The influence of pain and pain-related fear on muscle activation in the neck/shoulder of female office workers with pain during computer work

Gabrielle Adam

A Thesis
in
The Department
of
Exercise Science

Presented in Partial Fulfillment of the Requirements
for the Degree of Master of Science (Exercise Science) at
Concordia University
Montreal, Quebec, Canada

April 2015

CONCORDIA UNIVERSITY

School of Graduate Studies

This is to certify that the thesis prepared

By: Gabrielle Adam

Entitled: The influence of pain and pain-related fear on muscle activation in the neck/shoulder of female office workers with pain during computer work

and submitted in partial fulfillment of the requirements for the degree of

Master of Science (Exercise Science)

complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Signed by the final Examining Committee:

Dr.Andreas Bergdahl ______ Chair
Chair's name

Dr.Julie Côté ______ Examiner
Examiner's name

Dr.Richard Courtemanche ______ Examiner
Examiner's name

Dr.Geoffrey Dover ______ Co-supervisor
Co-supervisor's name

Dr.Nancy St-Onge ______ Co-supervisor
Co-supervisor's name

Approved by ______________________________

Chair of Department or Graduate Program Director

______________ 2015 ______________________________ Dean of Faculty

ABSTRACT

The influence of pain and pain-related fear on muscle activation in the neck/shoulder of female office workers with pain during computer work

Gabrielle Adam

Neck/shoulder musculoskeletal disorders in computer workers are a significant problem. Fear-avoidance has been correlated to work-related injuries. No study to date has measured the relationship between pain-related fear and muscle activity in the painful neck/shoulder during a computer task. Our research clarifies the relationship between pain-related fear, pain and muscle activity of the neck/shoulder in female office workers with pain and disability during a computer task. Twenty-six subjects volunteered for the study. Muscle activity was measured at the trapezius muscle during three computer tasks: typing, mousing and typing-and-mousing. All participants filled out pain-related fear questionnaires. Initial pain was measured before testing using a visual analog scale and evoked tenderness was measured after the computer tasks at the muscle recording locations. There was higher muscle amplitude and lower muscle rest in tasks involving typing (RMS: $F(2,40)=34.99$ $p<.001$; RRT $F(2,42)=43.05$ $p<.001$). There was a correlation between disability and muscle amplitude for the left trapezius during typing ($r_s=.495$, $p=.019$). There was a relationship between fear-avoidance beliefs and evoked tenderness at the trapezius (right: $r_s=.442$, $p=.039$; left: $r_s=.471$, $p=.027$) and a significant relationship between catastrophizing and evoked tenderness at the left UT ($r_s=.568$, $p=.006$). However, there was no relationship between pain and muscle activity. The relationship between fear-avoidance and evoked tenderness suggests that pain-related fear may be a factor in a painful muscle. Office workers with neck/shoulder pain should attempt more mousing activities compared to typing to reduce muscle activity. As well, addressing pain-related fear in treatments may be beneficial to patient outcome.

Acknowledgements

First of all, I would like to thank my supervisors, Dr.Geoffrey Dover and Dr.Nancy St-Onge, for their continual guidance and support. It was truly a pleasure to work with both of these two researchers and to get to know them as individuals. I would also like to thank the institut de recherche Richard-Sauvé en santé et en sécurité au travail (IRSST), Concordia University, Nexans, la corporation des thérapeutes du sport du Québec (CTSQ) and the centre de recherche interdisciplinaire en réadaptation du Montréal métropolitain (CRIR) for funding which supported me throughout the master's and allowed me to focus on the research and travel to conferences in Canada and the US. I would also like to thank Concordia University Support Staff Union, Jacques Adam and Nancy Ann Fex for assisting with recruitment. As well, I would like to thank committee members Dr.Julie Côté and Dr.Richard Courtemanche for being apart of the committee and for their research knowledge and expertise. In addition, I would like to express gratitude to Hana MacDougall who was at the front lines with me and whose help and support was invaluable. I would also like to thank Jacqueline Faribault who helped with all the data reduction. As well, I would like to thank Sofia DiGirolamo with whom I received the introduction into this research. Last but not least, I would like to acknowledge those who were in the "background" and yet who contributed to enriching this experience and walked this path alongside me: my parents, fellow master students and friends.

Table of Contents

List of figures

List of tables

Abbreviations

(CP) Cervical paraspinal

(EMG) Electromyography

(FABQ) Fear Avoidance Belief Questionnaire

(FPQ) Fear of Pain Questionnaire

(LT) Lower Trapezius

(MT) Middle Trapezius

(NDI) Neck Disability Index

(PCS) Pain Catastrophizing Scale

(RMS) Root mean square

(RRT) Relative rest time

(TSK) Tampa Scale of Kinesiophobia

(UT) Upper Trapezius

(VAS) Visual analog scale

The influence of pain and pain-related fear on muscle activation in the neck/shoulder of female office workers with pain during computer work

INTRODUCTION

The incidence rate for developing chronic neck/shoulder pain is two to three times higher for computer workers compared with the general population.[1-3] Sixty-seven percent of computer workers develop neck/shoulder pain.[1,4] Chronic pain affects all facets of life and well-being including motor function, sleep, activity level, and mood.[5,6] The development from acute pain to chronic pain is unclear making good treatment options difficult.[7]

The relationship between muscle activity and pain is unclear. For example, an increase in muscle activity in the painful muscle has been reported which supports the pain-spasm cycle.[8-10] However, other studies reported opposite results supporting the pain-adaptation theory.[11,12] In people with hypertonic saline injections, electromyographic (EMG) activity decreased in the painful agonistic muscle.[13] These conflicting results suggest there might be other factors that are influencing muscle activity in a painful situation.

Pain-related fear has been correlated to work-related injuries and has the possibility of influencing muscle activity in a painful condition.[14-17] In the fear-avoidance model, avoidance leads to disability and increased fear over time creating a vicious cycle.[7] For example, in workers, pain-related fear accounted for the greatest amount of variance in disability scores at 4-weeks compared to pain, physical impairment and initial disability.[14] There are few studies, however, that have evaluated the relationship between muscle activity during computer work and psychological factors . Most of the previous studies evaluated low back pain.[18-20,21] The relationship between these psychological factors and muscle activity in the neck/shoulder is unknown.

The purpose of this study was to investigate the relationship between muscle activity, fear-avoidance and pain in female office workers with neck/shoulder pain during a computer task.

1. LITERATURE REVIEW

1.1 Epidemiology

Neck/shoulder pain prevalence and incidence in the general population

Neck/shoulder pain is a common debilitating complaint throughout the population affecting over half of the general population. It was the most common health problem in a study done in 2006.[22] Out of a general population sample of over 3,500 people, 40% currently had neck/ shoulder pain.[22,23] The annual incidence for neck/shoulder pain in the general population was between 14.6% and 17.9%.[2 3]

As well as neck/shoulder pain being a common complaint, it is also hard to get rid of once you've had neck/shoulder pain once. People with previous neck/shoulder pain were more likely to develop future neck/shoulder pain. A person with a previous history of neck/shoulder pain was almost twice as likely to have recurrent neck/shoulder pain (31.7%) compared with a person who did not have a history of neck/shoulder pain (17.1%).[2] Neck/shoulder pain is a chronic problem that can affect a person for the rest of their life.

Work-related neck/shoulder pain

Neck/shoulder pain is prevalent not only in the general population but also in workers from all different professions including laborers, technicians and office workers. Almost 63% of Quebec workers, approximately 2 244 000 workers, polled by EQCOTESST in 2011 experienced pain in the past 12 months that affected their daily living of which the neck/shoulder accounted for 54.3% and was one of the four most frequent sites of pain.[4] In another study, roughly 30% of men and women with neck/shoulder and high back pain felt their daily life was limited due to the pain.[23] Neck/shoulder pain affected more women in non-manual work compared with manual work (11,1 % vs 9,6 %).[4] Within the non-manual work, most neck/shoulder pain in women occurred in office workers (13.7%) and professionals (12.5%).[4]

If we look specifically at computer workers, the incidence for neck/shoulder pain is approximately two times higher compared with the general population in studies completed in between 2001 and 2009.[1-3] Sixty-seven percent developed neck/shoulder pain[1]. Of the computer workers who have neck/shoulder pain, 62% also had pain at the upper extremity.[1] Neck/shoulder pain affected over two thirds of computer workers and many had neck and upper extremity pain combined.

The health problem most frequently associated with working conditions was neck/shoulder pain compared to low back pain, arm pain and fatigue.[22] Workers frequently associated their pain, more specifically neck/shoulder pain, as work-related. Thirty-eight percent of workers who had neck/shoulder pain associated their pain with work.[22]

Association between computer use and neck/shoulder pain

The specific aspects of computer use have been investigated to determine what contributes to neck/shoulder pain in computer workers. Results from questionnaires sent to 1700 women suggested that of those who performed a task with a high degree of repetitiveness, 31%-57% developed neck/shoulder pain.[24,25] Computer use can be a very repetitive task leading to the development of neck/shoulder pain.

There was an association between time at a computer and neck/shoulder pain. Women who spent more than 31 hours at a computer experienced more neck/shoulder pain than other women (13.8% compared with 6.8%).[4] Women who used a computer 100% of the time were more than 50% as likely to develop neck/shoulder pain compared with women who spent less than a quarter of their time working at a computer.[26] For workers at a computer for more than 2 hours or entering data/text for more than 3h, there was an increase in the likelihood of developing pain.[1] Computer use without a break for more than 3h a few times a week also corresponded with an increased likelihood for neck/shoulder pain.[1] Those who performed fewer than 2 work tasks had an increase odds ratio for neck/shoulder pain.[1]

There was also a significant relationship specifically between increased keyboard use and neck/shoulder pain.[27] Of women in non-manual occupations who used a keyboard (ie typist), 22.9% had neck/shoulder pain compared with 18.3% who did not use a keyboard (other office worker).[27] People who regularly used a keyboard were at an increased risk of developing neck/shoulder pain.

However, in several studies, there was no association reported between computer use and neck/shoulder pain. Computer duration and musculoskeletal symptoms were not significantly associated for men while mouse use was only significant in the development of hand-wrist symptoms but not in the development of neck/shoulder symptoms.[26] Sex was a significant factor in the development of neck/shoulder symptoms, which could explain why the study, where men and women were pooled together in the analysis, did not find a significant relationship between computer use and neck/shoulder symptoms. Mouse use in comparison with other computer tasks, such as typing, is a different movement and perhaps puts less strain on the neck/shoulder compared with the wrist and hand. This could explain why mouse use was only significant for hand and wrist symptoms. There was no association between length of time at a computer and neck/shoulder pain in another study.[24] In this study, men and women were grouped together. As previously stated, sex was a significant factor and may have led to a lack of significant results in this study.

Although, in studies, there were different results regarding a relationship between computer use and neck/shoulder pain, there did seem to be moderate evidence for a relationship.

Women vs. men neck/shoulder pain prevalence, incidence

Since sex is a factor in the development of neck/shoulder pain, we will look at this more in depth. Women were almost twice as likely to have neck/shoulder pain compared with men in the general population and in computer workers.[23,25] The neck/shoulder accounted for 42%-53% of current musculoskeletal pain in women computer workers while in men accounted for 23%-27%.[25] The annual incidence for neck/shoulder pain for women in the general population and in computer workers was 16.9% and 25.5% respectively compared with 10.0% and 15.4% for men.[2,3,24] Women workers more than men experienced neck/shoulder pain all the time or often according to the EQCOTESST report (39.3% versus 26.5%).[4] In another study, the incidence of neck/shoulder pain in women versus men, after 6 months at a new computer job, was 42% for women compared with 27% for men and at 12 months the incidence was 48% for women and 36% for men.[28]

Proportionally more women than men believed their neck/ shoulder pain was attributable to their work: 45% of women and 32% of men perceived their pain to be work-related.[22] The work-related fraction (ratio between prevalence of work-related health problems to health problems) was highest for neck/shoulder pain for both women (74%) and men (73%).[22]

1.2 Fear-avoidance

Fear-avoidance model

The fear-avoidance model explains how acute pain becomes chronic pain.[7] It is concerned with the perception of pain.[29] Fear of pain and subsequent pain avoidance are central to the fear-avoidance model.[29] There are two coping responses to the painful experience shown in figure 1: confrontation and avoidance.[29] Confrontation leads to reduction of pain over time and is characterized by someone who views their pain as temporary, who is motivated to return to work, leisure and social activities, and progressively increases their activities while gauging and testing their pain.[29] Avoidance leads to maintenance or an increase in fear over time and is characterized by someone who is motivated to avoid exposure to their pain.[29] Fear is an emotional reaction to an immediate threat while pain encompasses psychological and social aspects as well as pathological.[30,31] Fear of pain is made up of psychophysiological, behavioural, and cognitive elements.[30] The four components of the fear-avoidance model are: catastrophizing, fear of pain, fear of movement and fear-avoidance beliefs. In the avoidance pathway, pain is experienced followed by catastrophizing, fear of pain, fear of movement and avoidance leading to disability.[7] Catastrophizing is defined as exaggerated negative thoughts about pain.[32] Fear of pain refers specifically to the fear and anxiety associated with pain whereas fear of movement refers to a specific fear of movement.[33,34] Fear avoidance refers to a person's beliefs about pain and subsequent avoidance behaviour.[35] Recently, aspects of the fear-avoidance model have been called into question specifically, the simplicity of the model.[36,37] Wideman questions the sequential aspect of the fear-avoidance model opting more for a cumulative effect.[36] Crombez also questions fear of pain being the only thing motivating people when perhaps a more complex relationship exists between people's goals and fear of pain.[37] For the remainder of the document, we will refer to fear-avoidance or pain-related fear to denote the psychological factors associated with a chronic injury.[38]

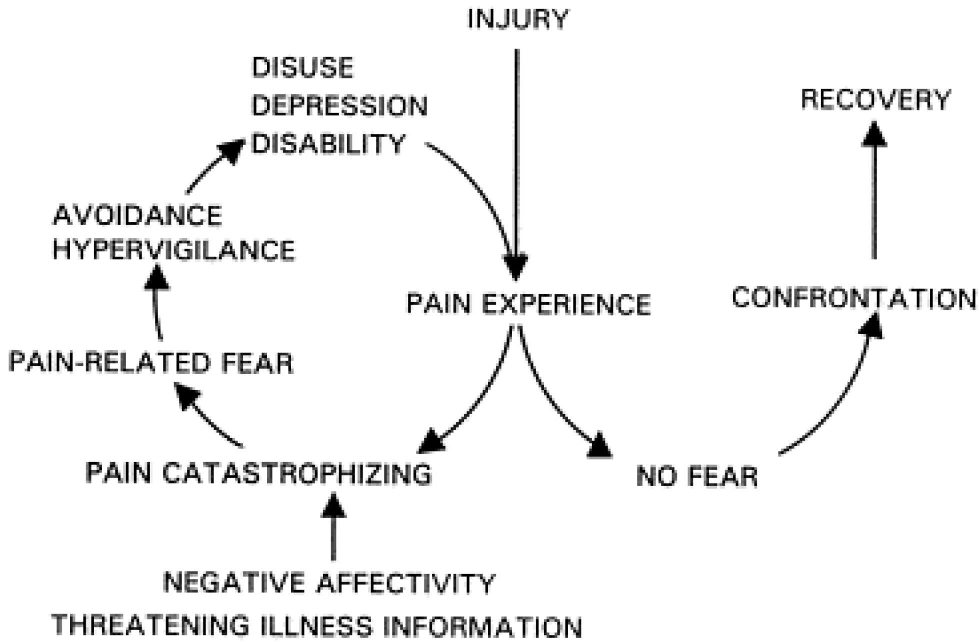


Figure 1: Fear-avoidance model: In the avoidance pathway, pain is seen as a threat and pain-related fear develops. This leads to avoidance which fuels disability and leads to a vicious cycle of increase fear, avoidance and disability.[39]

Fear-avoidance questionnaires

There were four questionnaires developed to measure the four components of fear-avoidance. Catastrophizing is measured with the Pain Catastrophizing Scale (PCS). Fear of pain is measured with the Fear of Pain Questionnaire (FPQ-III). Fear of movement is measured with the Tampa Scale for Kinesiophobia (TSK-DV) and fear-avoidance beliefs are measured with the Fear-Avoidance Beliefs Questionnaires (FABQ). We used these four questionnaires because together they have been cited over 2,300 times.

Sullivan developed and validated a self-report scale for measuring catastrophizing: the PCS.[32] The PCS has been cited over 990 times to date. The PCS is a valid and reliable measure of catastrophizing and has the strongest association to pain and emotional distress. It was validated on both men and women from a healthy university student sample and from a clinical sample of men and women with nerve entrapment.[32] The PCS is a 13-item self-report questionnaire. For each of the 13 statements, a patient circles any number from 0-4 (0 = not at all, 4 = all the time). Total score range is 0-52. An example of a question is “I keep thinking about how badly I want the pain to stop." A score of 30 would be clinically relevant for catastrophizing (Sullivan PCS manual). However in Sullivan's study, catastrophizers were identified as scoring above 24 on the PCS (upper third of score distributions) and noncatastrophizers were identified as scoring below 15 (lower third of score distributions). Test-retest reliability was r = 0.75 in a sample of healthy student volunteers. In the study by Sullivan, the PCS was validated as a self-report measure of catastrophizing.[32] Healthy participants were identified as catastrophizers and noncatastrophizers following a screening procedure. Catastrophizers had a higher frequency of catastrophizing thoughts than noncatastrophizers (33.4 ± 6.53 for catastrophizers versus 6.6 ± 3.25 for noncatastrophizers). Catastrophizers reported significantly more pain as well as sadness, anxiety and anger during the 1-minute ice immersion test. There was also a significant degree of stability for catastrophizing scores on the PCS between screening and testing, which meant that without intervention catastrophizing remained stable over time. The third study by Sullivan aimed to validate the PCS in a clinical sample consisting of people with radiculopathy.[32] There were two groups, catastrophizers and noncatastrohpizers, as in the second study. Catastrophizers reported a higher frequency of catastrophizing thoughts than noncatastrophizers. Catastrophizers experienced higher ratings of pain (41.7mm ± 32.1 vs 12.8mm ± 13.4) and anxiety (43.7mm ± 29.9 vs 25.1mm ± 31.2) on 100-mm visual analog scales during the needle insertion and first shock. The fourth and final study by Sullivan set out to determine the amount of overlap between catastrophizing and other constructs.[32] The study compared the PCS with depression, anxiety, negative affectivity and fear of pain in terms of ability to predict pain responses and amount of redundancy between measures. There was a significant amount of overlap among the measures. However, only the PCS and FPQ (fear of pain questionnaire) were significantly correlated with pain and only PCS contributed a unique variance to pain. The PCS also had the strongest relationship to sadness, anger, and anxiety. From the above-mentioned studies, we can conclude that the PCS is a valid and reliable tool to measure the relationship between catastrophizing and pain.

McNeil developed a self-report measure for fear of pain.[33] The FPQ-III has been cited over 135 times. The FPQ-III is a reliable and valid tool to measure fear of pain. The FPQ-III comprises 30 short phrases describing painful experiences. A patient rates their level of fear on a 5 point scale (1 = not at all, 5 = extreme).[33] An example of a question is " How fearful are you of experiencing pain associated with being in an automobile accident." The FPQ-III measures fear of severe pain, fear of minor pain and fear of medical pain.[33] Total score range is 30-150. Test-retest reliability was 0.74 and internal consistency was 0.92 in a sample of healthy student volunteers. In McNeil's first study, the FPQ was administered to healthy students who were divided into high (top 5% of the distribution) and low (bottom 20-30% of the distribution) fear groups after screening. The high fear group reported greater avoidance and escape behavior times while watching a fear-provoking video (mean for high fear group: 22.5 ± 36.1, low fear group: 2.7 ± 11.9). The high fear group also had greater anxiety and greater pain severity ratings when recalling a previous worst pain experience. Mean scores for State-Trait Anxiety Inventory for high fear group were 49.2 and 37.5 for the low fear group. The total possible score range for State-Trait Anxiety Inventory is 20-80. In another study by McNeil, the validity of the FPQ was determined in a chronic sample.[33] The chronic group, many of whom had pain in the back or neck/shoulder, consisted of people who had pain for more than 6 months. There were two control groups: patient group without chronic pain and a healthy student group. The chronic pain group reported more fear of severe pain than either control group. However, pain varied across groups and individuals and not all people with pain will report greater fear of pain.

The TSK-DV, a scale for fear of movement/reinjury, was developed by Kori and further tested by Vlaeyen.[34,40] Vlaeyen's article has been cited over 217 times. Kinesiophobia is an excessive fear of movement and physical activity with the assumption that movement and physical activity will lead to reinjury.[40] The TSK-DV is a 17-item self-report. Each item is measured on a four-point scale (1= strongly disagree, 4= strongly agree). Scores range between 17 and 68. An example of a question is "Pain lets me know when to stop exercising so I don't injure myself." A score of 37 and above would mean someone has a high degree of kinesiophobia.[39] Reliability (internal consistency) is 0.77 in chronic low back pain patients. High fear people had a significant difference on the TSK-DV, catastrophizing and pain disability compared with low fear people.[34] High fear people scored 44.0 out of 68 for fear of movement, 15.3 out of 24 for pain disability and 51.5/52 for catastrophizing compared with low fear people who scored 33.3/68 for fear of movement, 10.7/24 for pain disability and 41.5/52 for catastrophizing. Catastrophizing compared with pain duration and pain intensity was the strongest predictor of fear of movement.[34] The study by Vlaeyen demonstrated the relationship between fear of movement and catastrophizing and that catastrophizing was the best predictor of fear of movement.

Waddell developed the FABQ about work and physical activity.[35] Waddell's article has been cited over 973 times. The FABQ is a 16-item self-report. Patients circle a number from 0-6 (0 = completely disagree, 6 = completely agree) for each statement. Scores range from 0-42 for FABQ-W (work) and from 0-24 for FABQ-PA (physical activity). An example of a question is "My pain is caused by physical activity." There is currently no cut-off score although a higher score indicates a higher degree of fear-avoidance beliefs (Williamson FABQ 2006). Test-retest reliability was 0.74 and internal consistency was 0.88 for FABQ-W and 0.77 for FABQ-PA in low back pain patients. FABQ-W significantly correlated with pain severity (0.23), work loss (0.55), disability (0.55) and psychological distress (depressive symptoms) (0.41). FABQ-PA significantly correlated with disability, 0.51, work loss (0.23) and depressive symptoms (0.36). From the study by Waddell, we can conclude that the FABQ is a valid and reliable tool to measure the relationship between fear-avoidance beliefs and pain, disability and work loss.

Muscle activity and psychological factors

Results suggest a relationship between muscle activity and psychological factors[18,21]. There was a significant positive relationship between the coping strategy catastrophizing and muscle activity during a walking task in patients with chronic low back pain.[21] There was an increase in EMG at the erector spinae with catastrophizing compared with the coping responses of distraction and persistence and control. Although the correlation between EMG and catastrophizing was small, 0.26, it was significant whereas there was no significant correlation between EMG and distraction, persistence or control. A person who scores higher for catastrophizing will have higher low back muscle activity. A positive correlation between muscle activity and depression (r=0.33), anxiety (r=0.31), pain-related anxiety (r=0.29) and catastrophizing (r=0.29) was reported in subjects with low back pain.[18] The task consisted of alternating between standing on a stadiometer and lying down on a bed. Significant correlations were reported between increased erector spinae muscle activity and increased catastrophizing[18,21]. Patients whose pain was more than 8/10 had muscle activity higher than 80% reference contraction.[18] There was a trend for muscle activity to be a mediator between pain and anxiety, depression, pain-related anxiety, and catastrophizing in the study by Lewis.

In another low back pain study, the relationship between fear of movement and muscle activity was investigated.[19] Higher muscle reactivity in terms of microvolts was predictive of increase in pain reporting during the performance task in the left erector spinae. The two performance tasks were: lifting a 5.5kg bag and stationary biking until pain or discomfort was felt. However, higher fear of movement was not predictive of higher muscle reactivity. A reason for the non-significance could be due to subjects not being screened for high and low fear of movement, and therefore did not choose people who had very high and very low scores.

The results of the study by Vlaeyen were less clear. However, there did seem to be a relationship between people with high fear of movement and muscle activity. The study by Vlaeyen had the smallest sample size compared to the study by Lewis and Van der Hulst.

There was an increase in EMG at the site of pain during a stressful image in a study by Flor.[20] The patients consisted of people with chronic upper and lower back pain and temporomandibular (TMJ) pain. The patients also complained of significantly more hassles than healthy controls: 42.5 ± 20 for back pain patients, 36.4 ± 24 for TMJ pain and 21.33 ± 10.7 for healthy controls. The patients also significantly scored the stressful images as more unpleasant and anxiety-provoking than the healthy subjects. Although, this last study by Flor didn't look at a specific psychological component of the fear-avoidance model, there was a relationship between muscle activity at the painful site and stress and anxiety, a cognitive element.

Disability and psychological factors

The relationship between injured workers and fear-avoidance beliefs has been examined in several studies.[14-17] FABQ-W significantly correlated with disability (0.55) while FABQ-PA also significantly correlated with disability (0.51) in patients with low back pain.[35] FABQ-W accounted for more variance (23%) for disability compared with pain intensity and duration (14%). FABQ-PA also contributed to variance for disability (9%). There was a significant correlation between disability and fear-avoidance beliefs, although only a low to moderate strength, in people with neck/shoulder pain and low back pain.[14,16] Thirty percent of disability variance at 4 weeks was accounted for by pain severity, physical impairment, initial disability, treatment and FABQ-W, which was significant.[14] The FABQ-W explained the greatest variability in disability scores after 4-weeks ($r^2 = 21\%$).[14]

Vlaeyen reported a significant correlation between TSK-DV and pain disability in chronic low back pain patients. Fear of movement/reinjury was the best predictor of disability versus pain duration, pain intensity or catastrophizing.[34] The only significant difference between high and low disabled subjects was in the TSK and catastrophizing. High disabled people scored 43.3 ± 4.9 versus 38.1 ± 7.0 for low disabled on the TSK-DV and 53.0 ± 9.9 versus 44.1 ± 14.3 for catastrophizing. High fear people had a significant difference on the TSK-DV, catastrophizing and pain disability compared with low fear people. High fear people scored 44.0 ± 4.6 for fear of movement, 15.3 ± 3.5 for pain disability and 51.5 ± 12.6 for catastrophizing compared with low fear people who scored 33.3 ± 3.4 for fear of movement, 10.7 ± 3.8 for pain disability and 41.5 ± 11.9 for catastrophizing. Catastrophizing compared with pain duration and pain intensity was the strongest predictor of fear of movement. The study by Vlaeyen demonstrated that fear of movement was more important than pain in predicting disability.

As well as a relationship between psychological factors and disability, there are also significant correlations between work loss, return to work and fear-avoidance beliefs in people with neck/shoulder and low back pain.[14,16,17] FABQ-W was the strongest predictor of work loss in low back pain patients in the past year accounting for 26% of the variance while pain only accounted for 5%.[35] One of the best predictor for 1-yr return to work for low back pain patients was FABQ-W (FABQ mean score for patients returning to work 25.5 ± 9.0 versus not returning to work mean score 33.6 ± 5.8).[17] Thirty-nine percent to 57% of return to work variance after four and six weeks in people with low back and neck/shoulder pain was accounted for by pain severity, physical impairment, initial disability, treatment and FABQ-W which significantly contributed to the variance.[14,16] Fear-avoidance beliefs were also higher in people with chronic low back and neck/shoulder pain who were receiving workers' compensation compared with automobile and private insurance which George speculated could be a result of fear associated with work-related activities as a result of injury at work.[15] These studies demonstrated the importance of fear-avoidance beliefs above and beyond pain in explaining work loss.

Fear-avoidance interventions

Since pain related fear has been so well related to painful conditions, clinicians have developed pain related fear interventions in order to facilitate rehabilitation. Graded in vivo exposure (GivE) involves education regarding the fear-avoidance model, interactive therapy sessions where an individualized hierarchy of fear-eliciting activities is designed and exposure to the fear-eliciting activities is done gradually throughout therapy sessions.[41] Graded activity (GA) is also an interactive therapy where activities that have been abandoned are identified. Treatment goals based on the suspended activities are established and a baseline for tolerance for each activity is determined. Subsequent therapy sessions involve gradually increasing the activity level starting at 70-80% of baseline tolerance. GA uses positive reinforcement while GivE uses both positive and negative reinforcement to modify behaviour. Acceptance and commitment therapy (ACT) is another therapy to address fear-avoidance. Patients are taught to acknowledge and accept their pain and are encouraged to choose to engage in satisfying activities despite pain. According to Bailey et. al., GivE is the most effective at treating fear of pain, disability, pain intensity and catastrophizing. From the studies, GivE is a better treatment option than GA. However, ACT was only compared against a control group and not against GA or GivE. As well, catastrophizing was not a variable in the ACT studies making it difficult to conclude which of the treatments is the best.

GivE has lead to better results in chronic neck/shoulder and back pain population in all studies comparing GivE and GA.[42-44] A replicated crossover single case design was used for two of the studies and for both there was a significant decrease in TSK scores following GivE.[42,44] For Vlaeyen et. al., TSK mean scores decreased from 46.5 to 23.7.[44] For De Jong et. al., TSK mean scores went from 47.7 to 23.5. There has been a significant decrease in pain disability following GivE treatment, but not GA, as reported by Vlaeyen and de Jong. For Vlaeyen, pain disability scores went from 17 to 8 following GivE whereas following GA scores didn't decrease. For De Jong, there were similar results. Initial baseline score for group 1 (GivE-GA) was 37.8 and decreased to 7.5 following GivE whereas group 2 (GA-GivE) scores had a smaller decrease 35.5 to 27 following GA and following GivE decreased to 8.5. A randomized controlled trial by Woods et. al. compared GivE and GA.[43] There was a significant improvement in TSK, FABQ and PCS scores for GivE but not for the control group. There was a significant improvement in

TSK, and FABQ for GivE but not for GA. Scores for TSK following GivE went from 41.2 to 32.7. Scores for FABQ went from 30.4 ± 14.4 to 18.7 ± 10.4 and scores for PCS went from 17.9 ± 8.8 to 11.9 ± 5.4. The study by Woods did not find a significant decrease in pain disability although there was a trend for a significant decrease for GivE but not for GA and control.

ACT led to better results compared with a control group in people with chronic neck/shoulder pain.[45] There was a significant difference for pain disability with a large effect size for the treatment group. Pre-treatment scores for pain disability were 37.1 ± 12.3 for the treatment group and 33.9 ± 13.0 for the control group. Post-treatment scores were 24.3 ± 14.0 for the treatment group and 38.3 ± 15.2 for the control group. There was also a significant difference for TSK with a large effect size for the treatment group. Scores for the treatment group decreased from 33.4 ± 9.4 to 29.0 ± 6.1, whereas scores for the control group increased from 34.1 ± 9.7 to 40.1 ± 9.2.

1.3 Pain and Muscle activity

The relationship of muscle activity and pain

A painful muscle displays dysfunctional muscle activity. In one study, neck/shoulder muscle activity was evaluated in people with whiplash-associated disorders and idiopathic neck/shoulder pain.[11] Patients sat at a desk and with a pencil in the right hand and dotted three circles spaced 23cm away from each other in a triangle for 2.5min. The two pain groups had significantly greater muscle activity in the anterior scalenes, sternocleidomastoid and left upper trapezius compared with the control group. The right upper trapezius muscle activity was lower in the pain groups during the task. However, the right upper trapezius muscle activity was higher in the pain groups following the repetitive task. The decrease in muscle activity for the right upper trapezius for the pain groups during the task could be a protective mechanism as explained by the pain-adaptation model. A significant difference in the signal amplitude ratio (SAR) between the pain and control groups was observed in another study.[46] The SAR is a measure of muscle tension and is the ratio between RMS of the passive extension phase and RMS of the flexion phase. The two pain groups consisted of people with chronic whiplash-associated disorders (WAD) and fibromyalgia. Subjects were seated and performed 100 repetitions of maximal isokinetic shoulder flexion at a rate of 30 contractions per minute. Subjects allowed the arm to be passively extended back to the starting position after each contraction. The initial SAR (first three contractions) for the WAD pain group was 28.5% ± 23.8 compared with 12.9% ± 13.0 for the control group. The endurance SAR (contractions 51-100) was 14.8% ± 14.4 for the fibromyalgia pain group and 8.3% ± 5.6 for the control group. There was a significant positive correlation between muscle tension and pain (initial SAR 0.62 and endurance SAR 0.57). From these two studies, we can conclude that there appears to be a relationship between muscle activity and pain.

Computer use, muscle activity and pain

There is a relationship between computer use and muscle amplitude. Muscle amplitude in female office workers with neck/shoulder pain, was investigated by Szeto, while performing three computer tasks for 20min each: typing, mousing and type-and-mouse.[9,10] Electrodes were placed bilaterally on the cervical erector spinae and upper trapezii. There was significantly higher amplitude bilaterally for the cervical erector spinae across all three tasks for the workers with pain compared to those without except for mousing on the left side.[9,10] For the upper trapezius, there was significantly higher muscle amplitude for the pain group during mousing only on the left side and a trend for significance bilaterally for the other tasks.[9,10] In terms of the tasks, both the pain and control groups demonstrated higher muscle amplitude during the typing and type-and-mouse tasks compared with the mousing task with the pain group having higher amplitude than the control group. There was significantly higher amplitude for the typing tasks (9.9 %MVE (Maximum Voluntary EMG amplitude) (5.4-28.2)) compared with the mousing tasks (3.1%MVE (0.8-12.3)) for both pain and non-pain groups in the upper trapezius in another study.[47] Higher amplitude for typing compared with mousing tasks has been observed by both Thorn and Szeto. Muscle amplitude was higher in computer users with pain as well as during a typing task versus a mousing task.

There is also a relationship between muscle rest and computer use. Muscle rest was measured in terms of gap frequency, in the study by Szeto.[9,10] A lower gap frequency would mean the muscle was resting less. Gap frequency was measured in the cervical erector spinae and upper trapezius during typing, mousing and type-and-mouse tasks. There was a significantly lower gap frequency for the left cervical erector spinae during typing for the neck/shoulder pain group (0.0gaps/min ± 0.1 compared with 1.2gaps/min ± 2.3) and a trend towards significance bilaterally for both muscle groups and across all tasks. In terms of the tasks, both the pain group and control group had significantly lower gap frequencies for both muscles during the typing and type-and-mouse compared with the mousing task. As well, the pain group had lower gap frequencies than the control group. The painful muscle was on more during computer use and specifically during a typing task compared with a mousing task.

Another way of calculating and interpreting muscle rest is in terms of relative rest time (RRT). RRT is the percent of time the muscle is below 1% maximum voluntary electrical activity during a task.[47] One study investigated RRT and computer use.[47] Electrodes were placed bilaterally on the upper trapezeii. Four tasks were performed: typing, editing, precision and stress. There was a lower RRT for the typing tasks compared with the mousing tasks for both pain and non-pain groups for most of the tasks (RRT for typing task 0.3% (0-9.5) compared with RRT for mousing task 4.5% (0-68.8)). There was a significant difference in RRT for the stress mousing task for the pain group (4.5% (0-68.8)) compared with the non-pain group (33.7% (0.5-84.1)) on the mouse side and a trend on the non-mouse side. There was no significant difference for the other typing and mousing tasks between the pain group and non-pain group. The lack of difference for the other tasks was a different result compared with the Szeto study. A possible explanation was that the task times for the current Thorn study were much shorter only 2-5min each compared with 20min for the Szeto study. Thorn made an interesting point regarding the muscle activity on the non-mouse side for the two mousing tasks. There was a lower RRT for the stress task on the non-mouse side compared with the precision task, which could mean that mental stress had a more potent effect on bilateral muscle activity. Also, the RRT for the stress task on the non-mousing side was lower for the pain group compared with the non-pain group. This could mean that the mental stress effect on muscle activity was higher in people with pain compared to people without pain. This study demonstrated that muscle activity was influenced by, not only the computer task and pain, but also stress, a psychological factor.

However, a relationship between computer use and muscle activity is not always observed. There was no difference in RRT between office workers with and without pain in a study by Nordander.[48] There were several issues with this study. Firstly, there was no standardized task and so there would be a lot of variance between individuals and the tasks they performed at work. Secondly, the office workers tested included both men and women, which added a confounding variable. No significant difference in amplitude during computer tasks between the pain and non-pain group was observed in another study.[49] The typing and mousing tasks in this study were quite short, only 2min and 5min long. As with the study by Thorn, perhaps the tasks were too short to notice a difference. Also with the current study, the inclusion criteria did not mention how much pain was required to be a part of the pain group. Perhaps, the pain group did not have significantly more pain than the control group. Although there appears to be contradictory results for muscle activity and computer tasks, the studies showing no change in muscle activity had flaws that could account for the lack of change.

Muscle activity is affected by computer work and pain which will be discussed in more detail in the next section.

Pain theories

Two theories seek to explain the relationship between muscle activity and pain: the pain-spasm cycle and the pain-adaptation theory. Another theory was proposed to explain the development of chronic musculoskeletal pain.

The Cinderella hypothesis was developed by Hagg to explain the development of chronic muscle pain.[50] The model is named Cinderella to characterize a muscle that is constantly on without rest.[50] Muscles are made up of different types of muscle fibers that are activated at different thresholds. This activation at different thresholds is known as fixed recruitment order. Low threshold motor units are the first to come on and will stay on until total muscle relaxation. Subsequent motor units will be activated dependent on the task load. In the Cinderella hypothesis, too little rest leads to pain in the low threshold units and then to muscular disorder.

The pain-spasm cycle explains the relationship between muscle pain and muscle activity.[8] Johansson explains the physiology behind the pain-spasm cycle.[8] Static muscle contractions activate muscle receptors (III and IV muscle afferents). Muscle receptors (III and IV muscle afferents) have an excitatory effect on muscle spindles leading to increased reflex mediated stiffness. Muscle pain leads to an increase in muscle activity according to the pain-spasm cycle hypothesis.

The pain-adaptation theory developed by Lund et. al. explains a different relationship between pain and muscle activity compared to the pain-spasm cycle.[12] The pain-adaptation theory states that the muscle activity in the painful muscle decreases while the antagonist muscle activity increases as a protective mechanism.[12] He stated that pain in a muscle is not caused by muscular hyperactivity. He argued that there is very little evidence for increase in muscle activity in a painful muscle. Lund argued that there is abnormal muscle activity in the presence of pain but it is a protective mechanism. Lund explained that studies with contradictory findings on pain and muscle activity were perhaps the result of the injured muscle acting as an agonist or antagonist. Lund noted in his own study that the painful muscle did not have an increase in muscle activity however the antagonist muscle did have an increase in muscle activity. The pain-adaptation model states the agonist muscle will have a decrease in muscle activity while the antagonist will have an increase in the presence of pain. The reduction in muscle activity of the agonist and increase in antagonist leads to a decrease in maximum voluntary contraction, range of motion and velocity, which is a protective mechanism reducing further injury and pain. Muscles are supplied by an excitatory and an inhibitory pathway. A decrease in muscle activity in the agonist in the presence of pain is explained by excitation of the inhibitory pathway and inhibition of the excitatory pathway. An increase in muscle activity in the antagonist occurs as a result of facilitation of the excitatory pathway and reduction in transmission of the inhibitory pathway. Lund also stated that there was no change in muscle activity in postural muscles in the presence of pain.

Not all studies confirm the pain-spasm hypothesis and the pain-adaptation theory.[51] There are three issues with the pain-spasm hypothesis and the pain-adaptation theory including maintenance of force, variance between individuals and tasks, and postural muscle adjustment.[51] Muscle activity was not decreased and force was maintained in the experimentally induced painful calf muscle during isometric plantar flexion suggesting new motorneurons were recruited and possibly supporting the theory of non-uniform inhibition.[52] A model has been proposed by Hodge et. al. to explain some of the issues with the pain-spasm hypothesis and pain-adaptation theory.[51] The new model proposed by Hodges has five key elements: redistribution, change in mechanical behavior, protection from further injury, motor system changes and short-term and long-term effects. Non-uniform inhibition and excitation occurs within a muscle as compared to uniform inhibition and excitation as explained by the pain-adaptation theory and pain-spasm hypothesis respectively. Competition between excitation to maintain muscle force and inhibition to minimize pain could lead to recruitment of higher-threshold motor units leading to redistribution of muscle activity.[53] Redistribution of muscle activity leads to a modified movement protecting the painful area.[51] Short-term benefits include protection of the injured site.[51] However, there may be long-term consequences of changing the biomechanics and function of the muscle.[51] The nervous system has a range of options to protect the injured area including increasing (pain-spasm hypothesis), decreasing (pain-adaptation theory) and redistributing muscle activity.[51] Hodges' model explains some of the gaps with the Cinderella hypothesis and pain-adaptation model and that ultimate goal of the nervous system is to protect the injured area.

It is also important to note that many of the studies reporting conflicting results examined muscle activity in the presence of experimental pain or chronic pain. Many of the studies supporting the pain-adaptation theory were done in the presence of experimental pain while studies supporting the pain-spasm cycle were done on subjects with chronic pain. Perhaps, muscle activity increase or decrease is dependent on the length of time the pain has been present.

2. RATIONALE

The incidence rate for developing chronic neck/shoulder pain is two to three times higher for computer workers compared with the general population.[1-3] The relationship between muscle activity and pain is unclear as studies report conflicting results. EMG activity in the sternocleidomastoid muscle decreased during neck flexion from 130 μV to 85 μV following the injection of a hypertonic solution in female subjects without pain.[54] However, in another study, female office workers with chronic neck /shoulder pain had higher muscle activity in the upper trapezii during a 10min stress task on the computer compared with a control group without pain (muscle activity for the group with pain: 5.47 %MVE; muscle activity for the control group: 3.28 %MVE).[55] Conflicting results suggest there has to be other factors that are influencing muscle activity in a painful situation. Pain-related fear may be one of the missing factors. No study to date has measured the relationship between pain-related fear and muscle activity in the painful neck/shoulder during a computer task.

Our research attempted to clarify the relationship between the psychological factors (pain-related fear), pain and EMG activity of the neck/shoulder musculature in female office workers with neck/shoulder pain and disability during a computer task.

Specific Aim #1- Determine if the amount of muscle activity (RMS, RRT) is affected by time, task, and electrode location on the trapezius.

- Hypothesis 1a: RMS will increase and RRT will decrease over time for each muscle respectively.
- Hypothesis 1b: RMS will be higher and RRT will be lower during tasks involving typing.
- Hypothesis 1c: RMS will be higher and RRT will be lower for the cervical paraspinal and upper trapezii electrodes compared with the middle and lower electrodes.

Specific Aim #2 – Determine if there exists a relationship between initial pain (before computer tasks)/evoked tenderness (after computer tasks) and muscle activity (RMS, RRT).

- Hypothesis 2a: There will be a positive relationship between initial pain and RMS and a negative relationship between initial pain and RRT.
- Hypothesis 2b: There will be a positive relationship between evoked tenderness and RMS and a negative relationship between RRT and evoked tenderness.

Specific Aim #3 – Determine if there exists a relationship between pain-related fear/ disability and muscle activity (RMS, RRT).

- Hypothesis 3a: There will be a positive relationship between fear-avoidance/disability and RMS during a computer task.
- Hypothesis 3b: There will be a negative relationship between fear-avoidance/disability and RRT during a computer task.

Specific Aim #4 – Determine if there exists a relationship between pain-related fear, pain and disability.

- Hypothesis 4a: There will be a positive relationship between fear-avoidance/disability and initial pain.

- Hypothesis 4b: There will be a positive relationship between fear-avoidance/disability and evoked tenderness.
- Hypothesis 4c: There will be a positive relationship between fear-avoidance and disability.

3. METHODS

3.1 Subjects

Twenty-six female subjects volunteered and completed the study. All subjects had a history of neck/shoulder pain in the past 12 months and currently had pain. All subjects were full-time office workers who performed at least 4h daily of computer work. Any person with prior surgery to the neck/shoulder was excluded. After completion, four subjects were removed. Two of these subjects had very low initial and experimental pain (less than 2/10). All four subjects also displayed muscle patterns that were different from those seen in other subjects. Contrary to other subjects, muscle activity was higher for the middle and lower trapezii compared with the neck and upper trapezii and there was very little change across all muscles for the mousing task. Therefore, the low scores combined with inconsistent muscle activity patterns led to the removal of the four subjects. Although several other subjects had initial pain levels less than 4/10, their experimental pain, questionnaire scores and muscle activity values were consistent with the other subjects. Table 1 lists the descriptive statistics for the subjects.

Table 1: Descriptive statistics for the subjects. Pain was measured on a 100-mm visual analog scale

Subjects	Age (yrs)	Weight (kg)	Height (cm)	Initial pain (VAS 0-100mm)
N=22	**47.8 ± 10.9**	**67.5 ± 11.8**	**163.0 ± 6.0**	**39.8 ± 22.0**

3.2 Fear-avoidance Questionnaires

All subjects completed the following questionnaires as part of the assessment: PCS, FPQ-III, TSK and FABQ which can be found in Appendices A-D. The questionnaires have already been defined in the background section.

3.3 Disability

All subjects also completed The Neck Disability Index Questionnaire (NDI, Appendix E).[56] The NDI has been cited over 1000 times. The NDI is a self-report measure used to assess disability due to neck pain. It measures how much a person's neck pain affects their everyday life and activities. Each of the 10 items is scored from 0-5. An example of a statement is " I can't read at all." A score of 0-4 means no disability. A total score of 5-14 is mild disability. A score of 15-24 is moderate disability. A score of 25-34 is severe disability and 34-50 is complete disability. A 5-point change would be clinically meaningful.[56]

3.4 Initial pain

Initial pain in the neck/shoulder area was assessed using a visual analog scale (VAS) and was done before proceeding with the computer tasks. A VAS is a 10cm horizontal line with two descriptors at either extreme (Fig. 2). The descriptor on the left-hand side would be "no pain" and the descriptor on the right-hand side would be "unbearable pain."[57,58] Subjects drew a vertical line perpendicular to the horizontal line. The distance from zero to the vertical line drawn by the subject was measured in mm.

Figure 2: Visual Analog Scale

3.5 Evoked tenderness

A Wagner algometer was used to measure evoked tenderness by delivering a set amount of pressure at 9kg/cm^2.[59] The algometer was held at 90 degrees to the pressure site. After 9 kg/cm^2 was achieved at a specific location, the subject was asked to mark their pain intensity on a visual analog scale. After the computer tasks were completed, electrodes were removed and evoked tenderness was measured randomly at the locations where the electrodes had been placed in between the bipolar electrodes.

3.6 Surface electromyography

Surface EMG data was recorded from 5 different locations bilaterally on the trapezius and cervical muscles (Fig. 3) using the Noraxon Telemyo 2400T G2 system with a sampling frequency of 1500Hz.

The skin was carefully prepared by cleaning the area with gauze and alcohol before electrode placement. One electrode was placed vertically on the cervical paraspinal (CP) muscles at the level of the spine of vertebra C4 3cm from the spine. For the upper trapezii (UT), two electrodes were placed at 1/3 (medial) and 2/3 (lateral) on the line from spine of vertebra C7 to the acromion.   For the middle trapezius (MT), one electrode was placed at 50% between the medial border of the scapula and the spine of vertebra T3 in the horizontal direction. For the lower trapezius (LT), one electrode was placed at 1/3 on the line from the 8^{th} thoracic vertebra to the trigonum spinae of the scapula. A reference electrode was placed on the right acromion. An electrode was also placed on the sternum to pick up the heartbeats which made them easier to remove.

Figure 3: Electrode placement

3.7 Reference contractions

Reference contractions were measured at rest and during a mild resistance for the neck, upper trapezii and middle and lower trapezii. A mild reference contraction was used instead of a maximum voluntary contraction because the subjects had pain which makes a maximum contraction difficult.[60] Reference contractions lasted 10 seconds and were performed twice. For all the reference contractions, the subject was seated with their feet flat on the floor and their knees at 90 degrees. The resting reference contraction consisted of sitting and looking straight ahead with hands on lap. The neck contraction consisted of bending forward from the trunk and looking down with arms by the side. The upper trapezii contraction consisted of holding 2lb weights in both hands and abducting the arms to 90 degrees with elbows straight and the trunk vertical. The middle trapezii contraction consisted of bending forward as much as possible from the waist keeping the neck and back neutral and holding the arms out in a "Y" elbows straight with 2lb weight. The lower trapezii contraction consisted of bending forward as much as possible from the waist keeping the neck and back neutral and performing a row with elbows bent holding 2lb weight.

3.8 Computer tasks

Three computer tasks, the same tasks as used in a previously published study by Delisle et. al., were performed: mousing, typing-and-mousing and typing (Appendix F).[61] Each task was 10min. Within the mousing task, there were five activities. The first activity involved moving rectangles from smallest to biggest from one rectangle to a blank one to recreate the original image. The second activity involved moving colored crosses from one square to another to recreate the original image. The third activity involved highlighting all the blue words in the text and changing them to red. The fourth activity involved recreating the image in the left-hand square by dragging the objects into the right-hand square. The fifth activity involved moving each green cross on top of the corresponding red cross. The typing-and-mousing task consisted of two activities. The first activity involved retyping the given sentence in its corresponding blank box using the mouse to move to the next box. The second activity was composed of two parts. The first part involved typing each letter of the alphabet from A to X only using the mouse hand and using the mouse to move to each box. The second part involved typing the numbers 1-50 only using the mouse hand and using the mouse to move to each box. The typing task involved typing a standard document.

3.9 Procedures

All subjects filled out a consent form at the beginning of the visit. Subjects filled out the PCS, TSK, FABQ, FPQ-III and NDI questionnaires. Patients then indicated their initial pain level on the VAS. Then the electrodes were placed on the subjects' neck/shoulder muscles. Reference contractions were recorded. Computer tasks were then performed randomly at the subjects' workstations while EMG was recorded. The rest time between tasks was approximately 2 minutes where the subject was explained the next task. Evoked tenderness was then measured after completing all the computer tasks.

3.10 Data analysis

The electrical signals from the heartbeats interfered with the EMG recording of the muscle activity and needed to be removed (Fig. 4). The EMG recording device picked up the heartbeats as well as the muscle activity because the electrodes were on the neck, shoulders and back, which was close to the heart. We used a script in Matlab to remove the heartbeats. At the beginning of each file, we chose a reference heartbeat and clicked on the beginning and end of the chosen heartbeat. This heartbeat was used to remove all the other heartbeats in a given file. Each file was divided into 5-second windows and we manually clicked in between of each heartbeat. The script then found the highest point between the clicks. The maximum point of the reference heartbeat was then aligned with the maximum point between the clicks and the heartbeat was removed by subtracting the reference heartbeat from the signal. Data was then band-pass filtered (10-350 Hz).

We computed root mean square (RMS) in 1-minute blocks for all signals. Therefore, there were 10 RMS values for each muscle and task. Next, we normalized the data using the RMS from the respective 10s reference contractions.

RRT was computed and used to determine the percentage of muscle rest during the computer tasks (Fig.5). The RRT threshold represented the mean plus 2 standard deviations of the rectified resting trial. RMS was computed in 50ms blocks. When five consecutive blocks were above the RRT threshold, the muscle was considered on. When the EMG signal was below the RRT threshold or less than five consecutive blocks were above, the muscle was considered off. The percent time where the signal was off was used to determine the RRT value. RRT was also computed in 1-minute blocks for all muscles and tasks.

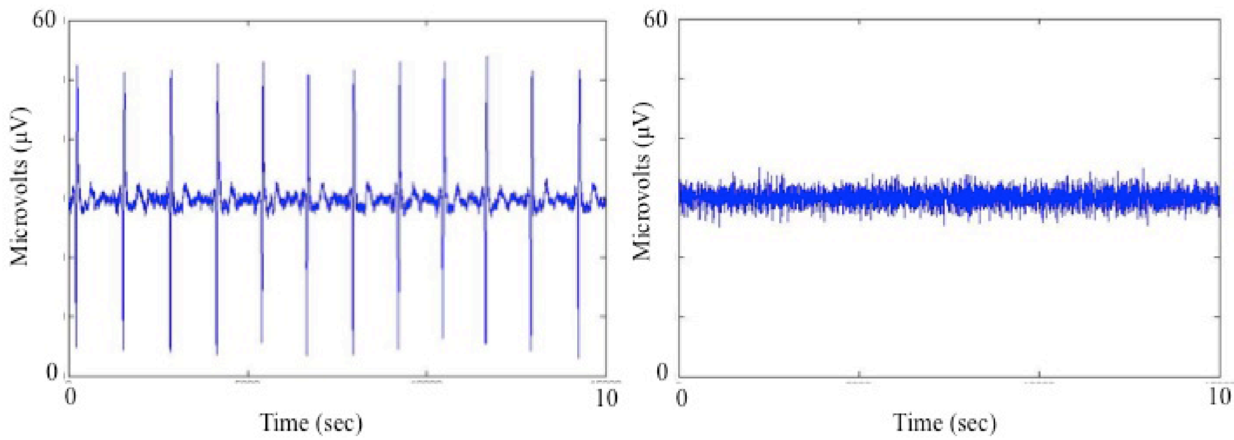


Figure 4: EMG signal: The left panel with heartbeats and the right with heartbeats removed.

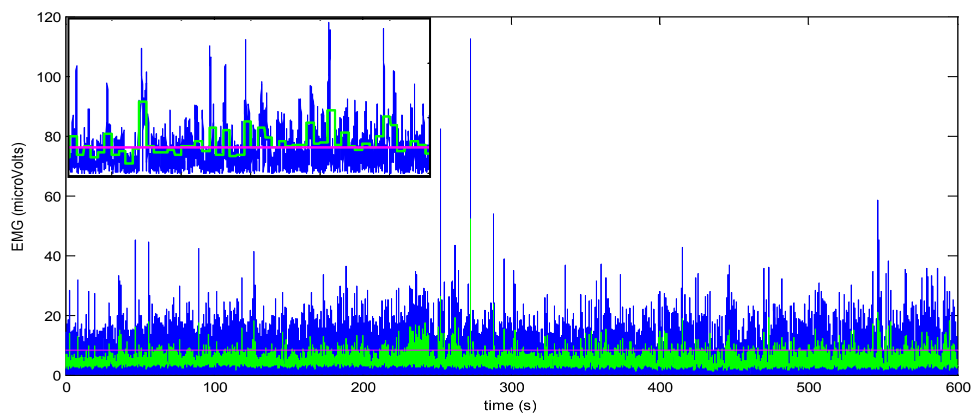


Figure 5: The blue line represents the rectified EMG signal. The green is the root mean square of the signal taken in 50ms blocks. The purple line is the RRT threshold taken as the mean + 2 standard deviations of the resting trial. Zoomed in section: When there are five green blocks above the purple line (RRT threshold), the muscle is considered on.

3.11 Statistical analysis

We used separate 3x10 ANOVA's (taskxtime) for each electrode to determine if there was an effect of time on muscle activity (RMS, RRT) (Hypothesis 1a). Twenty-two subjects remained following the removal of four subjects. Of the 22 subjects, three were not included in this analysis because of missing data. These subjects did not have minutes 9 and 10. Therefore, we decided to complete the analysis on 19 subjects for 10 minutes instead of 22 subjects for 8 minutes. We used a 3x10 ANOVA (taskxelectrode) to determine if there was an effect of task and electrode location on muscle activity (RMS, RRT) (Hypothesis 1b and 1c). Only 21 subjects were included for RMS because one subject did not have a right and left LT reference contraction. Therefore, there was no normalizing value for the right and left LT electrodes for that subject. Twenty-two subjects were included for RRT. For all the correlations, 22 subjects were included. We used Pearson correlations to assess the relationship between pain (initial and evoked tenderness) and global (full 10min trial) muscle activity (RMS, RRT) (Hypotheses 2a and 2b). We used Spearman correlations to assess the relationship between fear-avoidance/neck disability and global muscle activity (RMS, RRT) (Hypotheses 3a and 3b). We also used Spearman correlations to assess the relationship between fear-avoidance, neck disability and pain (initial and evoked tenderness) (Hypotheses 4a, 4b and 4c). Since, the upper trapezii were the site of pain for all subjects, we examined only the electrodes corresponding to the right UT medial and lateral and left UT medial and lateral for the correlations. We found the average of the two right UT electrodes and the average of the two left UT electrodes and used these averages for right and left UT respectively. We decided to use the average of the two electrodes because the values were very similar. For the remainder of the text, UT when not specified medial or lateral will be used to refer to the average of the medial and lateral locations. The correlations were not computed for the typing-and-mousing task because when we ran the taskxelectrode ANOVAs (RMS, RRT) there was no significant difference between the typing task and the typing-and-mousing task.

4. RESULTS

4.1 Muscle activity and time, task and electrode location

There was no time main effect nor was there a taskxtime interaction for any of the muscles for RRT (Fig.6). We looked for a taskxtime interaction because it was possible that a time effect was hidden when all the tasks were grouped together in the analysis. This would occur if the muscle activity increased for one of the tasks and decreased for another task. Since there was no interaction combined with no time main effect, there was no change over time for any of the tasks for RRT. For RMS, there was no time effect or interaction for most of the electrodes except for left lateral UT which had a time main effect ($p=.012$ $F=3.25$). Time was a main effect due to fluctuations during the 10min and not a systematic increase or decrease. Since there was no systematic time increase or decrease from beginning to end for either RMS or RRT, we computed a global RMS and RRT value over the entire 10min trials for each muscle and used this for the rest of the analysis.

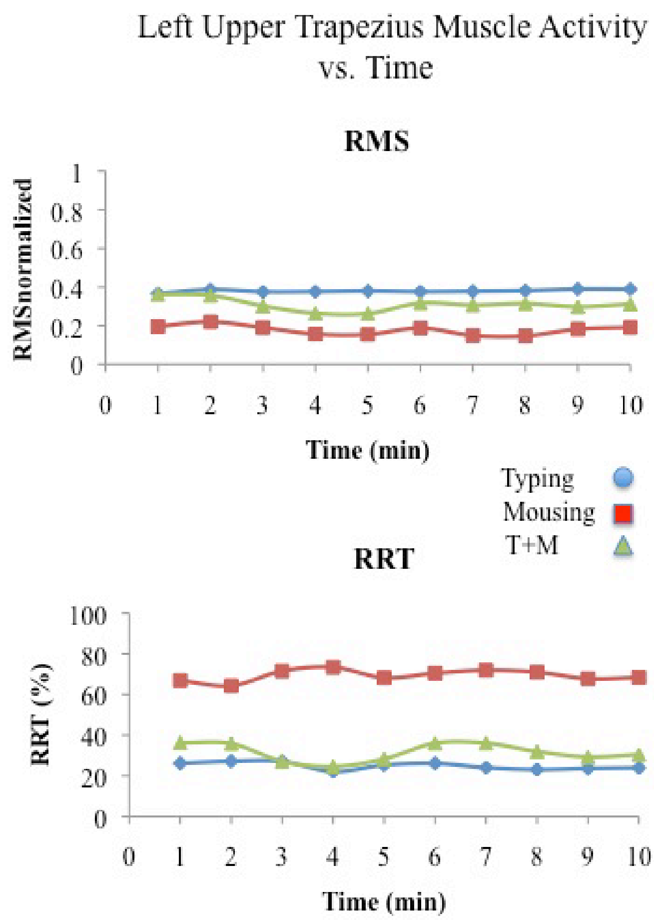


Figure 6: The evolution of muscle activity over time for left UT lateral for all tasks. Top panel: RMS, Bottom panel: RRT

For RMS and RRT, there was a task main effect (RMS: $F(2,40)=34.99$ $p<.001$; RRT: $F(2,42)=43.05$ p,.001) (Fig.7). From the post hoc, muscle amplitude (RMS) was significantly higher and muscle rest (RRT) significantly lower for the typing and typing-and-mousing tasks compared with the mousing task. There was no significant difference between the typing and typing-and-mousing tasks. For RMS and RRT, there was an electrode main effect (RMS: $F(9,180)=28.125$ $p<.001$; RRT: $F(9,189)=22.707$ $p<.001$). For RMS, although table 2 includes all comparisons between muscles as well as between sides, we focused on differences between sides for the same electrode. We did this because comparison between electrodes was difficult as each muscle was normalized to an arbitrary reference contraction. Only the middle and lower trapezii were different between the right and left side. From the RRT post hoc, muscle rest for CP was significantly lower than muscle rest for LT and muscle rest for the medial and lateral UT was significantly lower than the muscle rest for all the lower fibers (see table 3). There was also a taskxelectrode interaction for RMS and RRT (RMS: $F(18,360)=4.454$ $p=.022$; RRT: $F(18,378)=4.523$ $p<.001$). From the graph, for RMS, muscle activity for CP and UT was lower for mousing while muscle activity for MT and LT was similar for all tasks. For RRT, muscle rest was higher for all muscles for the mousing task. However, the difference was approximately doubled for CP and UT whereas for MT and LT the difference was much less.

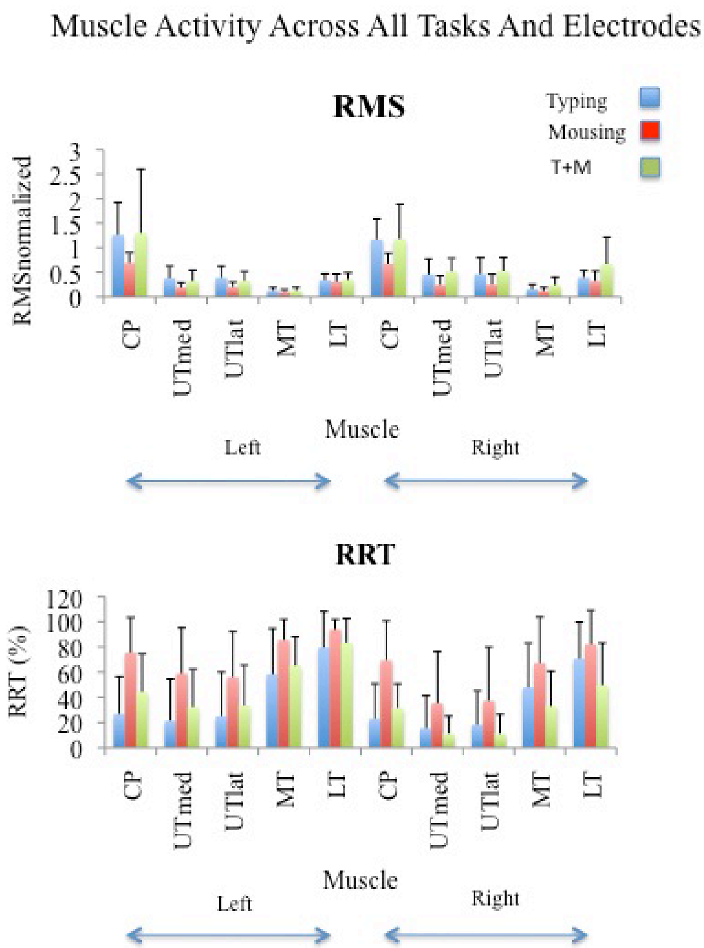


Figure 7: Muscle activity across all three tasks and 10 electrodes. Top panel: RMS, Bottom panel: RRT

Table 2: Electrode main effect for RMS

		Left					Right				
		CP	UT med	UT lat	MT	LT	CP	UT med	UT lat	MT	LT
Left	CP	---	x	x	x	x		x	x	x	x
	UTmed		------		x		x				
	UTlat			------	x		x			x	
	MT				-----	x	x	x	x		x
	LT					----	x			x	
Right	CP						----	x	x	x	x
	UTmed							----		x	
	UTlat								----	x	
	MT									----	x
	LT										------

X denotes $p<0.05$

Table 3: Electrode main effect for RRT

		Left					Right				
		CP	UT med	UT lat	MT	LT	CP	UT med	UT lat	MT	LT
Left	CP	---				x		x	x		
	UTmed		------		x	x					
	UTlat			------	x	x					
	MT				-----		x	x	x	x	
	LT					----	x	x	x	x	
Right	CP						----	x			x
	UTmed							----		x	x
	UTlat								----	x	x
	MT									----	
	LT										------

x denotes p<0.05

4.2 Pain and muscle activity

When we examined pain and muscle activity, there was no correlation between either initial pain or evoked tenderness and global muscle activity (RMS, RRT) during typing or mousing tasks. The correlation coefficients ranged from r(20)=.261, p=.241 to r(20)=.017, p=.941 for initial pain and muscle activity (RMS, RRT). The correlation coefficients ranged from r(20)=-.357, p=.102 to r(20)=-.040, p=.859 for evoked tenderness and muscle activity (RMS, RRT). See Fig.8 for two examples.

4.3 Pain-related fear/disability and muscle activity

For pain-related fear questionnaires, there was no significant correlation with muscle activity. However, there was a significant relationship for neck disability and global muscle activity. There was a positive correlation for NDI and RMS for the left UT during typing (r_s (20)=.495, p =.019). There was also a negative trend for NDI and RRT for the right UT during typing (r_s(20)=-.382, p=.079,) (Fig. 9).

4.4 Pain-related fear, disability and pain

There was no significant relationship between pain-related fear and neck disability. There was, however, a significant relationship for two of the pain-related fear questionnaires and pain. There was a significant positive relationship between FABQw and evoked tenderness at the UT (right: r_s(20)=.442, p=.039; left: r_s(20)=.471, p=.027) (Fig. 10). There was also a significant relationship between PCS and evoked tenderness at the left UT (r_s(20)=.568, p=.006) and a trend for PCS and evoked tenderness at the right UT (r_s (20)= 398, p=.066) (Fig.11). As well, there was a trend for PCS and initial pain (r_s (20)=.394, p=.069) (Fig.12).

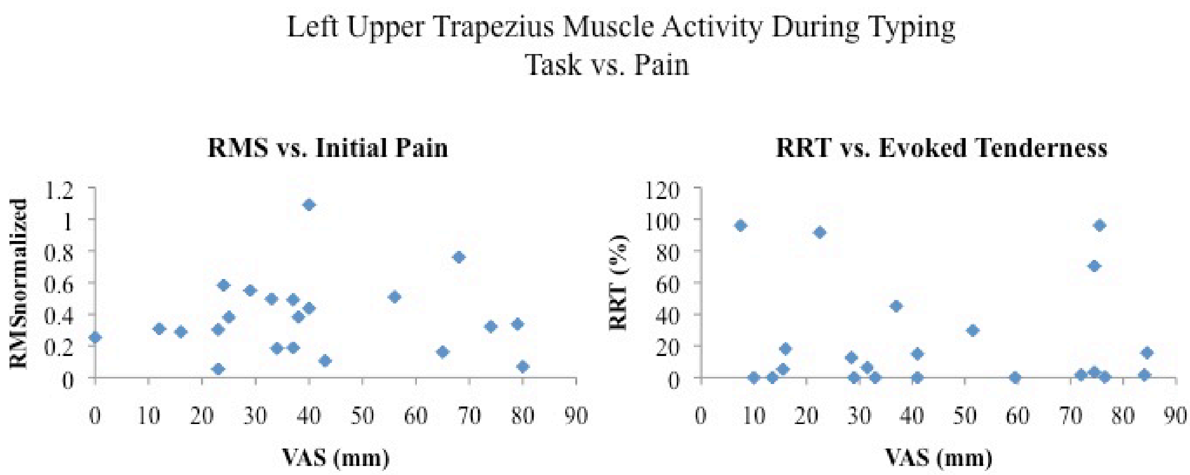


Figure 8: No significant relationship was found between initial pain and RMS (p=.941). No significant relationship was found between evoked tenderness and RRT (p=.859). Left panel: RMS, Right panel: RRT.

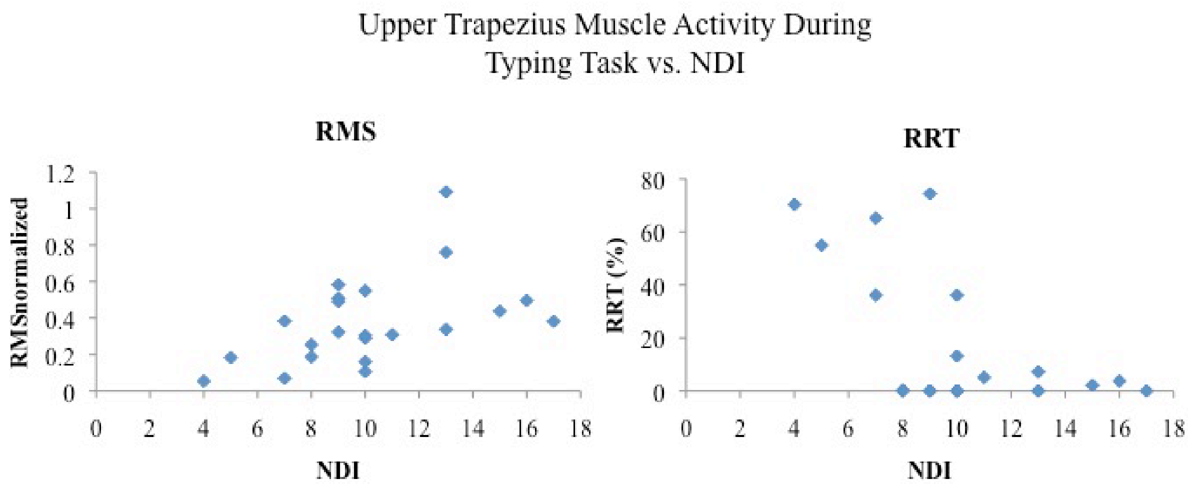


Figure 9: There was a significant correlation between NDI and RMS for the typing task at the left UT (p<.05). There was a trend for NDI and RRT for the typing task at the right UT (p=.079). Left panel: RMS, Right panel: RRT.

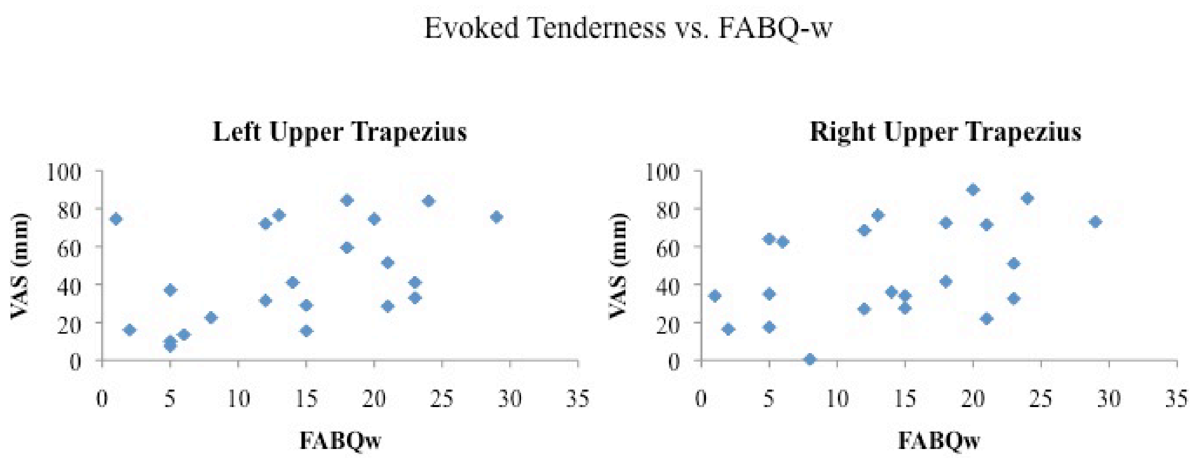


Figure 10: There was a significant correlation between FABQ-work and evoked tenderness at the right UT and left UT (p<.05). Left panel: Left UT, Right panel: Right UT.

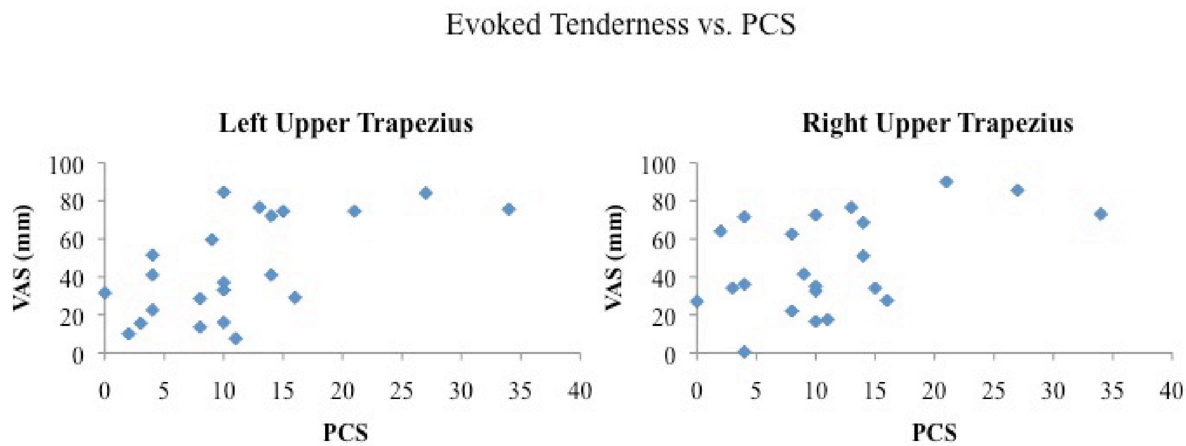


Figure 11: There was a significant relationship between PCS and evoked tenderness at the left UT ($p<.01$). There was a trend for PCS and evoked tenderness at the right UT ($p=.066$). Left panel: Left UT, Right panel: Right UT.

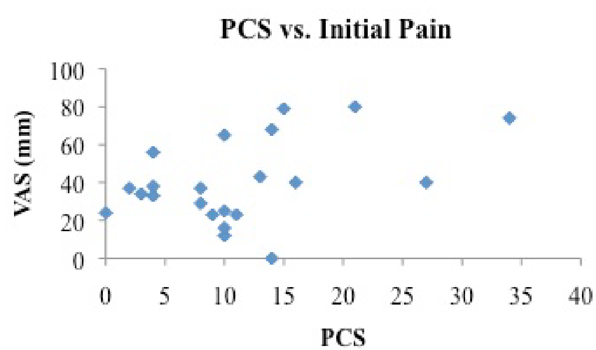


Figure 12: There was a trend for PCS and initial pain intensity ($p=.069$).

5. DISCUSSION

Results suggest a difference in muscle amplitude and muscle rest between different computer tasks. There was higher muscle amplitude and less muscle rest for CP and UT for the tasks involving typing. There was no correlation between pain-related fear and muscle activity. There was also no correlation between pain, both initial and evoked tenderness, and muscle activity. However, there was a correlation between disability and muscle amplitude. There was also a correlation between pain-related fear and evoked tenderness as well as a trend between pain-related fear and initial pain.

5.1 Difference in muscle activity between three tasks

We reported higher muscle amplitude in typing compared with mousing. Despite differences in methodology, muscle amplitude was also higher for typing compared with mousing for the trapezius muscle in other studies[9,10,61] However, the difference in amplitude of activation was larger in our study. The muscle amplitude difference was approximately double for typing compared with mousing for our study for both the CP and UT. While there were no values indicated in the text for the Delisle study, the data indicated from the graph suggested that muscle amplitude was ~ 1/3 higher for typing compared with mousing in the UT. For the Szeto study, muscle amplitude was also ~ 1/3 higher for typing in the UT and ~ 1/4 higher in the CP compared with mousing. Several possible reasons could account for why we saw greater difference in muscle amplitude between tasks compared with the other studies. Perhaps, muscle amplitude difference was lower in the Delisle study compared with our results because they had healthy subjects. There were many similarities between our study and the Szeto study: three computer tasks, female office workers, and neck/shoulder pain. However, their subjects spent equal time throughout their day using the mouse and keyboard. Perhaps, their subjects were more comfortable using a keyboard and a mouse compared with ours. Although, we did not ask our subjects about how much time they spent using a mouse versus a keyboard, many said that they did not type long documents often. As well, the tasks used in our study were different from the ones used in the Szeto study. The mousing task that Szeto used was minesweeper whereas our task consisted of different “dragging” activities. Perhaps, playing minesweeper elicited more muscle activity than the tasks we used which could account for the greater difference in muscle activity between typing and mousing for our subjects. We chose a different task from the Szeto study for several reasons. The first reason was that there was no typing-and-mousing task in the Szeto study. The second reason was that few subjects knew how to play minesweeper or had access to the game on their computer. For these reasons, we chose to use the tasks used by Delisle and which also report differences between the tasks involving typing and the tasks involving mousing.

In our study, we observed more muscle rest in mousing compared to typing tasks. The general pattern of decreased muscle rest in the trapezius muscle in typing compared with mousing, was reported in other studies[9,10,61]. Even though there were methodological differences between our study and the other studies, we reported similar results. In our study, more rest was observed during mousing for the CP and UT. In the Delisle study, results suggested lower gap frequency and time at rest for typing compared with mousing in the UT. In the Szeto study, results suggested lower gap frequency for all muscles for typing compared with mousing, except right UT where typing had more gaps than mousing. However, time at rest for typing was much lower in the Delisle study compared with our study (Delisle study time at rest left UT: 2.6%±8.0; our study RRT left UT: 23.1%±34.1).[61] Gap frequency, in the Delisle study, was determined as RMS lower than a threshold of 0.3% maximum voluntary exertion for at least 250ms. RRT, in our study, was defined as follows: when five consecutive blocks were above the RRT threshold (mean of rectified resting trial plus two standard deviations) the muscle was considered on. Perhaps the time at rest for typing was so much lower than RRT due to the fact that maximum reference contractions were used whereas we used submaximal contractions. Our study had subjects with pain and we decided to therefore use submaximal contractions. In the Delisle study, muscle rest was only significant between tasks for the left UT perhaps because the subjects were healthy. As well, subjects were typing for 80% of the time (16min) whereas in our study subjects spent equal time for all tasks (10min for each task). It was interesting to note that in the Szeto study there was a higher gap frequency for the right UT during typing compared with mousing. A third of the subjects had previous typing training and spent half their working day typing. Perhaps, the subjects were more adept typers and this was why the gap frequency was higher in typing.

Several factors could be at play contributing to a decrease in muscle activity during a mousing task compared to a typing task. In one study, there were differences in posture between typing and mousing that could account for decreased muscle activity in mousing[61]. During the typing task, there was 11 degrees more neck flexion compared with mousing.[61] The subjects were looking down at the keyboard during the typing task. It is possible that the subjects increased neck flexion led to an increase in muscle tension in the CP and UT and therefore an increase in muscle activity in the typing task. Another reason for lower muscle activity during mousing was that, contrary to the belief that during mousing the arm would move a lot, the arm was supported and only the hand and fingers were moving and therefore the UT would not be recruited.

5.2 Relationship of muscle activity to pain

We did not observe a relationship between muscle activity (RMS, RRT) and pain (initial or evoked tenderness). As mentioned in the literature, there is conflicting evidence when observing muscle activity in a painful muscle[12,55]. In one study, the group with chronic neck/shoulder pain had significantly more pain, higher muscle amplitude and lower muscle rest in the UT during computer tasks compared to the control group (neck/shoulder group baseline pain: 8.0±8.9, control group: 1.6±4.4).[10] In subjects with chronic low back pain, a correlation between muscle amplitude in the low back and pain was reported ($r(45)=.48$, $p<0.01$) during standing.[18] Baseline pain was higher in the study by Lewis compared with our study (4.8/10±2.2 vs. 39.8mm±22.0). In contrast to these studies, another study reported a decrease in muscle amplitude in the UT was observed in female office workers with chronic neck/shoulder pain compared to a control group during shoulder abduction.[65] Our correlations between muscle activity (RMS, RRT) and pain were not significant and ranged from $r(20)=-.357$, $p=.102$ to $r(20)=.017$, $p=.941$.Not observing a correlation between muscle activity and pain potentially supports the theory that there are other factors affecting muscle activity in a painful muscle.

5.3 Relationship of muscle activity to pain-related fear/disability

There was a relationship between muscle activity (RMS) and disability in our study. To our knowledge, the relationship between muscle activity and disability has not been examined in a typing or mousing task in any other study. However, it has been studied in other tasks. Although in one study, a direct correlation between muscle activity and disability was not examined, individuals with moderate/severe post-whiplash injury were shown to display higher NDI scores and higher muscle amplitude in the superficial cervical flexors during cranio-cervical flexion compared to recovered post-whiplash individuals.[62] Although our subjects' NDI scores were lower than the moderate/severe group, muscle amplitude was similar (our subjects' NDI scores: 20.2% ±6.6, moderate/severe group NDI scores: 37.1%±8; our subjects' RMS: .36±.24, moderate/severe group RMS: 48±.21). There was a correlation between muscle activity (RMS) in patients with chronic low back pain and disability in a study by Lewis et al. (r(46)=0.43, p,0.01).[18] We noted a similar correlation between neck/shoulder pain and disability (NDI and RMS for the left UT during typing (r_s (20)=.495, p =.019); NDI and RRT for the right UT during typing (r_s(20)=-.382, p=.079)). Although there were many differences between our study and the Lewis study, the correlation between muscle activity and NDI was similar.

There was no relationship between muscle activity and pain-related fear in our study. This is in contrast to other studies reporting correlations between fear-avoidance questionnaires and muscle activity (RMS) in the superficial neck flexors during cranio-cervical flexion and in the low back erector spinae muscles during standing in other studies.[18,62] A correlation between muscle activity (RMS) in the low back and catastrophizing was observed in one study (r(46)=0.29, p,0.04). There were many differences between our study and the Lewis study that could account for why we didn't find a correlation between muscle activity and catastrophizing. Stronger correlations have been reported in the low back compared with the neck/shoulder.[15] As well, the subjects in the Lewis study had higher catastrophizing scores compared to our subjects (21.2/52±12.8 vs. 11.2/52±8.1). In another study, when subjects were divided into high and low disability groups, results suggested a correlation between muscle activity (RMS) in the superficial neck flexors and TSK. The group with significantly more muscle activity (RMS) (moderate/severe post-whiplash) had significantly higher TSK scores than the other two groups (mild post-whiplash and recovered).[62] The moderate/severe group had higher TSK scores than our subjects (38.4±7 vs. 34.0±6.3). The moderate/severe TSK scores were indicative of a high degree of kinesiophobia.[31]Perhaps, we didn't find a correlation because pain-related fear questionnaire scores' were lower for our subjects compared with the other studies.

5.4 Relationship of pain to pain-related fear/disability

In our study, we observed a correlation between evoked tenderness and pain-related fear. One of the correlations was between evoked tenderness at the UT and the FABQ-w. Similar to our study, a correlation was also reported between pain in lumbar region and the FABQ-w.[15] However, in the same study, there was no correlation between pain and the FABQ-w for the individuals with pain in the cervical region. In another study, subjects with cervical spine pain and elevated fear-avoidance beliefs (>15 FABQ-pa) reported higher pain than subjects with low fear-avoidance beliefs (as estimated from graph for elevated fear-avoidance: pain 5/10; low fear-avoidance: pain 3.5/10).[63] This suggests a correlation between pain and FABQ-pa. Again, both our study and the one by George found associations between pain and pain-related fear, although it was with a different questionnaire in the George study. Our FABQ-pa scores were all below 15 except for 4 subjects. Perhaps we did not find a correlation between pain (initial or evoked tenderness) and FABQ-pa because of lower FABQ-pa scores.

We also reported relationships between pain, both initial and evoked tenderness, and catastrophizing. Other studies have reported similar results.[64]In one study, subjects with chronic neck/shoulder pain also reported higher PCS scores compared with a control group (pain group median PCS score and range: 15 (6-29); control group: 2 (0-21).[64] This suggests a correlation between pain and PCS. In another study, there was a significant correlation between initial pain and catastrophizing in subjects with low back pain ($r(45)=.38$, $p<.01$).[18] In our study, there was a trend between initial pain and PCS (r_s $(20)=.394$, $p=.069$) and a significant correlation between evoked tenderness and PCS (left UT: $r_s(20)=.568$, $p=.006$).

We did not report a correlation between pain-related fear and disability. In contrast to our study, a correlation was observed, in one study, between pain-related fear and disability in the cervical region (FABQ-pa and disability $r(51)=.43$, $p=.01$; our study FABQ-pa and disability $r_s(20)=.17$, $p=.44$) The subjects in our study reported mild disability whereas the subjects in the George study reported moderate disability (our subjects: 20.3%±6.6, George study: 34.0%±13.0). Subjects in the George study were seeking treatment whereas in our study subjects were not seeking treatment. This could indicate that their cervical spine injury was more disabling than our subjects.

5.5 Conclusion

Our results suggested that there was a relationship between pain and pain-related fear pain but not between pain and muscle activity. We could speculate that since there was a relationship between pain-related fear and pain that therefore pain-related fear could be a factor to consider when assessing someone with neck/shoulder disorder. Therefore, addressing psychological factors in an injury could prove beneficial in female office workers with neck/shoulder pain.

Our results also suggested that muscle amplitude and muscle rest differed depending on the computer task performed. Our study did not directly support the Cinderella hypothesis as we did not observe a correlation between pain and muscle rest. However, we could speculate that female office workers may benefit from performing computer tasks that do not lead to a decrease in muscle rest such as mousing.

5.6 Limitations

Originally, we would have liked to compare the painful and non-painful sides in terms of muscle activity and pain-related fear. We anticipated all subjects having pain on either the right side or the left side. However, there was no clear side of pain for our subjects. Twelve subjects had pain bilaterally. Seven had pain only on the right and two had pain only on the left and one had no initial pain. We considered analyzing the electrodes for the two subjects with pain only on the left side as if they were flipped and on the contralateral side, but two of the tasks involved mousing which takes place on the right side for every subject. Therefore we did not switch the data form one side to the other and did not analyze in terms of painful side versus non-painful side.

Subjects did not have high pain or NDI scores as reported by other studies. We had unforeseen difficulty in getting subjects who had higher pain (5-6/10) and were bothered by their pain yet were able to work full-time. There was also not a lot of variability in scores for most of the questionnaires (TSK, NDI, FPQ, FABQw). It would be difficult to find correlations between pain-related fear, pain, disability and muscle activity with low questionnaire scores. As well, we could not separate the subjects into low and high pain-related fear groups to compare muscle activity, pain and disability because of low variability in the scores of the fear-avoidance questionnaires.

Muscle activity comparison between electrodes should be taken lightly. As mentioned in the results, we did not compare between electrodes for RMS. The reference contractions were submaximal and therefore arbitrary. For one muscle the submaximal contraction could elicit more muscle activity compared with another reference contraction. This could lead to one muscle appearing to have higher muscle activity compared to another when in fact that is not the case. The RMS normalized value for the CP is a good example. The RMS value for the CP was above 1 and, by far, higher than all the other electrodes. This could mean that the reference contraction for the CP did not elicit a high level of activation. Although, we did compare between electrodes for RRT, the results should be taken with caution. This is because we cannot guarantee that during the resting contraction, which was used to determine the resting threshold, all the muscles were resting to the same amount. If a muscle was contracted and therefore the activity was higher than resting, this would increase the resting threshold. A higher resting threshold would lead to muscles appearing to be off when, in fact, they may be on.

Another limitation was the length of the tasks and time of testing and day of testing. Perhaps a 10min task was too short to show a time effect or to mimic a working day at the computer. As well, the time of day was not controlled for. Some subjects were tested in the morning, others at the end of the day, and testing occurred Monday to Friday. A subject being tested Monday morning might display different muscle activity compared to if they were tested a Friday afternoon and had spent the whole week at the computer.

As well, since the subjects did the testing at their workstation, there were differences in equipment (computer, chair, keyboard) setup. Although different workstations added a variable and therefore were a limitation, we wanted to test the subjects with the same setup that was eliciting pain.

Lastly, the study was only done on women so we cannot speculate the findings for men. However, typically there is a greater population of female office workers with neck/shoulder pain than men.[25]

5.7 Future studies

Future studies could examine the effect on pain of using more mousing or voice-recognition to type rather than typing tasks in people with pain. Also of benefit would be to divide the painful group into high and low fear-avoidance and compare variables such as muscle activity, disability and pain. It could also be interesting to compare if the beginning and end of the day affect muscle activity potentially leading to adjusting the type of task depending on the time of day.

REFERENCES

1. Tornqvist EW, Hagberg M, Hagman M, Risberg EH, Toomingas A. The influence of working conditions and individual factors on the incidence of neck and upper limb symptoms among professional computer users. International Archives of Occupational and Environmental Health 2009;82:689-702.
2. Croft PR, Lewis M, Papageorgiou AC, et al. Risk factors for neck pain: a longitudinal study in the general population. Pain 2001;93:317-25.
3. Cote P, Cassidy JD, Carroll LJ, Kristman V. The annual incidence and course of neck pain in the general population: a population-based cohort study. Pain 2004;112:267-73.
4. Enquête québécoise sur des conditions de travail, d'emploi et de sécurité du travail (EQCOTESST) rapport. Institut national de santé publique Québec : Institut de la statistique Québec ;
IRSST, 2011. at http://collections.banq.qc.ca/ark:/52327/2069255.)
5. Nijs J, Daenen L, Cras P, Struyf F, Roussel N, Oostendorp RA. Nociception affects motor output: a review on sensory-motor interaction with focus on clinical implications. Clin J Pain 2012;28:175-81.
6. Breivik H, Collett B, Ventafridda V, Cohen R, Gallacher D. Survey of chronic pain in Europe: prevalence, impact on daily life, and treatment. Eur J Pain 2006;10:287-333.
7. Vlaeyen JW, Linton SJ. Fear-avoidance and its consequences in chronic musculoskeletal pain: a state of the art. Pain 2000;85:317-32.
8. Johansson H, Sojka P. Pathophysiological mechanisms involved in genesis and spread of muscular tension in occupational muscle pain and in chronic musculoskeletal pain syndromes: a hypothesis. Medical hypotheses 1991;35:196-203.
9. Szeto GP, Straker LM, O'Sullivan PB. During computing tasks symptomatic female office workers demonstrate a trend towards higher cervical postural muscle load than asymptomatic office workers: an experimental study. The Australian journal of physiotherapy 2009;55:257-62.
10. Szeto GP, Straker LM, O'Sullivan PB. Examining the low, high and range measures of muscle activity amplitudes in symptomatic and asymptomatic computer users performing typing and mousing tasks. Eur J Appl Physiol 2009;106:243-51.
11. Falla D, Bilenkij G, Jull G. Patients with chronic neck pain demonstrate altered patterns of muscle activation during performance of a functional upper limb task. Spine 2004;29:1436-40.
12. Lund JP, Donga R, Widmer CG, Stohler CS. The pain-adaptation model: a discussion of the relationship between chronic musculoskeletal pain and motor activity. Canadian journal of physiology and pharmacology 1991;69:683-94.
13. Graven-Nielsen T, Svensson P, Arendt-Nielsen L. Effects of experimental muscle pain on muscle activity and co-ordination during static and dynamic motor function. Electroencephalography and clinical neurophysiology 1997;105:156-64.
14. Fritz JM, George SZ, Delitto A. The role of fear-avoidance beliefs in acute low back pain: relationships with current and future disability and work status. Pain 2001;94:7-15.

15. George SZ, Fritz JM, Erhard RE. A comparison of fear-avoidance beliefs in patients with lumbar spine pain and cervical spine pain. Spine 2001;26:2139-45.
16. Lee KC, Chiu TT, Lam TH. The role of fear-avoidance beliefs in patients with neck pain: relationships with current and future disability and work capacity. Clin Rehabil 2007;21:812-21.
17. Storheim K, Brox JI, Holm I, Bo K. Predictors of return to work in patients sick listed for sub-acute low back pain: a 12-month follow-up study. Journal of rehabilitation medicine : official journal of the UEMS European Board of Physical and Rehabilitation Medicine 2005;37:365-71.
18. Lewis S, Holmes P, Woby S, Hindle J, Fowler N. The relationships between measures of stature recovery, muscle activity and psychological factors in patients with chronic low back pain. Man Ther 2012;17:27-33.
19. Vlaeyen JW, Seelen HA, Peters M, et al. Fear of movement/(re)injury and muscular reactivity in chronic low back pain patients: an experimental investigation. Pain 1999;82:297-304.
20. Flor H, Birbaumer N, Schugens MM, Lutzenberger W. Symptom-specific psychophysiological responses in chronic pain patients. Psychophysiology 1992;29:452-60.
21. van der Hulst M, Vollenbroek-Hutten MM, Schreurs KM, Rietman JS, Hermens HJ. Relationships between coping strategies and lumbar muscle activity in subjects with chronic low back pain. European Journal of Pain 2010;14:640-7.
22. Mehlum IS, Kjuus H, Veiersted KB, Wergeland E. Self-reported work-related health problems from the Oslo Health Study. Occupational Medicine-Oxford 2006;56:371-9.
23. Picavet HSJ, Schouten J. Musculoskeletal pain in the Netherlands: prevalences, consequences and risk groups, the DMC3-study. Pain 2003;102:167-78.
24. Jensen C. Development of neck and hand-wrist symptoms in relation to duration of computer use at work. Scandinavian Journal of Work Environment & Health 2003;29:197-205.
25. Jensen C, Ryholt CU, Burr H, Villadsen E, Christensen H. Work-related psychosocial, physical and individual factors associated with musculoskeletal symptoms in computer users. Work and Stress 2002;16:107-20.
26. Jensen C, Finsen L, Sogaard K, Christensen H. Musculoskeletal symptoms and duration of computer and mouse use. International Journal of Industrial Ergonomics 2002;30:265-75.
27. Palmer KT, Cooper C, Walker-Bone K, Syddall H, Coggon D. Use of keyboards and symptoms in the neck and arm: evidence from a national survey. Occupational Medicine-Oxford 2001;51:392-5.
28. Gerr F, Marcus M, Ensor C, et al. A prospective study of computer users: I. Study design and incidence of musculoskeletal symptoms and disorders. American Journal of Industrial Medicine 2002;41:221-35.
29. Lethem J, Slade PD, Troup JD, Bentley G. Outline of a Fear-Avoidance Model of exaggerated pain perception--I. Behaviour research and therapy 1983;21:401-8.
30. Leeuw M, Goossens ME, Linton SJ, Crombez G, Boersma K, Vlaeyen JW. The fear-avoidance model of musculoskeletal pain: current state of scientific evidence. Journal of behavioral medicine 2007;30:77-94.

31. Vlaeyen JWS, KoleSnijders AMJ, Rotteveel AM, Ruesink R, Heuts PHTG. The role of fear of movement (re)injury in pain disability. Journal of occupational rehabilitation 1995;5:235-52.
32. Sullivan MJL, Bishop SR, Pivik J. The Pain Catastrophizing Scale: Development and validation. Psychological Assessment 1995;7:524-32.
33. McNeil DW, Rainwater AJ, 3rd. Development of the Fear of Pain Questionnaire--III. Journal of behavioral medicine 1998;21:389-410.
34. Vlaeyen J KA, Rotteveel A, Ruesink R, Heuts P. The Role of Fear of Movement/(Re)Injury in Pain Disability. Journal of occupational rehabilitation 1995;5:235-52.
35. Waddell G, Newton M, Henderson I, Somerville D, Main CJ. A Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability. Pain 1993;52:157-68.
36. Wideman TH, Asmundson GG, Smeets RJ, et al. Rethinking the fear avoidance model: Toward a multidimensional framework of pain-related disability. Pain 2013.
37. Crombez G, Eccleston C, Van Damme S, Vlaeyen JWS, Karoly P. Fear-Avoidance Model of Chronic Pain The Next Generation. Clin J Pain 2012;28:475-83.
38. Leuww M GM, Linton S, Crombez G, Boersma K, Vlaeyen J. The Fear-Avoidance Model of Musculoskeletal Pain: Current State of Scientific Evidence. Journal of behavioral medicine 2007;30:77-94.
39. Vlaeyen JW, Kole-Snijders AM, Boeren RG, van Eek H. Fear of movement/(re)injury in chronic low back pain and its relation to behavioral performance. Pain 1995;62:363-72.
40. Kori S MR, Todd D. Kinisophobia: A New View of Chronic Pain Behavior. Pain Management 1990;3:35-43.
41. Bailey KM, Carleton RN, Vlaeyen JW, Asmundson GJ. Treatments addressing pain-related fear and anxiety in patients with chronic musculoskeletal pain: a preliminary review. Cognitive behaviour therapy 2010;39:46-63.
42. de Jong JR, Vangronsveld K, Peters ML, et al. Reduction of Pain-Related Fear and Disability in Post-Traumatic Neck Pain: A Replicated Single-Case Experimental Study of Exposure In Vivo. Journal of Pain 2008;9:1123-34.
43. Woods MP, Asmundson GJ. Evaluating the efficacy of graded in vivo exposure for the treatment of fear in patients with chronic back pain: a randomized controlled clinical trial. Pain 2008;136:271-80.
44. Vlaeyen JW, de Jong J, Geilen M, Heuts PH, van Breukelen G. The treatment of fear of movement/(re)injury in chronic low back pain: further evidence on the effectiveness of exposure in vivo. Clin J Pain 2002;18:251-61.
45. Wicksell RK, Ahlqvist J, Bring A, Melin L, Olsson GL. Can exposure and acceptance strategies improve functioning and life satisfaction in people with chronic pain and whiplash-associated disorders (WAD)? A randomized controlled trial. Cognitive behaviour therapy 2008;37:169-82.
46. Elert J, Kendall SA, Larsson B, Mansson B, Gerdle B. Chronic pain and difficulty in relaxing postural muscles in patients with fibromyalgia and chronic whiplash associated disorders. Journal of Rheumatology 2001;28:1361-8.
47. Thorn S, Sogaard K, Kallenberg LAC, et al. Trapezius muscle rest time during standardised computer work - A comparison of female computer users with and without

self-reported neck/shoulder complaints. Journal of Electromyography and Kinesiology 2007;17:420-7.
48. Nordander C, Hansson GA, Rylander L, et al. Muscular rest and gap frequency as EMG measures of physical exposure: the impact of work tasks and individual related factors. Ergonomics 2000;43:1904-19.
49. Sjogaard G, Sogaard K, Hermens HJ, et al. Neuromuscular assessment in elderly workers with and without work related shoulder/neck trouble: the NEW-study design and physiological findings. Eur J Appl Physiol 2006;96:110-21.
50. Hagg GM. Static Work Loads and Occupational Myalgia - a New Explanation Model. Int Congr Ser 1991;949:141-4.
51. Hodges PW, Tucker K. Moving differently in pain: a new theory to explain the adaptation to pain. Pain 2011;152:S90-8.
52. Hodges PW, Ervilha UF, Graven-Nielsen T. Changes in motor unit firing rate in synergist muscles cannot explain the maintenance of force during constant force painful contractions. The journal of pain : official journal of the American Pain Society 2008;9:1169-74.
53. Tucker K, Butler J, Graven-Nielsen T, Riek S, Hodges P. Motor unit recruitment strategies are altered during deep-tissue pain. The Journal of neuroscience : the official journal of the Society for Neuroscience 2009;29:10820-6.
54. Falla D, Farina D, Dahl MK, Graven-Nielsen T. Muscle pain induces task-dependent changes in cervical agonist/antagonist activity. J Appl Physiol (1985) 2007;102:601-9.
55. Sjogaard G, Rosendal L, Kristiansen J, et al. Muscle oxygenation and glycolysis in females with trapezius myalgia during stress and repetitive work using microdialysis and NIRS. European Journal of Applied Physiology 2010;108:657-69.
56. Vernon H, Mior S. The Neck Disability Index: a study of reliability and validity. Journal of manipulative and physiological therapeutics 1991;14:409-15.
57. Carlsson AM. Assessment of Chronic Pain, I. Aspects of The Reliability and Validity of the Visual Analogue Scale. Pain 1983;16:87-101.
58. Sriwatanakul K, Kelvie W, Lasagna L, Calimlim JF, Weis OF, Mehta G. Studies with different types of visual analog scales for measurement of pain. Clinical Pharmacology and Therapeutics 1983;34:234-9.
59. Dover GC, Legge L, St-Onge N. Unilateral eccentric exercise of the knee flexors affects muscle activation during gait. Gait & posture 2012;36:73-7.
60. Mathiassen SE, Winkel J, Hagg GM. Normalization of surface EMG amplitude from the upper trapezius muscle in ergonomic studies - A review. Journal of electromyography and kinesiology : official journal of the International Society of Electrophysiological Kinesiology 1995;5:197-226.
61. Delisle A LC, Plamondon A, Imbeau D. Comparison of three computer office workstations
offering forearm support: impact on upper limb posture and muscle activation. . Ergonomics 2006;49:139-60.
62. Sterling M, Jull G, Kenardy J. Physical and psychological factors maintain long-term predictive capacity post-whiplash injury. Pain 2006;122:102-8.
63. George SZ, Stryker SE. Fear-avoidance beliefs and clinical outcomes for patients seeking outpatient physical therapy for musculoskeletal pain conditions. The Journal of orthopaedic and sports physical therapy 2011;41:249-59.

64. Sjors A, Larsson B, Persson AL, Gerdle B. An increased response to experimental muscle pain is related to psychological status in women with chronic non-traumatic neck-shoulder pain. BMC Musculoskelet Disord 2011;12:230.
65. Andersen LL, Nielsen PK, Sogaard K, Andersen CH, Skotte J, Sjogaard G. Torque-EMG-velocity relationship in female workers with chronic neck muscle pain. Journal of biomechanics 2008;41:2029-35.

APPENDIX A

PCS-EN

Client No.: __________ Age: _____ Sex: M(__) F(__) Date: _______________

Everyone experiences painful situations at some point in their lives. Such experiences may include headaches, tooth pain, joint or muscle pain. People are often exposed to situations that may cause pain such as illness, injury, dental procedures or surgery.

We are interested in the types of thoughts and feelings that you have when you are in pain. Listed below are thirteen statements describing different thoughts and feelings that may be associated with pain. Using the following scale, please indicate the degree to which you have these thoughts and feelings when you are experiencing pain.

0 – not at all 1 – to a slight degree 2 – to a moderate degree 3 – to a great degree 4 – all the time

When I'm in pain ...

1☐ I worry all the time about whether the pain will end.

2☐ I feel I can't go on.

3☐ It's terrible and I think it's never going to get any better.

4☐ It's awful and I feel that it overwhelms me.

5☐ I feel I can't stand it anymore.

6☐ I become afraid that the pain will get worse.

7☐ I keep thinking of other painful events.

8☐ I anxiously want the pain to go away.

9☐ I can't seem to keep it out of my mind.

10☐ I keep thinking about how much it hurts.

11☐ I keep thinking about how badly I want the pain to stop.

12☐ There's nothing I can do to reduce the intensity of the pain.

13☐ I wonder whether something serious may happen.

... Total

APPENDIX B

Fear of Pain Questionnaire-III

Name: Date:

INSTRUCTIONS: The items listed below describe painful experiences. Please look at each item and think about how FEARFUL you are of experiencing the PAIN associated with each item. If you have never experienced the PAIN of a particular item, please answer on the basis of how FEARFUL you expect you would be if you had such an experience. Circle one rating per item to rate your FEAR OF PAIN in relation to each event.

AMOUNT OF FEAR

1 = Not at All 2 = A little 3 = A fair amount 4 = Very much

5 = Extreme

I. Being in an automobile accident

2. Biting your tongue while eating

3. Breaking your arm

4. Cutting your tongue licking an envelope

5. Having a heavy object hit you in the head

6. Breaking your leg

7. Hitting a sensitive bone in your elbow-your "funny bone"

8. Having a blood sample drawn with a hypodermic needle

9. Having someone slam a heavy car door on your hand

10. Falling down a flight of concrete stairs

11. Receiving an injection in your arm

12. Burning your fingers with a match

13. Breaking your neck

14. Receiving an injection in your hip/buttocks

15. Having a deep splinter in the sole of your foot probed and removed with tweezers

16. Having an eye doctor remove a foreign particle stuck in your eye

17. Receiving an injection in your mouth

18. Being burned on your face by a lit cigarette
19. Getting a paper-cut on your finger
20. Receiving stitches in your lip
21. Having a foot doctor remove a wart from your foot with a sharp instrument
22. Cutting yourself while shaving with a sharp razor
23. Gulping a hot drink before it has cooled
24. Getting strong soap in both your eyes while bathing or showering
25. Having a terminal illness that causes you daily pain
26. Having a tooth pulled
27. Vomiting repeatedly because of food poisoning
28. Having sand or dust blow into your eyes
29. Having one of your teeth drilled
30. Having a muscle cramp

APPENDIX C

Tampa Scale for Kinesiophobia

(Miller , Kori and Todd 1991)

1 = strongly disagree

2 = disagree

3 = agree

4 = strongly agree

1. I'm afraid that I might injury myself if I exercise
2. If I were to try to overcome it, my pain would increase
3. My body is telling me I have something dangerously wrong
4. My pain would probably be relieved if I were to exercise
5. People aren't taking my medical condition seriously enough
6. My accident has put my body at risk for the rest of my life
7. Pain always means I have injured my body
8. Just because something aggravates my pain does not mean it is dangerous
9. I am afraid that I might injure myself accidentally
10. Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my pain from worsening
11. I wouldn't have this much pain if there weren't something potentially dangerous going on in my body
12. Although my condition is painful, I would be better off if I were physically active
13. Pain lets me know when to stop exercising so that I don't injure myself
14. It's really not safe for a person with a condition like mine to be physically active
15. I can't do all the things normal people do because it's too easy for me to get injured
16. Even though something is causing me a lot of pain, I don't think it's actually dangerous
17. No one should have to exercise when he/she is in pain

Reprinted from: *Pain*, Fear of movement/(re) injury in chronic low back pain and its relation to behavioral performance, 62, Vlaeyen, J., Kole-Snijders A., Boeren R., van Eek H., 371.

Scoring Information Tampa Scale for Kinesiophobia

(Miller et al 1991)

A total score is calculated after inversion of the individual scores of items 4, 8, 12 and 16.

Reprinted from: *Pain*, Fear of movement/(re) injury in chronic low back pain and its relation to behavioral performance, 62, Vlaeyen, J., Kole-Snijders A., Boeren R., van Eek H., 371.

APPENDIX D

Fear-Avoidance Beliefs Questionnaire (FABQ) for Patients with Back Pain
Overview:

The Fear-Avoidance Beliefs Questionnaire (FABQ) can help measure how much fear and avoidance are affecting a patient with low back pain. This can help identify those patients for whom psychosocial interventions may be beneficial. The authors are from the Western Infirmary in Glasgow (Scotland) and the Hope Hospital in Salford (England).

NOTE: This scale can be modified to apply to patients with other types of chronic pain. Only items 3 and 11 mention "back".

Instructions: Here are some of the things which other patients have told us about their pain. For each statement please circle the number from 0 to 6 to say how much physical activities such as bending lifting walking or driving affect or would affect your back pain.

Statements:
(1) My pain is caused by physical activity.
(2) Physical activity makes my pain worse.
(3) Physical activity might harm my back.
(4) I should not do physical activities which (might) make my pain worse.
(5) I cannot do physical activities which (might) make my pain worse.

The following statements are about how your normal work affects or would affect you back pain:
(6) My pain was caused by my work or by an accident at work.
(7) My work aggravated my pain.
(8) I have a claim for compensation for my pain.
(9) My work is too heavy for me.
(10) My work makes or would make my pain worse.
(11) My work might harm my back.

(12) I should not do my normal work with my present pain.

(13) I cannot do my normal work with my present pain.

(14) I cannot do my normal work till my pain is treated.

(15) I do not think that I will be back to my normal work within 3 months.

(16) I do not think that I will ever be able to go back to that work.

Response	**Points**
completely disagree	0
	1
	2
unsure	3
	4
	5
completely agree	6

fear-avoidance beliefs about work (scale 1) =

= (points for item 6) + (points for item 7) + (points for item 9) + (points for item 10) + (points for item 11) + (points for item 12) + (points for item 15)

fear-avoidance beliefs about physical activity (scale 2) =

= (points for item 2) + (points for item 3) + (points for item 4) + (points for item 5)

items not in scale 1 or 2: 1 8 13 14 16

Interpretation:

• minimal scale scores: 0

• maximum scale 1 score: 42 (7 items)

• maximum scale 2 score: 24 (4 items)

• The higher the scale scores the greater the degree of fear and avoidance beliefs shown by the patient.

Performance: • Internal consistency (alpha) 0.88 for scale 1 and 0.77 for scale 2 References:

Waddell G Newton M et al. A Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear- avoidance beliefs in chronic low back pain and disability. Pain. 1993; 52: 157-168 (Appendix page 166).

APPENDIX E

Neck Disability Index

THIS QUESTIONNAIRE IS DESIGNED TO HELP US BETTER UNDERSTAND HOW YOUR **NECK PAIN** AFFECTS YOUR ABILITY TO MANAGE EVERYDAY -LIFE ACTIVITIES. PLEASE MARK IN EACH SECTION THE **ONE BOX** THAT APPLIES TO YOU. ALTHOUGH YOU MAY CONSIDER THAT TWO OF THE STATEMENTS IN ANY ONE SECTION RELATE TO YOU, PLEASE MARK THE BOX THAT **MOST CLOSELY** DESCRIBES YOUR PRESENT -DAY SITUATION.

SECTION 1 - PAIN INTENSITY

I have no neck 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.

SECTION 2 - PERSONAL CARE

I can look after myself normally without causing extra neck pain.

I can look after myself normally, but it causes extra neck pain.

It is painful to look after myself, and I am slow and careful

I need some help but 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.

SECTION 3 – LIFTING

I can lift heavy weights without causing extra neck pain.

I can lift heavy weights, but it gives me extra neck pain.

Neck pain prevents me from lifting heavy weights off the floor but I can manage if items are conveniently positioned, ie. on a table.

Neck pain prevents me from lifting heavy weights, but I can manage light weights if they are conveniently positioned

I can lift only very light weights.

I cannot lift or carry anything at all.

SECTION 4 – READING

I can read as much as I want with no neck pain.

I can read as much as I want with slight neck pain.

I can read as much as I want with moderate neck pain.

I can't read as much as I want because of moderate neck pain.

I can't read as much as I want because of severe neck pain.

I can't read at all.

SECTION 5 – HEADACHES

I have no headaches at all.

I have slight headaches that come infrequently.

I have moderate headaches that come infrequently.

I have moderate headaches that come frequently.

I have severe headaches that come frequently.

I have headaches almost all the time.

SECTION 6 – CONCENTRATION

I can concentrate fully without difficulty.

I can concentrate fully with slight difficulty.

I have a fair degree of difficulty concentrating.

I have a lot of difficulty concentrating.

I have a great deal of difficulty concentrating.

I can't concentrate at all.

SECTION 7 – WORK

I can do as much work as I want.

I can only do my usual work, but no more.

I can do most of my usual work, but no more.

I can't do my usual work.

I can hardly do any work at all.

I can't do any work at all.

SECTION 8 – DRIVING

I can drive my car without neck pain.

I can drive my car with only slight neck pain.

I can drive as long as I want with moderate neck pain.

I can't drive as long as I want because of moderate neck pain.

I can hardly drive at all because of severe neck pain.

I can't drive my care at all because of neck pain.

SECTION 9 – SLEEPING

I have no trouble sleeping.

My sleep is slightly disturbed for less than 1 hour.

My sleep is mildly disturbed for up to 1-2 hours.

My sleep is moderately disturbed for up to 2-3 hours.

My sleep is greatly disturbed for up to 3-5 hours.

My sleep is completely disturbed for up to 5-7 hours.

SECTION 10 – 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 neck pain.

I am able to engage in most, but not all of my recreational activities because of pain in my neck.

I am able to engage in a few of my recreational activities because of neck pain.

I can hardly do recreational activities due to neck pain.

I can't do any recreational activities due to neck pain.

PATIENT NAME ____ DATE _____________

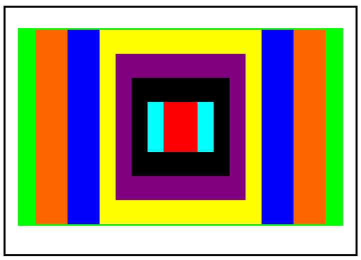
SCORE __________ [50]

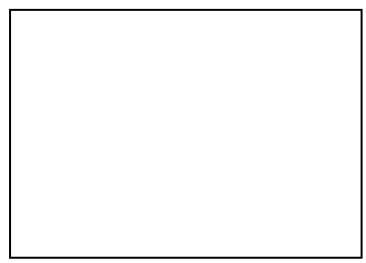
HVERNON@CMCC.CA

APPENDIX F

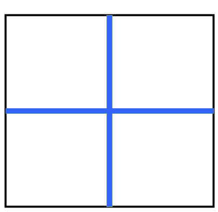
Mousing

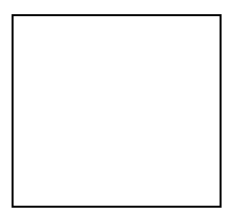
Activity 1





Activity 2





Activity **3**

WHY THE STATION AGENT AT COSTCO ?

According to the information recorded in the files of the CSST, the COSTCO stores are part of the 6413 sub-sector "Other general merchandise stores " as defined by the Standard Industrial Classification of Quebec in 1984. This sub- sector, which is reflected in the large sector of retail merchandise (CAEQ 641) , contains many stores , including superstores . Estimated for the period of 1998-2000 , an average of 11,000 workers work in the 6413 sub-sector per year. This sub- sector is highly risky as shown by the incidence rates of occupational injury compensation. Indeed, in 1998-2000 , more injuries or illnesses occured per year on average in this sub- sector (11.2%) than in other institutions performing retail merchandise (7.8%) . The duration of absence is however not comparable between these two groups (36 days) .

One of the characteristics of occupational injuries CAEQ 6413 is the importance of back injuries . During the period 1998-2000 , approximately 42 % of lesions , 46% of days of compensation and 46% of expenses are associated with this type of injury . If the frequency of back injuries in 6413 CAEQ (4.7%) is slightly higher than that calculated for other establishments engaged in the retail sale of various goods (3.0%), it is three times higher than that measured for all economic activities in Quebec (1.6%). There is also a slight increase in the frequency of back pain in 6413 CAEQ in 1998-2000 compared to 1995-1997. Finally, for events in 1998-2000 , back injuries cause absences from work in the shorter CAEQ 6413 (40 days) for all back injuries compensated in Quebec (55 days). This situation is similar for the period 1995-1997.

Musculoskeletal disorders in interpreters

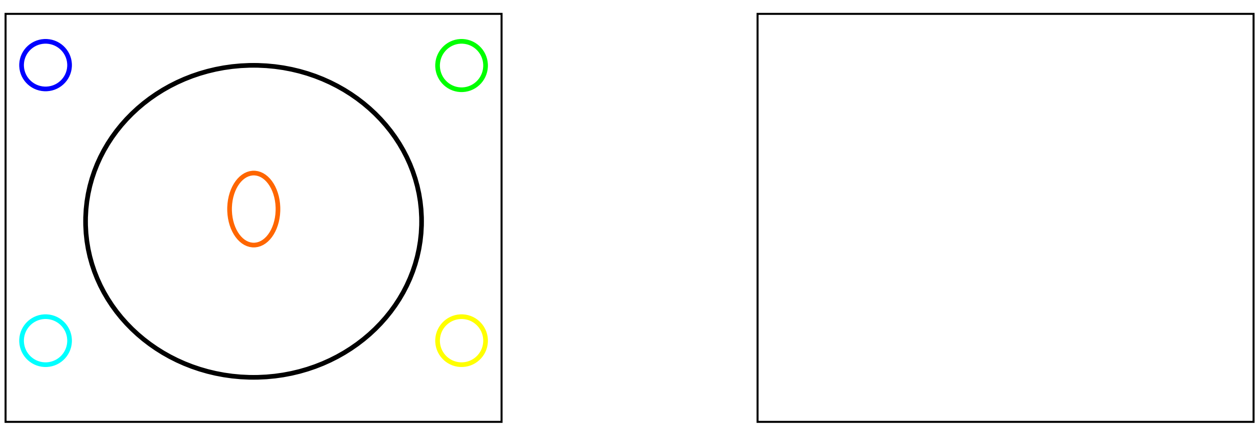
It is generally recognized that Visual Language Interpreters (ILV) frequently have musculoskeletal disorders (MSDs) (DeCaro et al 1992;Feuerstein et al 1992;Madden, 1995; Scheuerle et al 2000 . Stedt 1989 Sweeney et al . 1995). In a recent survey conducted by our team with Visual Language Interpreters of Canada , shoulder pain was reported by 81% of performers, neck pain by 79% , and pain in the region of the forearm, wrist and hand by 74 % of them (Durand et al . 2001). The corresponding figures for the adult population of Quebec were 50% , 41% and 28%, respectively (Health Canada , 1998). It is generally recognized that extreme postures , postures involving large net moment due to gravity , and other postures increasing tension on the tendons , muscles or other tissues are all postural characteristics that can cause musculoskeletal disorders skeletal (Hagberg et al. 1995).

In addition , changes in posture and more specifically the speed and acceleration of motion are other possible causes of musculoskeletal disorders with ILV. A semi -quantitative analysis revealed a typical task of interpretation of 50 minutes incorporated 13 600 wrist movements (Shealy et al . 1991). This high frequency movement also supports a possible link between the work of interpretation and musculoskeletal disorders considering the dynamic movements of the wrist have been reported as a risk factor for musculoskeletal disorders of the forearm region wrist and hand

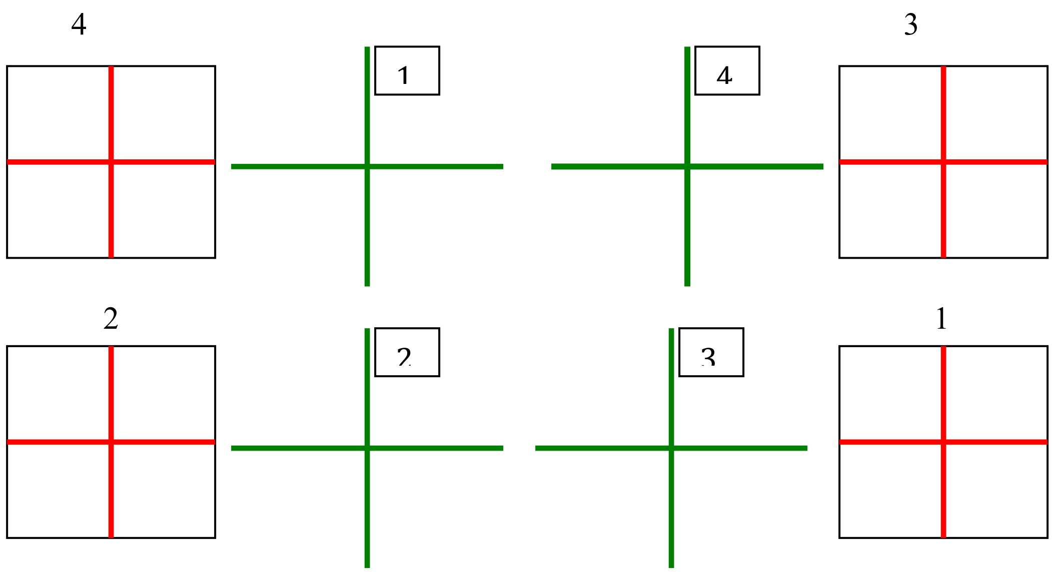
(Malchaire et al 1997 . Schoenmarklin and Marras 1993). The deployment of signs with upper limb involve static stabilization effort at the neck-shoulder region. Moreover, a sustained activation of the trapezius muscle was observed for an interpretive work (Hagberg et al. , 1987).

It seems plausible that maintaining a low long-term contraction may contribute to the development of a muscle injury in this region . In this type of contraction , soliciting long contraction duration in some motor units with a low activation threshold has been proposed as a possible mechanism of injury (the hypothesis of fiber Cinderella , "Cinderella hypothesis " Hagg , 1991; Sjogaard and Sjogaard , 1998) . In addition, the work of interpretation requires special attention to listening, understanding and translating the message of the speaker , which is an extreme mental stress . The message is not always clear and understandable , which can make it difficult to translate signs . This cognitive process contributes to increased stress , which can also have a significant impact on the muscle load in the region neck - shoulder , particularly in the trapezius (Westgaard , 1999) , thus contributing to the development of musculoskeletal disorders in ILV. It has also been shown that motor units with low activation threshold were also recruited during tasks involving a high cognitive load .

Activity 4



Activity 5



Typing and mousing

Activity 1

We have a beautiful day

The moon is full tonight

The temperature is not mild

The ice is melting very fast

There is a lot of rain!

It is bright!

The day like the night

It is important to sleep well	
The future belongs to the early risers	
It is important to eat well during the day	
Doing exercise is great!	
You have to know when to stop	
Make the most of life!	
But we also must work	

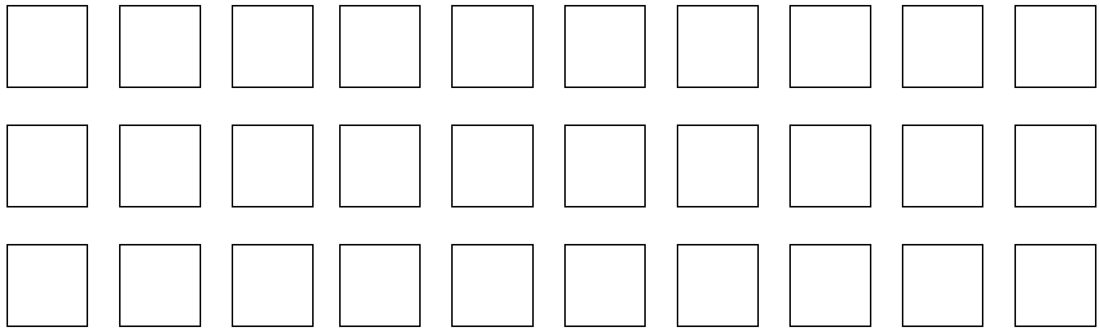
Activity 2

Part 1

a	b	c							

Part 2

1	2	3							



Typing

Type a standard document