of forward head position using the CROM and the craniovertebral angle with lateral photography. It was assumed that the testing procedures for function of the deep cervical muscles resulted in activation of this musculature as has been reported by Falla[81] and Harris et al.[12]

During the course of the study subjects' job or employment status could have changed. Injury or illness could have impacted an individual's ability to continue in the study. Intention to treat analysis was planned for these situations. Compliance with an exercise program is an issue in research and clinical practice, and cannot be completely controlled. Subjects were monitored biweekly by the research assistant, and were asked to keep exercise logs in an attempt to improve and assess compliance. The exercise program was designed to be performed for 10-15 minutes per day and did not require visits to a clinic or research site, in an attempt to minimize these potential barriers to compliance. Interaction between subjects in the workplace could occur. Subjects were asked not to discuss their participation in the study with co-workers in an attempt to limit diffusion; however there was no way to ensure that this request was followed.

Attrition was not a factor as all but 1 of the 67 subjects that entered completed the study. Regarding the exercise intervention group, illness/injury did not interfere with participation, though vacation time was a factor for a few, limiting their consistency with the exercise program. Group diffusion due to subject interaction was not a concern as subjects in close proximity (same physical office space or same department) were assigned to the same group.

Challenges of Study Implementation

Five large employers had initially agreed to allow access to their employee base of around 2,700 computer users. This would have provided about 485 individuals (18%) likely to have sub-clinical neck symptoms to draw from for a population base in this study. Only two employers of the original five, that had signed letters of intent to participate, provided subjects for the study. One of these provided just 1 subject from their 65 employees. Communication with the company owner indicated that he did not distribute the recruitment flyer to all of the employees, but discussed it personally with 1 individual who had agreed to participate. He cited a concern with the time commitment as a reason for limiting his employees' involvement. Thirty-four subjects were obtained from the second employer, resulting in a need to recruit more employers/employees for the study. Forty-three additional employers were contacted via phone and/or electronic mail between February and August of 2012, including local universities, insurance, accountant and medical offices, surveyors, media, governmental agencies, community and religious agencies. Sixteen additional employers agreed to allow recruitment, and subjects were obtained from 14 of these sites. The majority of these were small employers. This resulted in about 600 computer users, with an estimated 108 individuals (18%) with subclinical symptoms needed for inclusion in the study. Other recruitment efforts included booths set up and manned by the primary researcher at local health fairs in February and September of 2012, however the number of individuals fitting the inclusion criteria at these events cannot be estimated.

Some employers agreed immediately to allow subject recruitment; others required multiple phone calls, electronic mailings, multiple layers of approvals and face to face meetings with management prior to agreeing to allow recruitment of subjects from their employee base. It was more difficult to obtain approval from large employers as opposed to small, due to layers of management, and the need for multiple approvals. Because employers controlled access to the recruiting process it was not possible to determine the exact number of potential subjects in the population used for this study. This limits the ability to make comparisons to other studies related to the prevalence of individuals with sub-clinical neck symptoms.

Implications and Recommendations

Current Clinical Practice

As our society has moved from an agricultural to industrial and now technological focus the risk of development of neck pain related to use of computer workstations is likely to increase. There is an increased number of sedentary occupations, and more frequent use of computer workstations in homes, schools and in the workplace. Use of mobile technology such as cell phones, laptop computers and tablets further increases the time spent in forward flexed and forward head postures.

Research has demonstrated that individuals utilizing computer workstations are at increased risk of developing neck pain and associated disorders.[7] Physical therapists working in occupational health seek to prevent musculoskeletal dysfunction through ergonomic modifications, education and exercise. Results from the intervention component of this study demonstrate that education combined with low level exercise performed independently by individuals for 10-15 minutes a day, without equipment resulted in less pain and disability, improved posture and improved muscle function over a course of 8 weeks in individuals with sub-clinical neck symptoms, however these changes did not reach statistical significance. Interventions provided in the workplace by occupational health physical therapists may impact subjective and objective measures in this population; however additional studies with larger samples are needed.

Ergonomic modifications to the workplace have been thought to prevent musculoskeletal dysfunctions. Structural ergonomic modification alone does not ensure that a worker will utilize the equipment appropriately.[24] Results of the workstation screening performed as part of this study demonstrated that frequently individuals have the ergonomic equipment but do not know how to perform adjustments, or make incorrect adjustments, to their workstations. Education and screening remain important components of occupational health physical therapy.

Future Research

The comparison of standardized to preferred posture demonstrates that studies examining the relationship of neck pain and posture should utilize preferred posture and not standardized. The standardized positioning used in some studies may have resulted in an artificially improved head and neck posture of the subjects. This may have contributed to the findings of a lack of correlation between forward head posture and neck symptoms in other studies.

Data from this current study was examined for correlation between the reported neck symptoms (pain and disability) and forward head posture using the preferred position. No correlation was found using Spearman's Rho. Sahrmann[26] suggests that we should not expect a linear relationship between posture and symptom severity due to the number of other factors involved in musculoskeletal conditions. She postulated that there may be a range of normal, similar to that seen for blood pressure, heart rate or cholesterol.[26] Perhaps a multifactorial presentation of postural deviation with low muscle performance needs to occur for postural change to correlate with increased symptoms. Additional studies comparing head and neck posture to symptoms utilizing preferred posture need to be performed. The focus by physical therapists on improving neck posture via exercise and education should have evidence to support its use.

Although studies have found changes in forward head posture over short duration assessment at a computer workstation in individuals with neck pain,[29] the current study did not find a significant change over an 8 hour workday. This suggests that studies examining head and neck posture in workers may not need to consider time at work as a factor impacting measurements. Additional studies utilizing higher levels of technology which can generate angular measurements over a period of time, such as Dartfish, or other motion analysis software should be performed. This could better determine if there is a change in head and neck posture over the course of a workday. In addition, the study of movement patterns may provide a better picture of function than static measurements of work postures. Perhaps there are ranges of movement that are within a "safe" range which could be defined. Development of disabling neck pain may be related to the amount of time spent in a particular position or range and not whether an individual can attain a particular head and neck posture when placed in a standardized positon of their lower spine/body.

Minimal intervention of 10-15 minutes of exercise instruction and education in this study resulted in decreases in pain and disability over an 8 week period. Posture and muscle function also showed improvements. Perhaps the impact of persistent or episodic clinical level neck pain could be reduced via preventative care at this level. Longitudinal studies with follow-up over a year or more would be helpful in determining the impact of this type of program. The need to prevent sub-clinical neck pain from progressing to disabling neck pain has been identified[1] and the occupational health physical therapist may play a key role in this process.

Additional studies could compare those individuals who report compliance with exercise programs and those who do not in relation to differences in outcomes. Elimination of subjects from the intervention group who do not report performing at least 50% of the recommended exercises, with examination of their outcomes separately would better demonstrate potential benefits of an exercise intervention. A comparison of those subjects who had greater change in head and neck posture with those who did not in relation to pain, disability scores and muscle function may provide an interesting perspective. Despite the improvement in muscle performance with low level exercise in this study the specific dosage or amount of exercise needed to decrease the risk of development of disabling neck pain is still not known, and will require further study.

Summary

Sub-clinical neck symptoms are common in the adult population, particularly in office workers who utilize computer workstations.[4,54] Use of these workstations is increasing among employed individuals given the technological focus of our society. Additionally home and social uses of technology including cell phones, tablets and laptops result in flexed or forward head posture. It has been demonstrated that individuals with neck pain have neck posture that is different from those who do not.[13,17,30,31,58] Physical therapists have traditionally addressed neck pain with the use of education and exercises designed to address forward head posture.[15-21,26,56] The role of the deep cervical flexor muscles has been demonstrated in maintaining neck posture, and these muscles can be assessed with the Craniocervical Flexion Test and the Short Neck Flexor Endurance test.[20,45] Research supports the use of education and exercise to address neck pain.[29,22,26-38,60-62] The relationship between head and neck posture and neck symptoms has not been clearly defined in the literature, with conflicting study results and opinions.[17,27-32,39] One possible explanation for the conflicting evidence is the manner in which head and neck posture is assessed, utilizing standardized positioning which produces a change in the posture that is being measured. Some research findings have identified an increase in forward head posture at a computer workstation over a 10 minute period in individuals with neck pain,[29] however changes over an entire workday have been explored minimally.[31]

The primary purpose of this current study was to examine the effects of 8 weeks of exercise and education versus education alone in comparison to a control group on pain, self-reported disability, head and neck posture, and deep cervical flexor muscle performance in employed computer user adults with sub-clinical neck symptoms. Secondary purposes were to examine the differences in head and neck posture in standardized versus preferred positioning of the lower spine and extremities, and to determine if there were changes in head and neck posture over an 8 hour work day in a sub-group of 27 subjects (30% of the anticipated sample). A reliability study was performed to assess examiner reliability with the physical measurements utilized. Ergonomic worksite assessments were performed on the workstations of all participants to ensure that they all met basic recommendations of OSHA prior to implementation of the education and exercise interventions. The reliability study on a convenience sample of 12 individuals who fit the inclusion criteria for the study demonstrated excellent reliability of the physical measures for a single examiner (ICC range 0.92-0.99).

Forty-eight businesses in Erie, Pennsylvania were approached with a request to recruit subjects from their employees utilizing computer workstations in an office setting. Sixty-seven subjects were recruited from 16 employers including institutions of higher education, insurance, accountant and medical offices, surveyors, media, governmental agencies, community, and religious agencies. Sixty-six completed the comparison of standardized and preferred posture, 59 were assigned to the 3 groups for comparison of education and exercise (17 control, 23 education only, and 19 education and exercise), with 27 (40% of the total pool) used for assessment of postural change over an 8 hour workday. Seven of the 66 total pool did not participate in the comparison of education and exercise as they were recruited from the pilot study pool to complete the 27 subjects for the videotape portion of the study. Pilot study participants were not recruited for the group comparison portion of the study as their exposure to the testing procedures could have influence their results.

No change was found in posture over an 8 hour workday as measured with the craniovertebral angle. The measurements obtained in this portion of the study demonstrate a more forward head posture in this sample as compared to a number of other studies.[27,34,52,58,76] This difference may be related to the preferred position utilized as the current finding were similar to two studies which measured working posture or relaxed sitting.[17,31] The comparison of forward head posture with standardized or preferred positioning of the lower spine and lower extremities did demonstrate a significant difference, with greater forward head posture in the preferred position. This finding suggests that studies performed previously using standardized positions have measured a position altered by the study technique and not the position utilized by their subjects while working. The measurements of forward head posture in the standardized and the preferred position in this subject pool were greater than that of other studies including symptomatic and asymptomatic individuals. The symptomatic groups had greater forward head posture than asymptomatic groups with only one study reporting greater forward head posture than that noted in this current study. The single study that reported greater forward head posture also utilized office workers with neck pain, measured at their workstations, and did not restrict their pool to sub-clinical symptoms. The increased forward head posture noted in subjects in this current study may be related to the office work and sub-clinical symptoms of the subjects.

Ergonomic workstation assessment found that many individuals have adjustable equipment but they do not know how to make appropriate adjustments to their workstations. This demonstrates a continued need for assessment and education by the occupational health physical therapist. Almost half of the workstations assessed had ergonomic concerns which were easily modified to meet OSHA guidelines. Exercise compliance was fair with over ½ of the subjects performing at least 50% of the requested exercise sessions. Compliance with a 3 times a day program is likely to be lower than compliance with a 3 times a week program seen in other studies.

Subjects were primarily female, with persistent or recurrent low level pain and disability similar to those in similar studies.[9,10,33] The subject pool had a mean age near 50, consistent with other studies on low level neck pain in adult computer users.[2,3,54] The level of pain and disability of subjects was lower than those in other studies, likely related to the method of obtaining individuals through employee recruitment as opposed to through healthcare referrals as seen in other studies.[33] Muscle performance as measured by the CCFT was similar to those found in other studies of individuals with low level neck symptoms.[17,45] Performance on the SNFET was higher than that found in other studies, though differences could be related to differences in the level of symptoms in the study subjects.[12,48,49]

For the primary purpose of this study only the EEG demonstrated improvement on all 5 of the dependent measurements, though not at a level that met statistical significance. The EOG and CG improved on 3 of the 5 measurements, and demonstrated worsening scores on forward head posture and neck muscle endurance as measured with the Short Neck Flexor Endurance Test. Statistical significance was found on the gain scores of the Short Neck Flexor Endurance Test, but not maintained with post hoc pairwise comparison. Significance was found between groups on post intervention measurement of the NDI with the EEG significantly more improved than the EOG and the CG. The improvements seen in VAS and NDI scores in the CG and EOG may have resulted from ergonomic changes to the workstations, or the therapeutic alliance developed as a result of interaction with the researcher while participating in the study.

The exercise sessions in the study were brief, (3-5 minutes) and could be performed independently in an office setting without equipment. This study examined results following 8 weeks of exercise. Questions remain regarding dosage of exercise and the long term effects. Further studies are needed to determine if education and exercise can prevent sub-clinical neck symptoms from progressing to clinical level or disabling neck pain.

Conclusions

Over an 8 hour workday forward head posture of computer users at their own workstation did not show significant change. Computer users at their own workstation in preferred posture demonstrated a greater forward head position as compared to the posture assumed when placed in a standardized position of the thoracolumbar spine/lower extremities. Given this finding research examining the relationship between forward head posture and neck pain should utilize the subject's preferred posture. Education combined with 8 weeks of exercise resulted in decreased pain and perceived disability, improved posture, and neck muscle function; however, the degree of improvement for gain scores did not reach statistical significance. The EEG had significantly lower post intervention scores on the NDI as compared to the EOG and the CG. Findings suggest that education with low level exercise performed independently without the need for equipment can result in positive change.

There is a need for standardized terminology in subject description to facilitate comparisons between studies. There is also a need for a measure of activity limitation and participation restriction for individuals with low level neck symptoms. General knowledge in proper use of ergonomic equipment is lacking in office computer users, demonstrating a need for continued education. Examining individuals in their own work environment is challenging, however studies in a clinical or laboratory setting may unintentionally introduce variables that can impact results.

APPENDIX A

VDT Workstation Checklist

VDT Workstation Checklist Available at http://www.osha.gov

WORKING CONDITIONS **The workstation is designed or arranged for doing VDT tasks so it allows the employee's . . .**	**Y**	**N**
A. Head and **neck** to be about upright (not bent down/back).		
B. Head, neck and **trunk** to face forward (not twisted).		
C. Trunk to be about perpendicular to floor (not leaning forward/backward).		
D. Shoulders and **upper arms** to be about perpendicular to floor (not stretched forward) and relaxed (not elevated).		
E. Upper arms and **elbows** to be close to body (not extended outward).		
F. Forearms, wrists, and **hands** to be straight and parallel to floor (not pointing up/down).		
G. Wrists and **hands** to be straight (not bent up/down or sideways toward little finger).		
H. Thighs to be about parallel to floor and **lower legs** to be about perpendicular to floor.		
I. Feet to rest flat on floor or be supported by a stable footrest.		
J. VDT tasks to be organized in a way that allows employee to vary VDT tasks with other work activities, or to take micro-breaks or recovery pauses while at the VDT workstation.		
SEATING **The chair . . .**	**Y**	**N**
1. Backrest provides support for employee's lower back (lumbar area).		
2. Seat width and **depth** accommodate specific employee (seatpan not too big/small).		
3. Seat front does not press against the back of employee's knees and lower legs (seatpan not too long).		
4. Seat has cushioning and is rounded/ has "waterfall" front (no sharp edge).		
5. Armrests support both forearms while employee performs VDT tasks and do not interfere with movement.		
KEYBOARD/INPUT DEVICE **The keyboard/input device is designed or arranged for doing VDT tasks so that . . .**	**Y**	**N**
6. Keyboard/input device platform(s) is stable and large enough to hold keyboard and input device.		
7. Input device (mouse or trackball) is located right next to keyboard so it can be operated without reaching.		
8. Input device is easy to activate and shape/size fits hand of specific employee (not too big/small).		
9. Wrists and **hands** do not rest on sharp or hard edge.		
MONITOR The monitor is designed or arranged for VDT tasks so that . . .	**Y**	**N**

10. Top line of screen is at or below eye level so employee is able to read it without bending head or neck down/back. (For employees with bifocals/trifocals, see next item.)		
11. Employee with bifocals/trifocals is able to read screen without bending head or neck backward.		
12. Monitor distance allows employee to read screen without leaning head, neck or trunk forward/backward.		
13. Monitor position is directly in front of employee so employee does not have to twist head or neck.		
14. No glare (e.g., from windows, lights) is present on the screen which might cause employee to assume an awkward posture to read screen.		
WORK AREA The work area is designed or arranged for doing VDT tasks so that . . .	**Y**	**N**
15. Thighs have clearance space between chair and VDT table/keyboard platform (thighs not trapped).		
16. Legs and **feet** have clearance space under VDT table so employee is able to get close enough to keyboard/input device.		
ACCESSORIES	**Y**	**N**
17. Document holder, if provided, is stable and large enough to hold documents that are used.		
18. Document holder, if provided, is placed at about the same height and distance as monitor screen so there is little head movement when employee looks from document to screen.		
19. Wrist rest, if provided, is padded and free of sharp and square edges.		
20. Wrist rest, if provided, allows employee to keep forearms, wrists and hands straight and parallel to ground when using keyboard/input device.		
21. Telephone can be used with head upright (not bent) and shoulders relaxed (not elevated) if employee does VDT tasks at the same time.		
GENERAL	**Y**	**N**
22. Workstation and equipment have sufficient adjustability so that the employee is able to be in a safe working posture and to make occasional changes in posture while performing VDT tasks.		
23. VDT Workstation, equipment and accessories are maintained in serviceable condition and function properly.		
PASSING SCORE = "YES" answer on all "working postures" items (A-J) and no more than two "NO" answers on remainder of checklist (1-23).		

APPENDIX B

Neck Disability Index

ID Code # ______

Neck Disability Index

This questionnaire has been designed to provide information as to how much your neck pain has affected your ability to manage your everyday life. Please answer every section and mark in each section only the one box that most closely applies to you

Pain Intensity

- ☐ I have no pain at the moment
- ☐ The pain is very mild at the moment
- ☐ The pain is moderate at the moment
- ☐ The pain is fairly severe at the moment
- ☐ The pain is very severe at the moment
- ☐ The pain is the worst imaginable at the moment

Personal Care (Washing, Dressing, etc)

- ☐ I can look after myself normally without causing extra pain
- ☐ I can look after myself normally but it causes extra pain
- ☐ It is painful to look after myself and I am slow and careful
- ☐ I need some help but can manage most of my personal care
- ☐ I need help every day in most aspects of self care
- ☐ I do not get dressed, I wash with difficulty and stay in bed

Lifting

- ☐ I can lift heavy weights without extra pain
- ☐ I can lift heavy weights but it gives extra pain
- ☐ Pain prevents me from lifting heavy weights off the floor but I can manage if they are conveniently placed, for example on a table
- ☐ Pain prevents me from lifting heavy weights but I can manage light to medium weights if they are conveniently positioned
- ☐ I can only lift very light weights
- ☐ I cannot lift or carry anything

Reading

- ☐ I can read as much as I want to with no pain in my neck
- ☐ I can read as much as I want to with slight pain in my neck
- ☐ I can read as much as I want with moderate pain in my neck
- ☐ I can't read as much as I want because of moderate pain in my neck
- ☐ I can hardly read at all because of severe pain in my neck
- ☐ I cannot read at all

Headaches

- ☐ I have no headaches at all
- ☐ I have slight headaches which come infrequently
- ☐ I have moderate headaches which come infrequently
- ☐ I have moderate headaches which come frequently
- ☐ I have sever e headaches which come frequently
- ☐ I have headaches almost all the time

Concentration

- ☐ I can concentrate fully when I want to with no difficulty
- ☐ I can concentrate when I want to with slight difficulty
- ☐ I have a fair degree of difficulty in concentrating when I want to
- ☐ I have a lot of difficulty in concentrating when I want to
- ☐ I have a great deal of difficulty in concentrating when I want to
- ☐ I cannot concentrate at all

Work

- ☐ I can do as much work as I want to
- ☐ I can only do my usual work but no more
- ☐ I can do most of my usual work, but no more
- ☐ I cannot do my usual work
- ☐ I can hardly do any work at all
- ☐ I can't do any work at all

Driving

- ☐ I can drive my car without any neck pain
- ☐ I can drive my car as long as I want with slight pain in my neck
- ☐ I can drive my car as long as I want with moderate pain in my neck
- ☐ I can't drive my car as long as I want because of moderate pain in my neck
- ☐ I can hardly drive at all because of severe pain in my neck
- ☐ I can't drive my car at all

Sleeping

- ☐ I have no trouble sleeping
- ☐ My sleep is slightly disturbed (less than 1 hr sleepless)
- ☐ My sleep is mildly disturbed (1-2 hrs sleepless)
- ☐ My sleep is moderately disturbed (2-3 hrs sleepless) My sleep is greatly disturbed (3-5 hrs sleepless)
- ☐ My sleep is completely disturbed (5-7 hrs sleepless)

Recreation

- ☐ I am able to engage in all my recreational activities with no neck pain at all
- ☐ I am able to engage in all my recreational activities with some pain in my neck
- ☐ I am able to engage in most, but not all of my usual recreational activities because of pain in my neck
- ☐ I am able to engage in a few of my usual recreational activities because of pain in my neck
- ☐ I can hardly do any recreational activities because of pain in my neck
- ☐ I can't do any recreational activities at all

Reprinted with permission from: Vernon H, Mior S. The Neck Disability Index: A Study of Reliability and Validity. *J Manip Physiol Ther*.1991;14:409-415.

APPENDIX C

Job Satisfaction Survey

ID Code # _______

Job Satisfaction Survey

On the following scale please rate your satisfaction with your current work situation. This information is for study purposes only and will not be shared with your employer or utilized for any other purpose.

How satisfied are you with your job in general? (Circle one)

1	2	3	4	5
Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied

APPENDIX D

Standardized Position

Standardized Posture/Position – Feet flat on floor, hips and knees at 90 degrees, pelvis and lower spine upright .

APPENDIX E

Visual Analog Scale

ID Code # _____

Visual Analog Scale

Rate the discomfort/pain in your neck area **over the past 24 hours** with a mark on the line

No Pain ____ Worst You Experience

Rate the discomfort/pain in your neck area at it's worst **over the past week** with a mark on the line.

No Pain ____ Worst You Experience

APPENDIX F

Intake Form

Intake Form

Age:____ Worksite: ______________ ID # ______________

Average number of hours you spend at a computer per day: ______

Length of Time performing this type of work : ___________(years)

Have you had any episode of pain, discomfort, tightness or tenderness in your neck, top of your shoulders or between your shoulder blades within the last 3 months? Yes_____ No_____

If you answered "yes" please describe how long these symptoms lasted:

_____ Less than 7 days

_____ More than 7 days but less than 3 months

_____ More than 3 months

How many times have you experienced these episodes in the past 3 months?

_____ This time only

_____ 2 or more times

_____ Symptoms have never gone away completely

Have you ever had or been diagnosed by a physician with:

Yes___ No ____ Whiplash

Yes___ No ____ Fibromyalgia

Yes___ No ____ Rheumatoid arthritis

Yes___ No ____ Problems with your neck requiring hospitalization or surgery

Yes___ No ____ Other neuromuscular disorders (please describe)

____

Do you have any implanted devices (shunts, drug ports, pacemakers, deep brain stimulators or similar devices) in the neck region?
Yes _____ No _____

Have you seen a physician, chiropractor, physical therapist or other health care provider for treatment of your neck in the past 12 months?
Yes _____ No _____

APPENDIX G

Letter to Employers

Letter to Employer

Dear __________;

I am a faculty member in the physical therapy program at Gannon University, and a doctoral candidate at Nova Southeastern University. My dissertation involves studying neck symptoms in office workers who utilize computers, and how these symptoms may be addressed through the use of simple exercises and/or education in proper work postures and to explore the best methods to use in studying posture and neck symptoms. I am seeking subjects for this study, from employers in the Erie area. Subjects should be working adults with low level neck symptoms (not seeking or undergoing medical care for these symptoms).

Participation in the study would involve completion of forms (anticipated to take a maximum of 20 minutes) and measurements of neck position (at each individual's workstation) and muscle strength/endurance (using a portable table in a conference room, also anticipated to take a maximum of 20 minutes). Two thirds of the participants would then receive a 10-15 minute individual session on proper positioning at a computer and ½ of these will be instructed in a simple (10 min/day) exercise program for their neck. One third of the participants will serve as a control group. After an 8 week period the forms and measurements will be repeated. At that time the exercise or education sessions will be offered to those employees who did not receive them initially. As part of the study a review of the physical set-up of each workstation will be performed and suggestions made for improving the set up if appropriate. In addition a smaller subgroup (30%) of individuals will be asked to participate in sessions which would be videotaped for 15 minutes during the first and last hour of one workday.

To conduct this study I am looking for 90 subjects within the Erie community. While this does involve time during the workday for your employees it is my hope that you will see a benefit to your employees in the provision of education and exercise instruction, and a review of their workstation set-up. There may also be a benefit to the employer in possible decreased lost work days related to neck symptoms. I have received approval for this research project from the IRB at Gannon University as well as the Human Research Oversight Board at Nova Southeastern University in Florida. I would be happy to meet with you to discuss your company's involvement in this project and to share with you my dissertation proposal, and subject consent forms.

Thank you for your consideration,

Donna Skelly, PT, MS, OCS
Assistant Professor
Doctor of Physical Therapy Program
Gannon University
109 University Square
Erie, PA 16541-0001
Skelly001@gannon.edu
(814) 871-7505

APPENDIX H

Employer Letters of Intention to Participate

KNOX McLAUGHLIN GORNALL & SENNETT

Attorneys & Counselors

A Professional Corporation

120 West Tenth Street
Erie, Pennsylvania 16501-1461
814-459-2800
814-453-4530 (fax)

www.kmgslaw.com

June 27, 2011

Donna Skelly, Assistant Professor
Gannon University
109 University Square
Erie, PA 16541-0001

RE: Research Study

Dear Ms. Skelly:

This letter confirms our discussion regarding your research study on neck symptoms in computer users titled "Neck Symptoms, Disability, Posture and Muscle Function in Computer Users, and the Effect of Education versus Education and Deep Cervical Flexor Exercise". Our firm employs approximately 50 individuals who utilize a computer workstation on a regular basis. Knox McLaughlin Gornall & Sennett, P.C. will allow you to recruit subjects for your study from our employees following approval for the study by the Human Research Oversight Board of Nova Southeastern University.

You may contact me via email once you are able to proceed with the study to arrange for a recruitment letter/notice to be sent to our employees.

Very truly yours,

KNOX McLAUGHLIN GORNALL & SENNETT, P.C.

By: Tamara S. Philabaum
Tamara S. Philabaum
Director of Administration

GANNON
UNIVERSITY

Human Resources Department
109 University Square
Erie, Pennsylvania 16541-0001
(814) 871.7351 • fax (814) 871.7514
www.gannon.edu

INTEROFFICE MEMO

TO: Donna Skelly

FROM: Bob Cline

DATE: June 20, 2011

SUBJECT: Dissertation Project

This is to respond to your request for permission to solicit Gannon University Colleagues to volunteer to be subjects in a study you are conducting in connection with your PH.D. research.

Our conversation helped clarify the time commitment required of volunteers and it seems like a reasonable proposal that Gannon University will support. Yes, let's do this at Gannon. Please send me a draft in advance of the portal announcement or paper solicitation.

Good luck with the survey. I will encourage the Human Resources Department staff to participate.

Thank you.

Bob Cline

Believe. . .

Hamot

Hamot Health Foundation
201 State Street
Erie, PA 16550
(814) 877-6000
www.hamot.org

Donna Skelly, PT, MS, OCS
Assistant Professor
Gannon University
109 University Square
Erie, PA 16541-0001

Dear Ms. Skelly;

This letter confirms our discussion regarding your research study titled "Neck Symptoms, Disability, Posture and Muscle Function in Computer Users, and the Effect of Education versus Education and Deep Cervical Flexor Exercise". UPMC Hamot employs over 3400 individuals, and approximately 60 % of these employees utilize a computer workstation at least 4 hours per day. UPMC Hamot will allow you to recruit subjects for your study from our employees following approval for the study by the Human Research Oversight Board of Nova Southeastern University.

Please contact Brian Hammer, Manager of Employee Safety and Wellness at 877-4689 once you are able to proceed with the study, to arrange for a recruitment letter/notice to be sent to our employees.

Sincerely,

Christopher J. Kovski, JD
Executive Director Human Resources

LOGISTICS+™
"PASSION FOR EXCELLENCE"
1406 Peach Street
Erie, PA 16501 USA

Donna Skelly
Doctor of Physical Therapy Program
Gannon University
109 University Square
Erie, PA 16541

July 17th 2011

Dear Donna,

Please allow this letter to serve as confirmation of our interest to participate in your study and your ability to recruit our employees as subjects. We have 65 Employees here at our Corporate Headquarters that use a computer workstation at least 4 hours of their workday. Please work with Julie Slomski (814-461-7638-julie.slomski@logisticsplus.net), our Human Resources Manager to coordinate.

Best Regards,

Jim Berlin
CEO
814-461-7604
Jim.berlin@logisticsplus.net

C-TPAT
Customs-Trade Partnership Against Terrorism

ZURN®

Donna Skelly, PT, MS, OCS
Assistant Professor
Doctor of Physical Therapy Program
Gannon University
109 University Square
Erie, PA 16541-0001

September 6, 2011

Dear Ms. Skelly;

This letter confirms our discussion regarding your research study titled "Neck Symptoms, Disability, Posture and Muscle Function in Computer Users, and the Effect of Education versus Education and Deep Cervical Flexor Exercise". Zurn Industries employs ~200 individuals, and approximately 114 of these utilize a computer workstation at least 4 hours per day. Zurn will allow you to recruit subjects for your study from our employees following approval for the study by the Human Research Oversight Board of Nova Southeastern University.

Please contact Ginger Cartright, Senior Environmental Health & Safety Coordinator once you are able to proceed with the study, to arrange for a recruitment letter/notice to be sent to our employees.

Ginger Cartright
Zurn Industries, LLC
Senior EHS Coordinator

ZURN INDUSTRIES, LLC - SPECIFICATION DRAINAGE OPERATION
1801 PITTSBURGH AVENUE, ERIE, PA 16502-1916 PHONE: 814/455-0921 FAX: 814/875-1402
www.zurn.com

APPENDIX I

Recruitment Flyers

Recruitment Flier

Computer Users

Do you have mild discomfort, pain, stiffness or tenderness in your neck?

Do you work at a computer at least 4 hours of your workday?

Are you interested in participating in a research study?

Donna Skelly, a faculty member from Gannon University's physical therapy program, and doctoral candidate at Nova Southeastern University is seeking subjects for a study that will explore neck symptoms in individuals who have not had medical treatment for these symptoms over the past year. If you are 18-65 years old and have not had neck surgery or other medical problems affecting the nerves or muscles in your neck, you are eligible to participate.

The study will involve filling out forms (15- 20 minutes) related to your symptoms, and having measurements taken of your neck positions and muscles (15-20 minutes). You may be selected to participate in an 8 week exercise program that will take about 10 minutes to perform each workday, and you may receive a 10-15 minute educational session. The physical set up of your work area may be assessed, and any suggestions for change will be provided to you. Some of you will be asked to agree to be videotaped for 15 minutes at the beginning and end of your workday. All participants will complete the forms and measurements again after an 8 week period. If you are not selected for the exercise/education programs or the workstation assessment you will have the opportunity to request these after the 8 week study has been completed.

If you are interested or have questions about this study please contact Donna Skelly, PT at (814)871-7505, or skelly001@gannon.edu

APPENDIX J

Consent Forms

Consent Form for Pilot Reliability Study

Neck Symptoms, Disability, Posture and Muscle Function in Computer Users, and the Effect of Education versus Education and Deep Cervical Flexor Exercise

IRB #: 09021101Exp.
Funding Source: Gannon University, Gannon IRB #11-04-05

Principal Investigator
Donna Skelly, PT, MS, OCS
109 University Square
Erie, PA 16541
(814) 871-7505

Co-investigator
Leah Nof, PT, MS, PhD
3200 S. University Drive
Ft. Lauderdale, FL 33328
(954) 262-1276

Co-investigator
Dr. Carlos Ladeira
Nova Southeastern University
3200 South University Drive

Fort Lauderdale, FL 33328-2018
2018
(954) 262-1271

Co-investigator
Dr. John Echternach,
Nova Southeastern University
3200 South University Drive

Fort Lauderdale, FL 33328-

301-704-4753

For questions/concerns about your research rights, contact Dr. Clark, chair of the Gannon University IRB at (814) 871-7000 (clark021@gannon.edu) or the Human Research Oversight Board, Nova Southeastern University toll free, (866) 499-0790 (IRB@nsu.nova.edu).

What is the pilot study about?
The purpose is test the reliability of measurements to be used in the main study.

Why are you asking me?
To be included in the pilot study you will need to be between 18 and 65 years old, and speak English. If you have received treatment from a doctor, nurse practitioner, physician assistant, physical therapist or chiropractor for your neck within the past year, or if you have had surgery on your neck you are not eligible for this study.

What will I be doing if I agree to this?
Measurements will be taken of your neck position using a plastic frame that is placed on your head (similar to a wearing a pair of glasses) while you are sitting at a desk. You will be asked to lie down on a portable table, and 2 tests will be done for your neck muscles, one where you push into a pillow behind your neck 5-6 times, and one where you lift your head from the table and hold it as long as you can (typically less than a minute). All measurements will be taken twice. Small stickers will be placed on one ear and the base of your neck, and you will be asked to sit at a desk and perform computer activities during the videotaping. A camera will be set on a tripod 5 feet from the desk, and will be started and stopped by the researcher; however the camera will be unattended during a 10 minute period. These measurements will take about 30 minutes.

What are the dangers to me?
None of the activities in this pilot study are considered experimental or invasive; all are considered standard practice and may be used by physical therapists in the management of neck

symptoms. You will be exposed to no more than minimal physical or mental stress. There is no penalty or loss of benefits to you if you choose not to participate, or if you change your mind after agreeing to participate. Your information collected as part of this study will not be shared with anyone else other than those overseeing the study. Confidentiality cannot be guaranteed, however the researcher will make every attempt to maintain confidentiality of all data collected.

Are there any benefits to me for taking part in this research study?
No

Will I get paid for being in the study? Will it cost me anything?
No

How will you keep the information private?
Any information that you provide will be kept confidential, only the researcher and a research assistant will have access to the information. Paper files will be kept in a locked file in a locked office at Gannon University; all electronic files will be password protected on a secured server at Gannon University. The IRB, regulatory agencies or Dr. Nof may review research records. Records will be destroyed 5 years after the study ends.

What if I don't want to participate in this part of the study, or want to leave after I agree?
You may withdraw your agreement to participate in this portion of the study at any time without penalty, and may request that the video footage be destroyed at that time. If you choose to withdraw, any information collected about you **before** the date you leave the study will be kept in the research records for 5 years from the conclusion of the study and may be used as a part of the research.

Other Considerations
If significant new information relating to the study becomes available, which may relate to your willingness to continue to participate, this information will be provided to you by the investigators.

By signing below, you indicate that:

- this pilot study has been explained to you
- you have read this document or it has been read to you
- your questions about this research study procedure have been answered
- you have been told that you may ask the researchers any study related questions in the future or contact them in the event of a research-related injury
- you have been told that you may ask Institutional Review Board (IRB) personnel questions about your study rights
- you are entitled to a copy of this form after you have read and signed it
- you voluntarily agree to participate in the study entitled *Neck Symptoms, Disability, Posture and Muscle Function in Computer Users, and the Effect of Education versus Education and Deep Cervical Flexor Exercise*

Participant Signature ____________________________________ Date ____________

Participant Name (Print) ____

Signature of Person Obtaining Consent _________________________ Date ________

Consent Form for Participation in the Research Study
Neck Symptoms, Disability, Posture and Muscle Function in Computer Users, and the Effect of Education versus Education and Deep Cervical Flexor Exercise

IRB #: 09021101Exp.
Funding Source: Gannon University, Gannon IRB #11-04-05

Principal Investigator
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Co-investigator
Dr. Carlos Ladeira
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Fort Lauderdale, FL 33328-2018
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Dr. John Echternach,
Nova Southeastern University
3200 South University Drive

Fort Lauderdale, FL 33328-

301-704-4753

For questions/concerns about your research rights, contact Dr. Clark, chair of the Gannon University IRB at (814) 871-7000 (clark021@gannon.edu) or the Human Research Oversight Board, Nova Southeastern University toll free, (866) 499-0790 (IRB@nsu.nova.edu).

What is the study about?
The purpose is to learn more about neck symptoms and positions in office workers who use computers, and how exercise and /or education can affect these symptoms.

Why are you asking me?
To be included in the study you will need to be between 18 and 65 years old, speak English, use a computer at least 4 hours of your workday, and have some discomfort, pain, stiffness or tenderness in your neck within the past 3 months. If your neck symptoms are so bothersome that you have received treatment from a doctor, nurse practitioner, physician assistant, physical therapist or chiropractor within the past year, or if you have had surgery on your neck, or an injury to your neck requiring medical treatment you are not eligible for this study. Certain other medical diagnoses including fibromyalgia, rheumatoid arthritis or other nerve/muscle disorders may also limit your participation in this study.

What will I be doing if I agree to be in the study?
You will fill out papers about your neck symptoms, medical history related to your neck, computer use, and satisfaction with your job. Measurements will be taken of your neck position using a plastic frame that is placed on your head (similar to a wearing a pair of glasses) while you are sitting at your desk. You will be asked to lie down on a portable table, and 2 tests will be

done for your neck muscles, one where you push into a pillow behind your neck 5-6 times, and one where you lift your head from the table and hold it as long as you can (typically less than a minute). These measurements will take about 20 minutes. You may be asked to perform some simple neck exercises for 3 minutes, 3 times a day for 8 weeks and/or be given some education about positioning while at work. A researcher may assess your workstation to see if there are any suggestions for changing the set up. If you are selected for the control group you will not receive the exercises, educational session, or workstation assessment during the study, however after it has been completed you may request any of these. Over the next 8 weeks a research assistant may contact you at work to see if you have any questions. All measurements will be taken again at the end of the 8 weeks. You may be asked if you will agree to participate in an additional aspect of the study which involves two 15 minute sessions of videotaping you working at your desk during the first and last hours of your workday. Small stickers will be placed on one ear and the base of your neck, and you will be asked to remain at your desk and perform your normal work activities during the videotaping. A camera will be set on a tripod 5 feet from your desk, and will be started and stopped by the researcher; however the camera will be unattended during the 15 minute periods.

What are the dangers to me?
None of the activities in this study are considered experimental or invasive; all are considered standard practice and may be used by physical therapists in the management of neck symptoms. You will be exposed to no more than minimal physical or mental stress. There is no penalty or loss of benefits to you if you choose not to participate, or if you change your mind after agreeing to participate. Your information collected as part of this study will not be shared with your employer, or anyone else other than those overseeing the study. Confidentiality cannot be guaranteed, however the researcher will make every attempt to maintain confidentiality of all data collected.

Are there any benefits to me for taking part in this research study?
Potential benefits include decreased neck symptoms and improved awareness of what you can do to manage future neck symptoms.

Will I get paid for being in the study? Will it cost me anything?
There are no costs to you or payments made for participating.

How will you keep my information private?
Any information that you provide will be kept confidential, only the researcher and a research assistant will have access to the information. Results will be presented in group format without names. A general report will be provided to your employer summarizing suggestions made (without names) for the work station set ups following completion of the study. Videotapes will be viewed only by the primary researcher and/or research assistant to obtain measurements, and will not be utilized for any other purpose. Paper files will be kept in a locked file in a locked office at Gannon University; all electronic files will be password protected on a secured server at Gannon University. The IRB, regulatory agencies or Dr. Nof may review research records. Records will be destroyed 5 years after the study ends.

What if I do not want to participate or I want to leave the study?
Your participation in this study is voluntary. You have the right to leave at any time, or to refuse to participate without penalty. You can contact Donna Skelly (skelly001@gannon.edu) or (814) 871-7505 if you have any questions, or to withdraw from the study. If you choose to withdraw, any information collected about you **before** the date you leave the study will be kept in the research records for 36 months from the conclusion of the study and may be used as a part of the research.

Other Considerations
If significant new information relating to the study becomes available, which may relate to your willingness to continue to participate, this information will be provided to you by the investigators.

Voluntary Consent by Participant:
By signing below, you indicate that

- this study has been explained to you
- you have read this document or it has been read to you
- your questions about this research study have been answered
- you have been told that you may ask the researchers any study related questions in the future or contact them in the event of a research-related injury
- you have been told that you may ask Institutional Review Board (IRB) personnel questions about your study rights
- you are entitled to a copy of this form after you have read and signed it
- you voluntarily agree to participate in the study entitled *Neck Symptoms, Disability, Posture and Muscle Function in Computer Users, and the Effect of Education versus Education and Deep Cervical Flexor Exercise*

Participant Signature ____ Date ____________

Participant Name (Print) ____

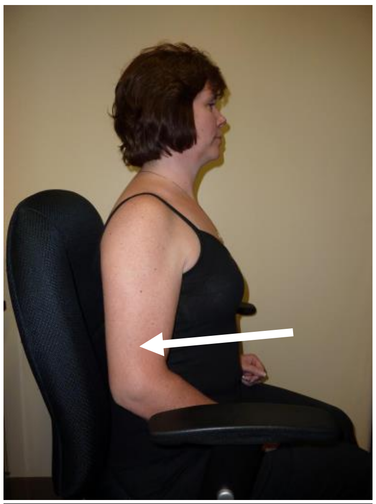
Signature of Person Obtaining Consent ____________________________ Date ___________

APPENDIX K

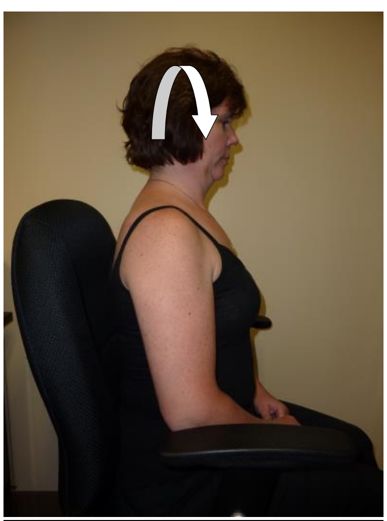
Exercise Program

Exercise Program

1. **Shoulder Squeeze (Scapular Adduction/Retraction) –** sit up straight, pushing your chest forward, with elbows at your side. Squeeze your shoulder blades together tightly without shrugging your shoulders (think about trying to push your elbows downward as you squeeze).



2. **Nods (Upper Cervical Flexion) -** sit up straight, pushing your chest forward. Nod your head (as if indicating "yes") as far as you can without moving your neck and hold it tightly without tensing the muscles in the front of your neck.



3. **<u>Pull Backs (Neck Retraction) –</u>** sit up straight, pushing your chest forward. Pull your head and neck backward as far as you can while looking straight ahead (don't tip head up or down).

Participants will be instructed in the three exercises with demonstration and practice with instructor feedback on performance. They will be asked to hold each position for 5 seconds with a 5 second rest period between, 5 repetitions each, 3 times a day. They will be given the pneumonic "3553" for 3 exercises, 5 seconds on/off, 5 repetitions, 3 times a day to recall the exercise program.

The exercise log will be provided as shown below in two week increments, and they will be asked to keep the log on their desk and check the box each time the exercises are performed.

Exercise Log (2 weeks) **ID Code ________**

	M	T	W	Th	F	S	S	M	T	W	Th	F	S	S
1														
2														
3														

APPENDIX L

Educational Program

Educational Program

Each participant will be instructed on the following information

- The importance of good posture to minimize stress to the joints and muscles of the neck while working will be explained as follows: Attention to posture may result in decreased symptoms in the neck and shoulders. When performing work at a computer there is a tendency for an individual to slouch the back and shoulders, and allow the head to fall forward. Maintaining this posture for long periods of time can increase stress to the muscles around the neck and shoulders and is associated with increased discomfort. Paying attention to your posture while working can minimize this stress to your muscles and joints.

- A demonstration by the instructor in “poor” versus “good” posture

“Good” Posture

“Poor” posture

- Verbal instruction with tactile cues for the individual to sit back in the chair, roll the pelvis forward so they are sitting on the ischial tuberosities instead of the sacrum, with a lumbar lordosis, pulling the scapula down and back and lifting the sternum upward, and raising the occiput to create slight upper cervical flexion. This will be explained in lay terms of “sit all the way back in the chair, have a slight arch in your lower back, pull your shoulders down and back, lift your chest forward and lengthen your neck by lifting the back of your head.” Tactile cueing will occur at the low back, shoulder blades, upper chest, occiput and chin.

- If lumbar support is not provided by the individual's chair instruction will be provided to obtain a lumbar cushion or towel roll for additional support.
- Practice will occur with each individual sitting relaxed/slouched then sitting up in the instructed manner 3 times
- Business size cue cards with the word "Posture" will be provided to be fixed to a visible spot at the computer workstation
- Individuals will be asked to correct their posture throughout the day as often as possible

APPENDIX M

Copyright Authorizations

for

Table 1 and Neck Disability Index

Copyright Authorizations

Authorization to Copy Table 1 (p 23)

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Authorization to Copy Neck Disability Index

E-mail correspondence received Thursday, July 29th, 2010

Hello,

Thank you for your message and for your interest in the NDI. Of course, you have my permission to use it in your research and to copy it in your thesis appendices. However, please don't copy it in any publications that arise from this work.

I would be interested in learning what your thesis and research is about.

Good luck with your work.

Dr. Howie Vernon

>>> "Skelly, Donna L" <SKELLY001@gannon.edu> 07/28/10 5:38 PM >>>

Dr Vernon,

I am writing to request permission to utilize a copy of the Neck Disability Index in a dissertation (currently at the proposal stage) for a PhD program in physical therapy at Nova Southeastern University, Florida. I am referencing your 1991 and 2008 articles from the Journal of Manipulative and Physiological Therapeutics in a study on neck pain in computer users, and would like to include a copy of the NDI in the appendices of the dissertation report, and utilize the tool in the study.

Thank you for your consideration,

Donna Skelly, PT, OCS
Assistant Professor
Gannon University
Doctor of Physical Therapy Program
Erie, PA, USA
(814) 871-7505

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