UNIVERSITÉ DU QUÉBEC À MONTRÉAL

L'UTILISATION D'UN ALGOMÈTRE MANUEL AFIN D'ÉVALUER LE SEUIL DE LA DOULEUR AU NIVEAU DU TRONC ET DES MEMBRES SUPÉRIEURS CHEZ DES JEUNES FEMMES DE NIVEAU COLLÉGIAL

MÉMOIRE

PRÉSENTÉ

COMME EXIGENCE PARTIELLE

DE LA MAÎTRISE EN KINANTHROPOLOGIE

PAR

DAVID H JONES

AVRIL 2008

UNIVERSITÉ DU QUÉBEC À MONTRÉAL

THE USE OF A HAND-HELD ALGOMETER TO EVALUATE PRESSURE PAIN THRESHOLDS IN THE TORSO AND THE UPPER EXTREMITY OF COLLEGE AGED WOMEN

MASTER'S THESIS

AS PART OF THE MASTER'S PROGRAM

THROUGH THE

DEPARTMENT OF KINANTHROPOLOGIE

BY

DAVID H JONES

APRIL 2008

PREAMBLE

THE ORIGIN OF THE PROJECT

Pain in the upper arm, shoulder, upper back and neck region commonly occurs in women who have undergone or are undergoing breast cancer therapy. The original goal of this project was to see if applying a therapeutic modality, such as ice, would be effective at controlling the post operative pain in women who had undergone a partial mastectomy with an axillary node dissection, as part of the breast cancer therapy. It was decided that several preliminary projects would have to be performed before the effectiveness of this therapeutic modality on shoulder pain could be properly evaluated. The preliminary projects included 1) Identifying an appropriate measurement tool and testing protocol to quantify the subjective changes in perceived pain of different individuals; 2) Identify the potentially problematic locations on the body where the measurement tool and testing protocol would be used; 3) Evaluating the testing protocol on populations that do not presently have any dysfunction, to understand what may be considered "normal" in the locations to be tested; 4) Using the testing measurement tool and testing protocol on patients that are going to have breast sparing surgery to note any trends that may occur; and 5) Finally using the measurement tool and testing protocol to collect baseline values on women undergoing a partial mastectomy with an axillary node dissection, having the women utilize ice as part of their post operative treatment plan and then retest the locations after a fixed period of time.

In this project only stages one (measurement tool and testing protocol), two (determining the testing locations) and three (using the testing protocol on a normal population) were completed. The material being presented in this manuscript includes the data that was collected during the experimental trials of these stages. It will be speculated that the measuring device and the testing protocol maybe also used for various groups dealing with upper body dysfunction as well as women undergoing breast cancer therapy.

Preliminary work has begun with a local breast cancer clinic to implement projects four (the use of the testing protocol with breast cancer patients) and five (use the testing protocol to measure the effectiveness of a therapeutic intervention to reduce pain).

ACKNOWLEDGEMENTS

It would have been extremely difficult to complete this project with out the tremendous support of my supervisors Dr. Alain Steve Comtois and Dr. Robert Kilgour and my fellow staff members Mr. Ron Rehel, Ms Tracy Griffiths and Ms. Christina Grace in the Department of Exercise Science at Concordia University. My two thesis supervisors played a significant role in helping to shape and define a strong research project. My three colleagues from the Department of Exercise Science who were always ready and willing to help when needed and did make a significant contribution to the project. I would also like to thank Dr. Karen Messing for the use of the hand-held algometer to this project and her comments to help make a stronger thesis, Mr. Jean-Bapiste Laporte for his help in translating the abstract of the thesis, as well as to Dr. Marc Belanger for all his constructive criticism on the thesis.

I say goodbye to Alex, Moe, my Dad, Bill, Steve, Anita, Maize, Jean and Helvi.

A final thank you goes to my family, to my Mom and Dad for helping to give me direction and to my wonderful wife and two super sons for all of their patience and encouragement.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

RÉSUMÉ :

Objectifs : le but de ce projet fut d'utiliser un algomètre manuel afin de pouvoir apprécier l'intensité du seuil de douleur à la pression (appelé PPT pour pain pressure threshold) sur huit locations cutanées différentes au niveau des membres supérieurs et du tronc chez des jeunes femmes en bonne santé, durant quatre jours consécutifs d'évaluation. Les différentes études sur ce sujet à ce jour nous permettaient de croire que les huit locations ne présenteraient pas de "PPT" même intensité. Le fait de noter des variations de "PPT" pourrait alors être une première étape dans le développement d'un protocole diagnostique rigoureux qui aurait un intérêt dans l'approche de différents groupes de patients présentant des maux et souffrances au niveau de la nuque, des épaules et des bras.

Méthode : les mesures de l'intensité du "PPT", furent obtenues à partir de huit sites différents sur le bras et le tronc (coté droit seulement) de dix-neuf jeunes femmes. Tous les sujets testés étaient droitières, avaient des cycles menstruels réguliers et n'avaient présenté aucun problème musculo-squelettique relié à l'épaule au cours des six mois précédant la période d'évaluation. Chacune d'entre elle fut recrutée au sein de la population de l'Université Concordia.

Deux thérapeutes du sport expérimentés eurent à identifier, valider et marquer les huit différents sites sur la peau de chaque sujet. Les deux thérapeutes du sport palpèrent

également les huit sites afin de déterminer la présence ou l'absence d'un nodule musculaire (contracture) pouvant s'associer à un point gachette " trigger point" potentiel à chacun des emplacements. Cette palpation fut effectuée en début et en fin de chaque session de tests. Au cours de quatre jours consécutifs d'évaluation, un algomètre manuel fut employé sur chacun des emplacements marqués afin de mesurer l'intensité du "PPT" sur chaque sujet. Après la collecte des mesures enregistrées par l'algomètre et l'évaluation palpatoire des deux thérapeutes du sport, une mesure des plis cutanés fut également prise pour chacune des huit sites.

Résultats : la principale conséquence de cette recherche fut de révéler un abaissement significatif de l'intensité du "PPT" pour les huit emplacements lors des quatre jours d'évaluation. Une différence significative de l'intensité du seuil de douleur fut également démontrée au niveau du bras comparé aux valeurs du tronc. Les emplacements de la partie supérieure du bras et de la partie antérieure de l'épaule montrèrent des valeurs de PPT significativement plus faibles lorsque qu'ils furent comparés aux cinq autres emplacements du tronc et de la partie postérieure de l'épaule.

Aucune corrélation ne fut trouvée entre l'épaisseur du pli cutané d'un emplacement et l'intensité du "PPT" de ce même emplacement chez les sujets testés. Les régions ayant une épaisseur du pli cutané plus importante n'ont pas forcément montré d'intensités de "PPT" plus élevées ou faibles.

La mesure statistique « interclass correlation scores » qui permet d'évaluer le degré d'accord entre les deux thérapeutes du sport sur la présence ou l'absence d'un nodule musculaire associé à un point gachette fut de 0,54. Cette valeur peut être considérée comme basse statistiquement mais se révèle consistante et en rapport avec les autres valeurs du même type retrouvées dans d'autres études évaluant les habilités manuelles de praticiens à des fins diagnostiques.

Cette étude peut donc fournir aux praticiens et chercheurs des indications claires à propos d'un protocole d'évaluation des mesures de "PPT" qui permettrait d'obtenir des valeurs initiales de base au niveau des régions du bras et du tronc de jeunes femmes ne présentant pas de dysfonctions scapulo-humérales. Des études futures auraient donc comme intérêt d'utiliser ce même protocole d'évaluation chez des femmes souffrant effectivement de douleurs à l'épaule ou chez des femmes pouvant présenter des facteurs de risques quant au développement de ces mêmes douleurs lors d'interventions associées au traitement du cancer du sein.

Mots-clés : PPT, cancer du sein, point gachette, douleur à la pression.

ABSTRACT:

Objective: The goal of this project was to use a hand-held algometer to evaluate the pressure pain thresholds (PPT) of eight locations in the upper arm and torso of young healthy female subjects over four consecutive days of testing. Based on previous research, it was expected that not all eight locations would have the same PPT level. Noting the differences in PPT levels at the eight locations would be one of the first steps in the development of an effective diagnostic protocol which may be used on different groups who are experiencing pain in the neck, shoulder and arm region.

Methodology: PPT measures were obtained from eight different locations in the upper arm and torso (right side only) of 19 female subjects. All subjects were right hand dominant, had regular menstrual cycles and had not experienced any musculoskeletal problems related to the shoulder in the 6 months prior to being tested. All subjects were recruited from the Concordia University community.

Two experienced athletic therapists identified, agreed upon and marked the eight different skin surface locations on each subject. The two athletic therapists also palpated the eight locations to determine the presence or absence of a nodule associated with a potential trigger point at each of the locations. Palpation occurred at the beginning of the testing

session and at the end of the testing session. Over 4 consecutive days of testing, a hand-held algometer was applied to each location to determine the subject's pressure pain threshold.

Upon completion of the algometer measurements by the data collector and the palpation evaluation by the two athletic therapists, skin-fold measurements were taken at each of the 8 locations.

Results: The main effect of this research project showed a significant decline in the PPT values across all 8 locations over the 4 days of testing. A significant difference was also seen in the PPT values of the upper extremity compared to the PPT values of the torso. The locations in the upper arm and anterior shoulder were found to have significantly lower PPT values when compared to the other 5 locations on the torso and posterior shoulder.

No correlation was found between the skin-fold thickness of a location and the PPT value obtained at the same location in the subjects that were tested. Regions that had higher levels of skin-fold thickness did not necessarily have higher or lower PPT values.

The interclass correlation score evaluating the agreement between the 2 athletic therapists on the presence or absence of a nodule associated with a trigger point was 0.54, which is considered low, but is consistent with scores reported in other studies evaluating diagnostic manual skills of clinicians.

This project gives clear guidelines as to the testing protocol that may be used by clinicians and researchers on how to obtain baseline PPT measures in the upper arm and torso region of young women who are not experiencing any shoulder dysfunction. The next step in this project will be to utilize this testing protocol on women who maybe experiencing shoulder problems or who are at risk at developing shoulder problems such as women undergoing adjuvant therapy associated with breast cancer.

Keywords: PPT, Pressure pain thresholds, Breast cancer, Trigger point

CHAPTER I

INTRODUCTION -REVIEW OF THE CURRENT LITERATURE

1.01 Breast cancer

The advancement in diagnostic tools has led to improvements in the early detection of suspicious lumps in breast tissue that are associated with breast cancer (Ugnat et al., 2004). This has led to an increase in of the number of women being identified as being at risk for developing breast cancer, along with a significant decrease in morbidity in this same group (Jatoi and Miller, 2003, Miller et al., 2002, Ellison and Gibbons, 2004). The primary goal of the oncology team is to remove the cancerous tissue and preserve the patient's life, which certainly should be paramount (Harris et al., 1996). Unfortunately there are some negative side effects that are associated with breast cancer therapy, which include fatigue, reduction in the ability to complete some activities of daily living, swelling, edema along with the possibility of developing prolonged shoulder dysfunction (Harris et al., 1996). The following thesis will be focusing on the shoulder dysfunction that occurs for breast cancer patients and how some women may have certain characteristics that place them at an increased risk for developing pain in the upper arm, shoulder, upper back and neck region.

1.02 Adjuvant therapy

When breast cancer is suspected, the medical team often recommends some form of adjuvant therapy. Adjuvant therapy for breast cancer typically involves four major areas 1) surgery 2) chemotherapy, 3) radiation therapy, and 4) hormonal therapy (Ugnat et al., 2004). It may be recommended to patients that at least one and sometimes all four of the therapies be used to treat the breast cancer (Ugnat et al., 2004). As with many interventions, whether surgical or non-surgical, various adverse effects may occur (Giordani et al., 2005, Varabi, 2003).

When surgery takes place, an area slightly larger that the tumour itself (that includes the tumour) is removed from the breast region to ensure obvious cancerous tissue has been excised. A sampling of axillary lymph nodes also takes place, to see if any migration of cancerous cells to other parts of the body has occurred. The sampling of lymph nodes may include a removal of a single lymph node or several nodes (Arnaud et al., 2004).

Chemotherapy involves the introduction of toxic agents to the body. The cancerous cells that created the initial tumour in the breast of the patient are no longer recognized as being foreign and dangerous to the immune system of the individual. The body has begun to accept their presence in the body, making them a significant threat. The goal behind chemotherapy is to introduce toxic agents into the system and stimulate cell death, defined

as "apoptosis". This systemic approach kills off any cancerous cells that may have migrated from the original tumour location (Gajdos et al., 2002). The cell death that is initiated through chemotherapy not only occurs to the cancerous cells but also to the healthy cells of the individual. It becomes easy to see why often patients undergoing chemotherapy experience a significant amount of fatigue that may last well after the chemotherapy has been completed. This fatigue often affects the patient's activities of daily living (Cella et al., 2007).

Radiotherapy or radiation therapy involves the delivery of small but concentrated amounts of radiation to the breast area to kill any cancerous cells that may still be in close proximity to the site where the tumour was removed. This local approach will cause a reddening of the breast area, similar to having a significant sunburn. Present day refinement of radiation therapy has reduced the impact on nerve endings and blood vessels in close proximity to the treatment area. As with chemotherapy, fatigue is a reoccurring problem for the patient (Lee et al., 2007).

One approach in hormonal therapy involves the suppression of the hormone oestrogen within the woman's body. Medications such as Tamoxifen try to suppress the oestrogen uptake by the oestrogen receptors within the breast tissue, preventing accumulation, and without disrupting oestrogen homeostasis elsewhere in the body (Harris et al., 1996). Drugs

such as Tamoxifen are also used to help maintain bone density in women, which is normally the role of oestrogen. Hormonal therapy along with chemotherapy has been shown to move pre-menopausal women who are undergoing treatment into menopause (Harris et al., 1996).

Women do periodically experience hot flashes with Tamoxifen medication along with other side effects (Cella et al., 2007). Other problems that are associated with various forms of adjuvant therapy may include cognitive symptoms, musculoskeletal pain, vasomotor symptoms, nausea, sexual problems, bladder problems, body image, and vaginal symptoms (Cella et al., 2007).

The role of chemotherapy, radiotherapy and hormonal therapy does seem to be directly related to women initiating shoulder dysfunction although they do seem to aggravate any initial shoulder problems and cause them to last much longer than they should. It is important then to take a closer look at the surgical intervention.

1.03 Breast cancer, breast surgery and shoulder dysfunction

During surgery for a partial mastectomy the tumour is identified as being in one of four quadrants of the breast, upper medial, upper lateral, lower medial and lower lateral. To remove the tumour an incision is typically made along the lateral border of the breast and the tumour is removed (Harris, 1996).

As mentioned previously, a sampling of lymph nodes takes place to verify if any migration of the cancer cells to other regions of the body has occurred. Figure 1 outlines the upper torso and the lymphatic channels in that region; the axillary node dissection associated with a partial mastectomy involves the excising of tissue that will harvest lymph nodes from the axillary lymph node at levels 1 (point B) and 2 (point C) and occasionally level 3 (point D). During the removal of the tumor, the surgeon avoids cutting into the pectoralis major muscle, which is in close proximity to the breast, unless it is in the area that is affected by the tumor. Cutting into the muscle would increase the risk of shoulder dysfunction for the patient. The surgery does require that incisions be made into the pectoral fascia, the thin layer of tissue which surrounds the chest area, since these incisions are considered less invasive for the patient (Harris et al., 1996). The surgeon will then try to harvest the lymph nodes through the same incision site where the tumour was removed. Occasionally a second incision will need to made, if the first incision site is far away from where the axillary lymph nodes may be harvested (Harris et al., 1996).

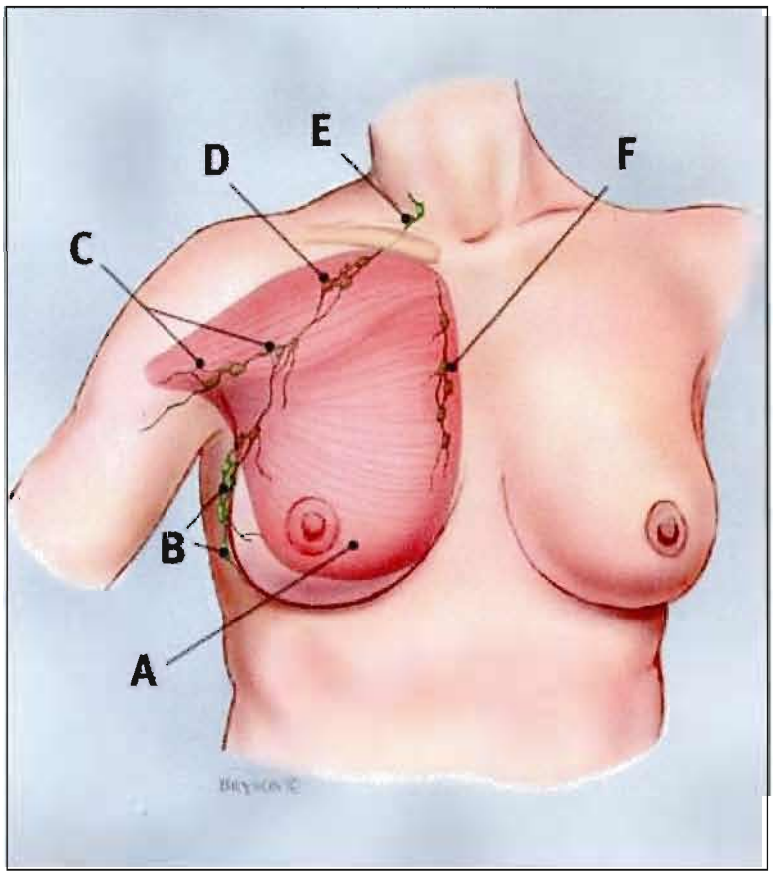

Figure 1: Upper torso and lymph nodes (www.breastcancer.org)

- **A** Pectoralis major muscle, **B** Axillary lymph nodes: levels I,
- **C** Axillary lymph nodes: levels II, **D** Axillary lymph nodes: levels III

  E Supraclavicular lymph nodes, **F** Internal mammary nodes lymph

The lymphatic system of the body is used to recover fluid in the interstitial spaces that has not been taken up by the venous system (Guyton and Hall 2000). The harvesting of lymph nodes during a partial mastectomy diminishes this uptake process, which may lead to pooling of the lymph in the upper extremity (Taylor 2004).

Following a partial mastectomy with an axillary lymph node dissection, women may experience pain, swelling in the upper extremity, loss of shoulder mobility and a decrease in their ability to perform activities of daily living (Swenson et al., 2002).

After having undergone surgery, it is often recommended that women receive additional therapy, which may include chemotherapy and radiotherapy. Literature reviews indicate that women who enter radiotherapy with shoulder dysfunction are much more likely to maintain these problems when re-evaluated two years post surgery. (Bendz, Fagevik and Olsen, 2002)

A study by Maunsell, Brisson and Deschene (1993) found that 82 % of respondents reported at least one problem, 3 months after receiving a surgical intervention that required a partial mastectomy with an axillary lymph node dissection. In this study 55 % of the women (n=233) reported experiencing pain in their shoulder or arm. A follow up on the women 18 months after surgery found that 79% of the respondents (n=210) reported having at least one

shoulder problem. The women reported experiencing pain, swelling or numbness in the shoulder and arm regions.

It is clear that the need to regain shoulder mobility exists for this cohort of women, to avoid prolonged shoulder problems. One approach that maybe utilized to address this problem is to control the amount of postoperative pain the women are enduring so that they may begin to move their arm.

There has been some work by different groups (Kilgour, Jones and Keyserlingk, 2007) to try and minimize the amount of post operative shoulder dysfunction that does take place through the use of a home based exercise program, but there is still much work to be done.

Certainly having a portion of one's body removed is a very traumatic event but in comparison to many other types of orthopedic surgery in and around the shoulder, this intervention is considered minor surgery (Leidenius et al., 2003). Oncology physicians are still not certain why so many women run into problems, yet many of the women who do undergo this regime of treatment are at risk for developing chronic arm, shoulder and neck problems (Leidenius et al., 2003).

It is possible that women may be predisposed to developing problems in the upper body. Thus, it may also be important to look at other areas of daily living where women may be at risk for developing pain in the neck, shoulder and arm regions. These are outlined in the following section.

1.04 Work-related injuries

Women seem to be at greater risk for developing pain in the neck, shoulder and arm regions in comparison to men (Chesterton et al., 2003). Women often comprise a significant portion of different occupations (Sorock and Courtney, 1996) that are most at risk to upper body injuries. Men have also been shown to have repetitive injury syndrome, but not to the same extent as women. When evaluating the work of men and women who work on production lines, there is a similarity in the type of chronic injuries that occur (Westgaard and Winkel, 1996), although women seem to be affected to a greater extent.

In some instances there is a misunderstanding as to the actual demands of the tasks that are being performed. Activities, specifically jobs that maybe perceived at being easy and not being physically demanding may in reality turn out to be quite physically demanding. A good example of this involved a study looking at women who worked at sewing machines sewing clothes. An activity that may take a short period of time to complete (on one piece of clothing) but because of the repetitive demands and the materials being used (such as denim

in jeans) it turns into a more physically challenging activity (Vezina, Tierney and Messing, 1992)

Lindman et al., (1990, 1991) evaluated pain in the neck and shoulder region in women and noted differences in morphological development of the trapezius muscle between men and women. Lindman believes this may explain why women seem to be at greater risk for developing neck, shoulder and arm problems. When Lindman et al., (1990, 1991) performed muscle biopsies on both groups he found that women had a significantly greater proportion of type 1 muscle fibers when compared to men. Lindman et al., (1990, 1991) hypothesized that the difference in fiber composition may explain why the two genders may have ended up moving towards specific type of jobs. Women who have a greater composition of type 1 (slow twitch fatigue resistant) fibers in their trapezius muscle have a greater aerobic capacity and do not fatigue as quickly, as compared to type 2 fibers (Guyton and Hall, 2000; Lindman, Eriksson and, Thornell, 1991). Men who have a greater composition of type 2 fibers (fast twitch non-resistant to fatigue) fibers in their trapezius muscle, are able to generate greater explosive contractions/force, but will fatigue faster, as compared to type 1 fibers (Guyton and Hall, 2000; Lindman, Eriksson and, Thornell, 1991). Lindeman et al., (1991) also looked at the way women and men perform the same the activity, specifically data entry. The women involved in the study were shown to use shoulder; arm and wrist motions in a different manner compared to men and were expending significantly more

energy. The women were also often found to be much more effective at entering large volumes of data compared to men. Entering more data and expending more energy may also be two factors that have contributed to women experiencing more pain while performing this task in comparison to men, who used less energy as well as entered less data.

Work by Hooftman et al., (2004) found gender differences in relation to musculoskeletal pain where men were more likely to complain of pain in the low back and women were more likely to complain of pain in the shoulder. Hooftman et al., (2004) did not find any gender relationship with neck pain.

Karlqvist, Leijon and Harenstam (2003) believe that workers that are in poor physical condition are at greater risk for developing pain and dysfunction in different regions of the body. Their work has shown that workers, both men and women, but in particular females, are not in good physical condition and that the jobs they perform on a regular basis do not improve their fitness level. If anything, the jobs tend to be deleterious towards the workers health.

Many different occupational groups, such cashiers, dental hygienist and people who work at computer terminals have been found to have significant problems with pain in the neck,

shoulder and arm regions (Johansson et al., 2003; Luime et al., 2004). The problems experienced by workers have included different forms of neck and shoulder pain, tendonitis/tendinosis in the forearm; lateral epicondylitis (Johansson et al., 2003), and shoulder; supraspinatus tendonitis (Lundberg et al., 1999), shoulder bursitis (Luime et al., 2004), periodic numbness; thoracic outlet, brachial plexopathies (Mense and Simons, 2001), nerve entrapment (Pascarelli and Hsu, 2001) and carpel tunnel syndrome (Rice, Nindl and Pentikis, 1996).

Workers who experience pain in the neck, upper torso and arm regions are often asked to perform a task(s) that require a muscle or group of muscles to maintain a static position for a prolonged period of time (Mense and Simons, 2001). The tasks that are being performed often do not require a significant amount of muscular strength or force, usually having low biomechanical demands, but are repetitive in nature (Mense and Simons, 2001). Workers having pain in the neck shoulder and arm region include people who operate computers terminals, super-market cashiers (Lundberg et al., 1999), dental personnel (Rice, Nindl and Pentikis, 1996; Rising et al., 2005), nursing home workers (Luime et al., 2004) and musicians (Pascarelli and Hsu, 2001; Zaza and Farewell, 1997). A common trend that is seen in many of these studies is the high prevalence of neck–shoulder pain in females (Chesterton et al., 2003).

There is growing consensus that musculoskeletal disorders may be related to the occupational activities of the individuals (Punnett and Wegman, 2004) but it is still unclear how much predisposing factors play a role in a worker developing musculoskeletal disorders.

As Messing et al., (2003) point out in their literature review of work demands and gender differences, the actual number of women who suffer injury that is associated with the tasks that they perform at their jobs may be much larger than what has been recorded to date.

1.05 Cinderella theory

The Cinderella syndrome theory developed by Hägg (1991) explains how repetitive movements may have a negative impact on the body and why women may be at greater risk for certain musculoskeletal disorders (Johansson et al., 2003; Ge, Madeleine and Arendt-Nielsen, 2005). During active movement (whether static or dynamic) where force is required, motor units associated with small muscle fibers will be the first muscle fibers to be recruited and as the intensity of the work increases and greater force is required, motor units associated with larger muscle fibers will be recruited. This concept was outlined in Henneman's principle (Henneman, Somjen and Carpenter, 1965) concerning the order of recruitment of motor units. The Cinderella syndrome (Ge, Madeleine and Arendt-Nielsen, 2005) attempts to utilize Henneman's principle (Henneman, Somjen and Carpenter, 1965)

of the order of muscle fiber recruitment where small muscle fibers are being asked to perform work at a low intensity for a prolonged period of time and the larger fast twitch fibers being sporadically recruited. This situation may lead to excessive shearing forces at the level of the small slow twitch fibers and some form of dysfunction at the motor endplates (Mense and Simons, 2001).The shearing forces would lead to a disorganization of the actin and myosin cross bridges. In the story of Cinderella, Cinderella was always the first to start working in the morning and the last to stop working at night, similar to what maybe happening to the smaller fibers. One of the drawbacks with the Cinderella theory is the concept that during active muscle contraction the same muscle fibers (Type 1 muscle fiber motor units) will be continually recruited and will have limited recovery time leading to the same motor units of muscle fibers being continuously contracted. We know from the physiology literature that during active movement, motor units of small and large muscle fibers will be contracted and relaxed continuously and that not all motor units may be recruited at one time (Gardiner 2001). It is only through the use of electrical stimulation that all motors units of small and large muscle fibers may be stimulated leading to a muscle contraction (Gardiner 2001). This continuous recruitment and relaxation of the motor units is not really addressed in the explanation of the Cinderella theory. Nonetheless, the Cinderella theory is a promising theory that has led researchers to question Henneman's principle of recruitment especially as it pertains to repetitive work related syndromes.

The connection with the Cinderella hypothesis as it pertains to women is that if women have a greater composition of type 1 fibers in trapezius muscle compared to men, then it may explain why women appear to develop neck pain and shoulder more frequently than men. When performing a low intensity task for a long period of time, men would fatigue more quickly with type 2 fibers and may be less likely to develop chronic pain in this region; because before the problem develops the men are more likely stop performing the required task. Women with a larger composition of type 1 fibers in the trapezius would be able to perform the low intensity tasks for longer periods of time before fatigue would set in and might only notice the area becoming painful long after tissue damage started to occur.

1.06 Perception of pain

Why women may likely experience more pain in the neck, shoulder and arm region maybe related to the way in which men and women process pain on a cognitive level (Nie et al., 2005; Wahlstrom et al., 2000). A study by Sarlani et al. (2004) that evaluated gendered response to chronic painful stimulation found women to be less likely to habituate to the chronic painful stimulus in comparison to men. In the study, both groups received a continuous low level stimulation which was irritating but did not cause any type of tissue damage. Over time, men were able to adapt to the chronic painful stimulus, eventually being able to habituate to and/ or block out the stimulus. The women in this study were less able to accommodate to the chronic stimulus and were less likely to develop a coping strategy (Sarlani et al., 2004). This lack of adaptation may also apply to the neck and shoulder

region, where women may have been less likely to ignore pain or develop a coping strategy so that they may continue to perform their job (Sarlani et al., 2004; Greenspan and McGillis, 1994).

A final reason why more women than men have been identified as having pain in this region may be related to the fact that women tend to be more verbal and forthcoming about pain and issues they are experiencing (Sarlani et al., 2004; Sarlani, Farooq and Greenspan, 2003; Sarlani and Greenspan, 2002). There is evidence that women are conscientious about taking care of their body and may seek out medical attention more readily than men (Sarlani et al., 2004; Sarlani, Farooq and Greenspan, 2003; Sarlani and Greenspan, 2002).

To summarize this section, women who work outside of the home seem to make up a disproportionate number of the work force that ends up coping with pain in the neck, shoulder and arm. The number of women who make up this group maybe underreported. The risk of injury maybe related to the tasks the women perform at their jobs and there appears to be an underestimation of the physical demands placed on women to complete the different jobs. The muscle fiber composition of the trapezius muscle and possibly other muscles in the region may place women at greater risk for developing neck pain. Women may be more aware of how their body handles stress, especially when stress provokes pain, compared to men.

1.07 The role of a hand-held algometer

One of the first challenges for this project was to validate the efficacy of the measuring tool that could quantify the subjective impression of pain of an individual. Measuring devices such as algometers have been used to give a quantitative measure of the subjective pain threshold of individuals (Messing and Kilbom, 2001). The algometer has been used on mammals to evaluate the pressure pain threshold (PPT) of the paw, noting what pressure has to be applied before the mammal attempts to remove its paw from the area (Garell, McGillis and Greenspan, 1996). The algometer has also been used on humans, looking at pain thresholds in different groups of individuals and body locations (Itoh, Okada and Kawakita, 2004; Kosek and Ordeberg, 2000; Messing and Kilbom, 2001; Svendsen et al, 2005).

There are at least 3 different measurements that may be derived from the algometer: 1) the **perception of pressure** when the subject first feels pressure being applied from the algometer to a location on the individual; 2) **Pressure pain threshold** (PPT) when the sensation of pressure to the skin surface changes to the sensation of pain; and 3) **Maximal pain tolerance** or the maximum amount of force the individual is able to tolerate (Nussbaum and Downes, 1998; Persson et al., 2000; Vanderweeen et al., 1996). For this study, we used the PPT as a standard measure.

Algometers have evolved over time, moving from manual devices to electronic and computer assisted devices. The original algometer was a spring loaded gauge unit that required verbal feedback from the subject as to when different thresholds have been attained. (Nussbaum and Downes, 1998) Electronic algometers followed, allowing subjects to depress hand-held switches that connect to the algometer and indicate the threshold. The electronic algometer also has a digital read out, which improves the testing accuracy. This change has lead to studies comparing the PPT values obtained using electronic algometers and manual algometers on the same locations and same subjects (Atkins et al., 1992) Electronic algometers have been shown to be more sensitive than manual algometers and may give a more accurate reflection of the subject's PPT (Atkins et al., 1992). Electronic algometers were also found to record lower PPT values than manual algometers. The third generation of algometers have computer links and are attached to support stands so that progressive loads maybe carefully applied and monitored (Stohler and Ashton-Miller, 2007). The electronic algometer was used for this study on multiple locations to be tested on each subject and in two different testing positions.

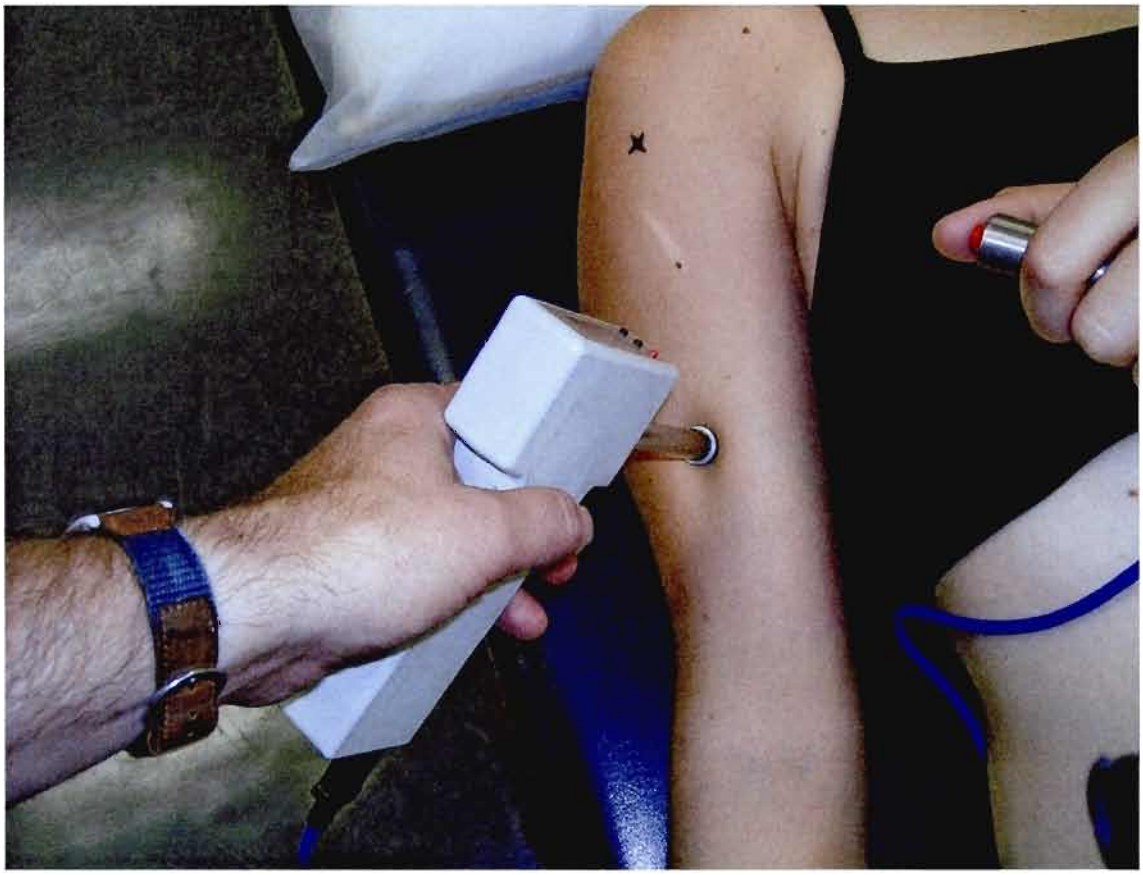

Figure: 2 Electronic algometer (hand with wristwatch) with hand-held patient switch (red button with subject thumb over it).

1.08 Factors that affect the use of the Algometer

As researchers learned how to use the algometer certain factors became apparent. When utilizing an algometer, there is a learning curve the subject must undergo before understanding what sensations the data collector wants to record (Nussbaum and Downes, 1998; Persson, Brogargh and Sjolund, 2004). The practice in some studies involves applying the algometer to the designated landmarks, discarding the first set of trials and calculating the mean of the subsequent trials (Persson, Brogargh and Sjolund, 2004). For this thesis project, the algometer was applied to a skin surface landmark four different times. Details of the algometer application are presented in the methods section.

A number of studies have looked at the reliability of the algometer, between different evaluators. The interclass correlation of the testers has been found to be high (Nussbaum and Downes, 1998). This type of testing has usually occurred on the same day or days. Earlier studies with manual algometers used mixed groups (males and females) over consecutive days of testing and found little variation in PPT values or in some instances elevation of values over the testing period (Persson et al., 2000).

Handedness appears to play a role in sensitivity to shoulder pain (Ozcan et al., 2004). Right hand dominant subjects have been shown to have a significant difference between their dominant and non-dominant sides in PPT scores, compared to left hand dominant subjects

(Ozcan et al., 2004). The non –dominant side of right handed dominant subjects was shown to have significantly lower pressure pain threshold values. This is in contrast to left hand dominant subjects who did not show as much variation in PPT scores between their dominant side and non-dominant sides (Ozcan et al., 2004).

The female menstrual cycle has been recently indicated as having an impact on values obtained using an algometer (Bajaj et al., 2001; Sherman et al., 2005). Studies evaluating women's PPT values at different stages of their menstrual cycle noted variations in the subject's level of pain tolerance. Women showed stable palpation pain intensity ratings at menses, ovulatory, and midluteal phases, with increased intensity at the late luteal phase (Bajaj et al., 2001; Sherman et al., 2005). Many older studies have failed to include this fact or have not mentioned it in their methodology. It is therefore important to take into consideration the female subjects' menstrual cycle and standardize the starting time for all subjects, in order to collect valid data.

To summarize this section, implementing a learning phase for the subjects has been shown to be important. Mixed gender groups show different values compared to single gender groups, males show different values from females. Hand dominance has to be considered when testing ipsilateral and contralateral sides. The female menstrual cycle has only begun to be considered when using the algometer and may influence results.

1.09 Types of Pain

For this project, we have focused on the physiological and subjective responses to pain. Pain is normally thought of as the body's early warning system to prevent further injury to an already damaged structure. A protective tissue response to stress exists in the body in response to stress, strain on the tissue. Should any of the protective mechanisms that are in place become over stressed or exceed the tissue's tolerance for injury, pain may result. These mechanisms include level of tissue stiffness, viscoelasticity, creep of tissue, uncrimping of tissue, and stress relaxation (Mcgee, Zachazewski and Quillen, 2007).

Crimp: under a microscope the collagen fibers have a wavy appearance in a relaxed state which is known as crimp. The uncrimping of tissue occurs as the tissue is being lengthened and the wavy appearance of the collagen fibers will disappear. This slack area known as crimp is one of the first lines in response to stress (Mcgee, Zachazewski and Quillen, 2007).

.

Viscoelasticity: is the primary mechanism used by tissues which include ligaments, capsules and muscles to increase their length. The elasticity component enables the tissue to return to its original shape when stress has been removed (Mcgee, Zachazewski and Quillen, 2007).

.

Creep: also considers part of viscoelasticity and is related to the continuous deformation of the tissue. The creep of the collagen fibers occurs all the way along the fiber. Creep allows for the constant lengthening of tissue in response to stress (Mcgee, Zachazewski and Quillen, 2007).

Stress or force relaxation occurs when the tissue is stretched to its pathophysiological end of range. The tissue that has been stressed (or injured) will progressively shorten after the stress has been removed, with the greatest amount of stress relaxation (shortening) taking place between 6-8 hours after a trauma (Mcgee, Zachazewski and Quillen, 2007).

When movements are slow and controlled (small load) or the tissue is warm, there is a plastic type of flow of the tissue where creep and stress relaxation is followed by gradual tissue lengthening and eventual tissue remodeling (Mcgee, Zachazewski and Quillen, 2007).

Tissue injury may occur with a quick movement, an uncontrolled movement, a large load being applied to the tissue, or normal load being applied to cold tissue. When one of these four mechanisms occurs, there is deformation of the tissue and trauma, which may lead to injury. (Mcgee, Zachazewski and Quillen, 2007).

The pain that occurs with tissue injury may be classified as being transient, acute or chronic (Mense and Simons, 2001).

Transient pain that lasts a few seconds to a few minutes (Mense and Simons, 2001) is an experience that many individuals feel on a daily basis. This is the pain associated with bumping into an object or an overenthusiastic handshake. This type of pain quickly disappears after the incident has taken place.

Acute pain is often associated with but not exclusive to acute trauma (Mense and Simons, 2001). Acute pain may be seen when the cell walls of tissue within the body are damaged, causing the release of a number of chemical agents from dopamine and norepinephrine as precursors, to the later release of prostagladins, which will increase nerve fiber sensitivity and bradykinin, which increases vascular permeability during the inflammatory response of the body (Guyton and Hall, 2000; Simons, 2004). This type of pain may last from 12 hours to 72 hours and may be perceived as intense.

Chronic Pain may occur when the early warning system that was in place for acute pain has lost its function. The responses that were in place for acute pain, to prevent further damage and diminish symptoms, continue with chronic pain, but they do not alleviate symptoms; instead they continually aggravate a painful condition (Mense and Simons, 2001). Chronic

pain maybe associated with a specific trauma or a systemic problem and may last a series of months or a whole lifetime.

In this present thesis, we have focused on the transient pain that occurs through the use of the algometer being applied to the different locations in the neck, shoulder and arm. We hope to eventually implement this testing protocol with people who are suffering with acute and/or chronic pain.

1.10 Testing locations on the neck shoulder and arm region

PPT values obtained on bony prominences tend to be more variable compared to PPT values obtained over muscular areas (Baker, Kelly and Eston, 1997). Bony areas have been found to be more sensitive and have lower PPT values compared to muscular areas on the same individual (Baker, Kelly and Eston, 1997). Some studies have used bony areas (locations of the proximal tibia) as a benchmark to compare sensitivity at different locations. In this thesis, the algometer was to be used over muscle and not bone.

A number of different locations have been used in other research projects evaluating torso and upper extremity dysfunction (Nussbaum and Downes, 1998; Persson et al., 2000;

Persson, Brogargh and Sjolund, 2004). In some instances, single locations have been used to identify PPT (Nussbaum and Downes, 1998). In other instances, researchers have tested multiple locations along the same muscle (Persson et al., 2000), or have done comparisons between muscle and bone (Baker, Kelly and Eston, 1997; Kelly and Eston, 2001; Falla and Farina 2005). Researchers have found that more consistent PPT values are obtained when an examiner has applied the algometer to a muscle. This is in comparison to applying the algometer to a bony location where PPT values were found to be more variable between the same examiner (Kosek, Ekholm and Nordemar, 1993).

When applying the algometer to a muscle it is important to recognize that the PPT values would be different if the algometer was to be applied to the mid point of the muscle compared to the distal or proximal ends of a muscle. In this study, the algometer was to be applied to the mid point of muscles for consistency.

Some of the locations (trapezius, rhomboids, supraspinatus) selected for the project are frequently cited in other studies (Falla and Farina, 2005) and we have included other locations (biceps, triceps, deltoid) that are often found to be painful after a partial mastectomy with an axillary node dissection (McCredie et al., 2001). The clinicians who treat people with musculoskeletal disorders often describe a location in the middle of a muscle as being hypersensitive and thickened. This thickened structure is often thought to be

the cause of some of the pain and discomfort. These locations are known as trigger points (Davies and Davies, 2004; Mense and Simons, 2001; Takahashi et al, 2005).

1.11 Trigger points

A trigger point, as illustrated in Figure 3, is thought to be a hypersensitive area in a muscle which may cause pain (Simons, 2004). When an individual is in pain, whether acute or chronic pain, the person may seek advice from a doctor and treatment from a rehabilitation therapist. The medical professionals who evaluate patients with musculoskeletal problems will often try to palpate the involved area to note whether a trigger point nodule is present and may be a component of the patient's underlying problem (Travell and Simons, 1999). The presence of a nodule at the location of pain in muscular tissue is further confirmation of a potential trigger point.

Different types of trigger points may be found by the therapist on the patient, including active trigger points, latent trigger points (Davies and Davies, 2004; Mense and Simons, 2001; Travell and Simons, 1999; Simons, 2004), and satellite trigger points (Davies and Davies, 2004; Mense and Simons, 2001; Simons, 2004). An active trigger point is a location on the muscle that is presently causing pain which may be either local or referred (Mense and Simons, 2001). Referred pain is pain in a different location from where the original problem is located, such that pain in the trapezius may refer pain to the head region or down

the arm (Travell and Simons, 1999). The active trigger point may also restrict joint movement and cause the individual to seek out a remedy to reduce the pain, such as applying ice to the location or consulting a therapist. An active trigger point is thought to always provoke pain.

A latent trigger point is only painful when pressure is applied to it, and is not considered as significant a problem as the active trigger point. It is common for an individual to not experience any pain in the area of a latent trigger point unless someone or something applies pressure to the area (Simons, 2004). At that point the person with the latent trigger point will feel pain.

A satellite trigger point is a trigger point that will cause referred pain to multiple locations on the individual (Simons, 2004). When pressure is applied to the location of the trigger point, pain is felt in more than one location and may stay present for a period of time long after the stimulus has been removed from the original location. An example of this would be applying pressure to a trigger point in the middle of the upper trapezius fibers and noting how it may provoke pain in the back of the neck up to the occipitus (the back of the head) and down to the shoulder and upper arm regions (Travell and Simons, 1999).

A trigger point is thought to develop from a muscle performing a single movement or a series of repeated movements leading to a contracture in the tissue (Simons, 2004). A contracture takes place when the muscle fibers have not return to a resting position but have remained in a shortened or contracted position. The trigger point is described as being a nodule-like structure attached to or resting within the muscle. The nodule structure is thought to occur because of thickening of muscle fibers. When the therapist palpates the nodular structure, a cord or rope-like formation is found underneath their finger tips (Davies and Davies, 2004; Mense and Simons, 2001; Travell and Simons, 1999).

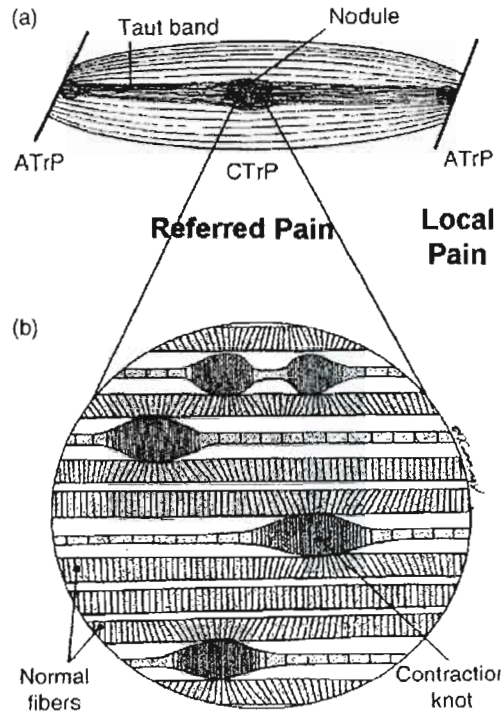

Figure 3: Diagram of trigger point nodule (contraction knot) in a muscle (Adapted from Simons, 2004)

In diagram 3, CTrP is defined as the contraction knot of the trigger point and ATrP is the active trigger point location on the muscle where the person would be experiencing pain.

It is not uncommon for a trigger point to be called a myofascial trigger point (Stecco, 2004). The name, myofascial trigger point, describes the tissue"fascia" that envelopes a muscle,

becoming adherent at the same location where a trigger point has developed (Figure 3). Fascia is known to be adherent at different points (Stecco, 2004) in the body. If the fascia was not adherent at different locations throughout the body, it would be continuously moving and become displaced. The location where the fascia is adherent to the muscle is often in close proximity to where potential trigger point nodules may develop. If a trigger point nodule develops at the site where the fascia is adherent to the muscle the location will become thickened and less pliable potentially aggravating an underlying problem. This would be in contrast to no nodule developing at the location where the fascia is adherent to the muscle or if the nodule develops in another location other than where the fascia adheres to the muscle (Stecco, 2004). The fascial adherence and the trigger point may lead to a common problem, the myofascial trigger point.

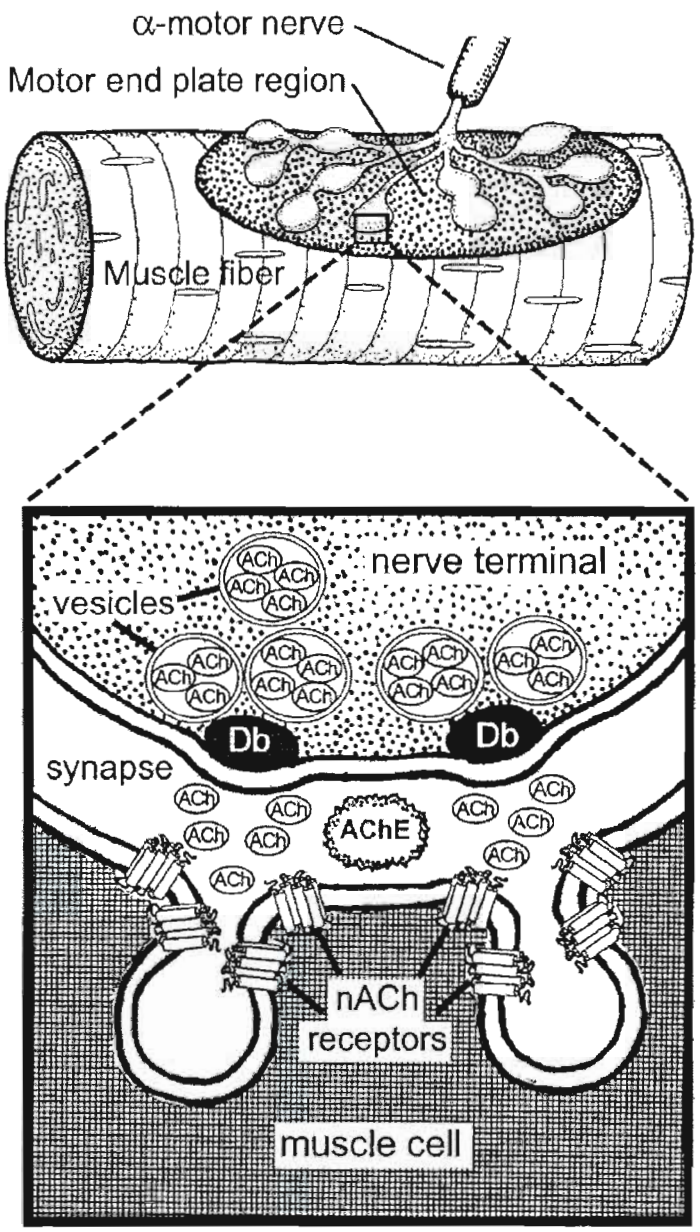

Figure 4 Diagram of the neuromuscular junction (adapted from McPartland, 2004)

1.12 Why does a trigger point develop?

A trigger point is thought to develop because of some form of dysfunction that takes place at either the presynaptic or the post synaptic end plate of the neuromuscular junction. The release of acetylcholine (ACh) across the neuromuscular junction allows for action potentials to occur and for a muscle contraction to take place (Guyton and Hall, 2000). An integrated hypothesis developed by Simons (2004) explaining the etiology of the myofascial trigger point, speculates that excessive levels of acetylcholine released from the presynaptic end plate to the post synaptic end plate cleft may be one of the reasons why a trigger point develops. Simons along with Travell (1999) have done extensive investigation into the role of trigger points and pain over the last 40 years.

Acetylcholinesterase, (AChE) is the enzyme that would normally breakdown the acetylcholine at the neuromuscular junction (Figure 4). When a problem occurs, some type of dysfunction may prevent the acetylcholinesterase from being released to break down the acetylcholine. As well, the release of acetylcholine at the presynaptic cleft (Point 1 in Figure 5) is dependent on the voltage-gated calcium Ca^{2+} channels (L-type and N^{-} type) (Guyton and Hall, 2000) . If there is a defect/dysfunction of one of these Ca^{2+} channels there will be a continued release of acetylcholine (Simons, 2004). Thus, two mechanisms leading to a dysfunctional motor end plate causing muscle contracture may cause the development of trigger point nodules (Figure 3).

As mentioned above, dysfunction at the motor end plate may lead to a sustained contraction of muscle contraction. A sustained muscle contraction, as illustrated in Figure 5 (points 2 to 6) will lead to compression of local sensory nerves, reduced local blood supply, decrease local supply of circulation oxygen and eventual energy crises within the tissue (Simons, 2004). A resulting lack of ATP (Points 4 and 5' in Figure 5) may lead to impairment in the Ca^{2+} reuptake by the sacroplasmic reticulum, maintaining elevated cytoplasmic Ca^{2+} concentrations, which may continue contractile activity. As well, the reduction in ATP may lead to an increase in chemicals (Point 5 in Figure 5) being secreted by the sustained muscle contractures that stimulate free nerve endings. These chemicals include bradykinin, cytokines, serotonin and histamine. This continued dysfunction may lead to some form of disorganization of the mitochondria. (Simons, 2004)

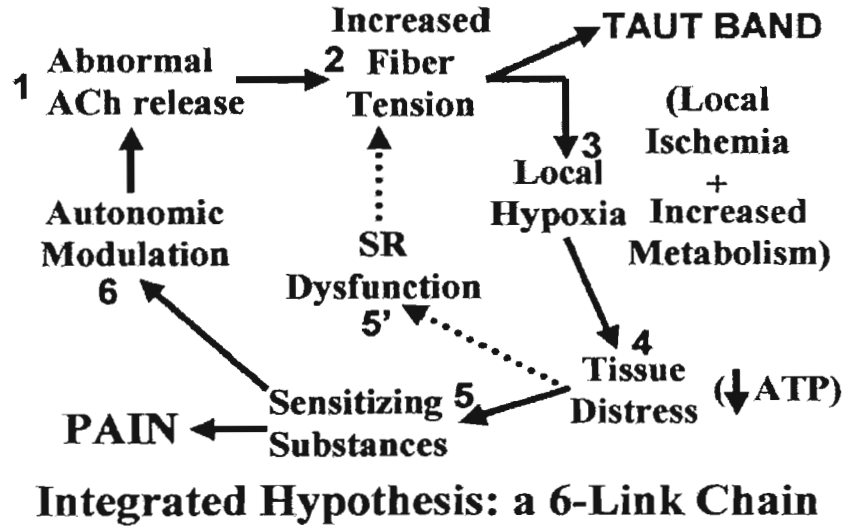

Figure 5: Theoretical model of the development of a trigger point (adapted from Simons, 2004)

Different components of the integrated model put forward by Simons (2004) have been looked at by researchers using animal models. Hou et al., (2002) has looked at the role of calcium blockers and trigger points. Chen et al, (1998) has looked at the role of the autonomic nervous system and trigger points. Kuan et al., (2002) has looked at the role of excessive acetylcholine release and trigger points. Each of the studies has confirmed Simons's integrated hypothesis so far.

At least three other structures may be found in tissue that are somewhat similar to a trigger point nodule and should be identified. These structures include: 1) calcification of tissue

leading to calcium deposits which are bone-like structures hard to the touch (myositis ossificans), 2) a fatty nodule (often seen in the low back) which is soft and pliable and 3) a ganglion which is closely linked to superficial nervous tissue. What differentiates the calcium deposit and the fatty nodule from a trigger point is the mobility of the structures. Both the calcium deposit and the fatty nodule have a slight mobility, and both structures may be moved in close proximity to where they are found. This is in contrast to a trigger point, which is not mobile and will remain in the same location until some form of intervention takes place (Davies C, Davies, 2004; Travell and Simons, 1992). A ganglion is similar to the trigger point in that it does not move, but the ganglion is more likely to be attached to a superficial structure such commonly palpated around the anterior aspect of the distal forearm. The ganglion often does not elicit pain when palpated and a common therapeutic approach to remove the ganglion has been to quickly apply a compressive force to flatten the ganglion, or to have the ganglion surgically removed (Dumontier et al., 2006)

1.13 The rationale for investigating trigger points in this project

A trigger point is often found near the mid point of the muscle in close proximity to the motor points of that muscle. Knowing that trigger point nodules are commonly used by clinicians to interpret pain for their patients and having a general idea of where to locate a potential trigger point nodule on the muscle, it was deemed appropriate the same locations be used in this project. Also, knowing what is not considered a trigger point nodule gave the athletic therapists clear guidelines as to what to look for when palpating the subjects.

1.14 Summary of literature review

Pain in the upper arm, shoulder and neck are common problems after breast cancer therapy.

Women seem to be at greater risk for developing shoulder and neck problems, but it is unclear whether it is because of their muscle composition in that region, the jobs that they are required to perform on a daily basis or, as in men, due to their lack of physical activity.

The algometer has been used to quantify the subjective pain of an individual through the use of PPT values. PPT measured at the mid point of a muscle tends to be more consistent compared to other locations on the body. Studies that have used the algometers to evaluate pain have only recently taken into consideration the idea that a women's menstrual cycle may have an effect on the values obtained.

Clinician's that work with people experiencing musculoskeletal pain believe that trigger point nodules found in the muscle tissue contribute to a patient's musculoskeletal problem. A number of charts have been developed and books written outlining the locations of potential trigger point nodules in the body.

1.15 Implementing the literature review into this protocol

A hand-held algometer was used to give a quantifiable measure of pain in the upper arm, shoulder and neck region. The algometer was applied to the mid point of muscles where potential trigger point nodule may be located. The muscles that were to be tested were locations that are consistent with problematic areas associated with breast cancer surgery or common musculoskeletal disorders.

The protocol was to be first used with individuals who are not experiencing any musculoskeletal dysfunction as to limit the number confounding variables. A women's menstrual cycle is known to influence her perception of pain. The subjects who were selected for the project would have to be pre menopausal, with regular menstrual cycles. (A decision to limit the number of confounding variables) All of the women participating in the study should be tested at the same stage of their menstrual cycle.

1.16 Main hypothesis for this study

The **main hypothesis** of this study was: The application of the hand-held algometer to eight different locations in the upper arm and torso over four consecutive days of testing would show variation in pressure pain threshold values between the different locations on the same subject. It was expected there would be little or no variation in the pressure pain threshold values obtained between days.

1. 17 Additional questions

It was thought that the amount of adipose tissue an individual has at each of the 8 different locations may influence the PPT values that will be obtained.

Additional question 1) we anticipated that a testing location with a higher skin-fold value would also have higher PPT values compared to a location with low skin fold value, on the same subject.

We wanted to blind the data collector on whether a trigger point was present at the testing location. This required the use of two different therapists to identify the testing locations and to palpate for the presence or absence of a trigger point at each location.

Additional question 2) We expected that there would be significant agreement ($p< 0.05$) between the two athletic therapists palpating for the presence or absence of a nodule at the testing location.

Additional question 3) We expected that subjects that did have a nodule at a specific location would have a lower PPT value when compared to a location that did not have a trigger point nodule on the same subject

Pain is a complex problem that is very subjective and is perceived differently between individuals, this led to our last question, which has been answered in the literature and repeated in this study.

Additional question 4) the PPT values that were collected were expected to vary for the same location between different subjects.

CHAPTER II

METHODOLOGY

2.01 Subject selection:

Nineteen female subjects with a mean (± SD) age of 23.9 ± 5.2 yrs, mean height of 1.7 ± 0.1 m, average weight of 64.6 ±10.3 kg and a mean body mass index of 23.6± 3.5 were recruited from the university community. To limit the number of confounding variables all subjects were non-smokers (Pauli et al., 1993) and were involved in some form of regular physical activity (van Amelsvoort et al., 2006). The forms of physical activity varied and included dance, running, swimming and martial arts. None of the subjects had experienced any shoulder pain or significant musculoskeletal pain that required medical review over the last 6 months. Subjects were recruited for this study following approval of the University Human Research Ethics Committee at UQAM. Each subject was explained the risks of participating in this study and voluntarily gave their written informed consent. (Annexes 1 and 2)

The subjects were asked not to undertake any new physical activity over the four day testing period. New physical activities were defined as activities that the subjects had not performed routinely for an extended period of time (for example, weight training after a prolonged period of inactivity). The ingestion of caffeine has been found to alter a person's perception of pain so subjects were also asked to avoid ingesting any caffeine products (Galeotti et al.,

2002) for at least 4 hours prior to each testing period. Subjects were asked to avoid any analgesic medication throughout the entire 4-day experimental period.

2.02 The calibration and application of the algometer:

Calibration: The algometer was calibrated at the onset of each day of testing, before being applied to the subject. The algometer (Somedic Sales AB; Model type 2, Sweden) was calibrated using a standard protocol that is recommended by the manufacturer. The protocol requires that the algometer be placed on to a stable surface; we used a table top, with the nozzle surface facing upwards. A one kilogram weight (provided by the manufacturer) was applied to the 0.5cm diameter applicator head attached to the end of the nozzle. Values were obtained and recorded from the LCD display of the algometer. The acceptable calibration values ranged from 98 to 102 kilopascals. This would mean a potential 4% error in the recorded values. The calibration process was repeated 3 times and values would have to fall within the expected range. When the values did not fall within the acceptable ± 2 kilopascal range the algometer was restarted and the calibration process was repeated.

2.03 Application:

After following the manufacturer's calibration guidelines, the 0.5cm applicator head was replaced following calibration with the 2cm applicator head to measure PPT's. The 2cm applicator head was used because we were concerned about future projects working with patients undergoing adjuvant therapy for breast cancer. We felt that a smaller applicator head being applied to testing locations on these future subjects (dealing with breast cancer) may place them at an increased risk of bruising and localized tissue trauma. This may heighten their concern about developing lymphedema, a significant problem for this population (McCredie et al., 2001). A second point is that the 2 cm applicator appears to give indication of local pain sensation when compared to smaller applicator heads (Takahashi et al., 2005).

The testing locations were identified through the placement of marks on the skin; over two (2) anterior locations and six (6) posterior upper torso locations (see Figures 6-13). The marks served to identify the appropriate location in which to place the nozzle of the algometer. The experimenter applied the algometer to each of the eight locations in the following sequential manner (i.e., 1 through 8): 1) the mid-point of the muscle fibers of the long head of biceps, figure 6, 2) the mid-point of the anterior fibers of the deltoid figure 7, 3) the mid-point of the muscle fibers of the lateral head of the triceps figure 8, 4) the upper half

of the fibers of the rhomboids major figure 9, 5) the mid-point of the posterior fibers of the deltoid figure 10, 6) the proximal one-third of the fibers of the supraspinatus (the location closest to the medial border of the scapula) figure 11, 7) the upper fibers of the trapezius (medial to the superior angle of the scapula), figure 12 and 8) the distal one-third of the muscle fibers of the infraspinatus figure 13. The specific locations were selected for one of the three following reasons: 1) the location has been used in a previous study such as the trapezius, deltoid and infraspinatus (Galeotti et al., 2002; Jensen, Pilegaard and Sjogaard, 2000; Lindman et al., 1991); 2) the location is often identified in a clinical setting as being problematic such as the rhomboid and supraspinatus (Brandt et al., 2004; Bunn et al, 2006; Ge, Madeleine and Arendt-Nielsen, 2005), and 3) the biceps and triceps were found to be frequently painful following breast surgery with an axillary node dissection for breast (McCredie et al., 2001).

The location selected on the muscle was based on the possibility of a trigger point nodule being present at the site. Some muscles had multiple locations where a trigger point nodule may be located. We tried to have 8 distinct locations to avoid any confusion in the testing protocol. Confusion may have arisen in the sites where 2 or more trigger point locations may be in close proximity, such as infraspinatus/rhomboids and trapezius/ supraspinatus (Falla and Farina, 2005). No location tested on the 19 subjects had an active trigger point. An

active trigger point being defined as causing pain and restricting mobility. A subject who would have had an active trigger point nodule would have been removed from the project.

The subject was placed in a supine position and then a prone position for the application of the algometer. The 2 positions allowed for better stabilization of shoulder and torso compared to a seated position. With the subject in the supine position, the algometer was applied to the anterior aspect of the shoulder and arm for the PPT measurement over the marks located on the anterior deltoid and bicep. With the subject in a prone position, the algometer was applied to the posterior aspect of the arm (triceps), shoulder (posterior deltoid) and torso (infraspinatus, supraspinatus, rhomboids and the trapezius) for the measurement of PPTs. Pillows and padding were used to support the subject's shoulder and arm when appropriate. The total time required to a collect 3 complete sets of data for each subject (4 trials total) was approximately 25 minutes. This time included the changing of position of the subject (8 times total supine-prone- supine) as well as the set up and stabilization of the shoulder. This worked out to approximately a 5 minute rest time between applications of the algometer at each location. It was decided not to randomize the order of application to minimize the amount of unnecessary movement by the subject and to have a consistent time interval between each location.

2.04 Experimental Procedures

Practice session: Before the data collection process began a pilot project was completed that tested 8 different locations on 5 subjects. The goal of the pilot project was to familiarize the evaluator with the algometer and to identify any potential problems.

Starting time for subjects: The subjects' first day of testing occurred within four days after last day of the subject's menstrual cycle. The subjects were tested over four consecutive days. Each testing session took place in the morning at approximately the same time of day, over each of the four days.

Testing schedule: An initial trial was performed at the outset of each testing session to familiarize the subject to the testing procedure. The data from this trial was discarded. Thereafter, three complete sets of data were collected on the subject. A complete set of data included applying the algometer to each location (1 through 8 in sequence) and recording the values obtained from the location. This order of measurement was done two more times. Each trial (of all 8 locations) was recorded on a single data sheet. When the data sheet was completed, the sheet was removed from view of the experimenter, so that subsequent data sets were collected without bias. This procedure was repeated for each trial over the four consecutive days.

2.05 Determination of the PPTs:

At the beginning of each testing session, the subject was reminded that the PPT was defined as the "instant or moment that the pressure on the skin surface changed from the sensation of pressure to the sensation/perception of pain". The experimenter explained to each subject that they would feel a gradual increase in pressure on the skin. The pressure would continue to increase until the subject experienced a sensory transition from pressure to pain. The experimenter explained to each subject that the trial at a specific location would end if and when the readings went beyond 400 kilopascals. This precautionary measure served to avoid any unnecessary pain or damage to the skin and underlying structures. The experimenter applied the nozzle of the hand-held algometer at each landmark location at an approximate rate of 30 kilopascals per second. The increase in the force applied to the skin surface was viewed by the experimenter, via the digital output display on the algometer. The experimenter continued to apply pressure until the subject pressed the button on hand-held switch indicating that they perceived a sensory transition from pressure to pain. The subject never viewed the recorded values.

2.06 The locations that were tested

Biceps brachii trigger point

The trigger point location of the long head of biceps brachii was identified by moving in a caudal direction from the bicipital groove of the humerus, to the upper one half of the biceps muscle. At the mid point of the muscle a small mark was made on the skin surface.

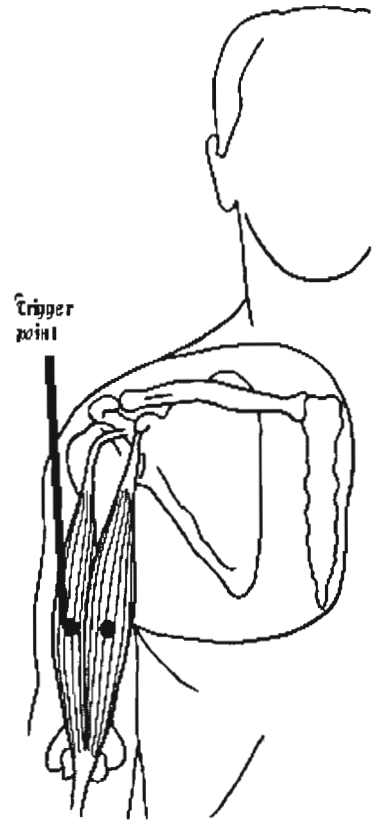

Figure 6: Long head of the biceps trigger point location

(Adapted from Davies and Davies, 2004)

Anterior deltoid trigger point

The anterior fibers of the deltoid muscle trigger point location were located by finding the most lateral aspect of the acromial cavicular joint. The athletic therapist then moved in an anterior and inferior direction, to the upper 1/3 of the anterior fibers of the deltoid using the deltoid tuberosity of the humerus as a distal reference point.

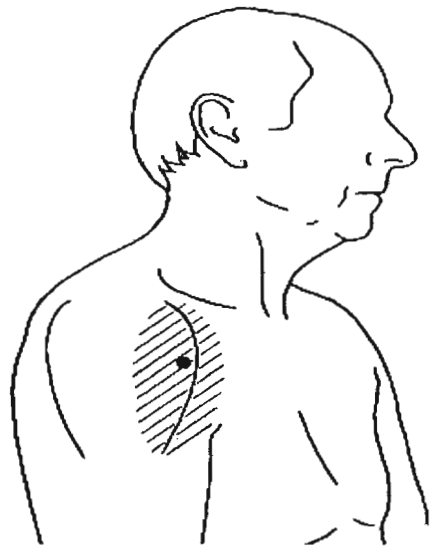

Figure 7: The anterior fibers on the deltoid trigger point location

(Adapted from Davies and Davies, 2004)

Triceps Brachii trigger point

The trigger point location on the triceps brachii was identified by moving in a cranial direction from the most proximal aspect of the olecranon process of the ulna. The upper half of the lateral head of the triceps was marked.

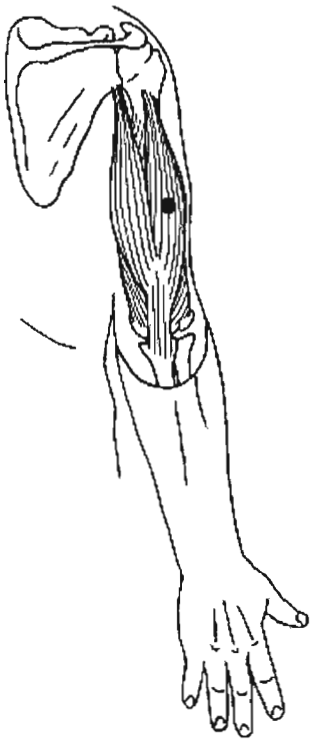

Figure 8: The lateral head of the triceps trigger point location

(Adapted from Davies and Davies, 2004)

Rhomboids major trigger point location

The trigger point location for the rhomboids major was identified by locating the spine of the scapula and moving slightly medial and inferior. The spine of the scapula attaches to the 3rd thoracic vertebrae, moving in a caudal direction to the mid point between the scapula and the spine, at the level of T3 the trigger point was marked.

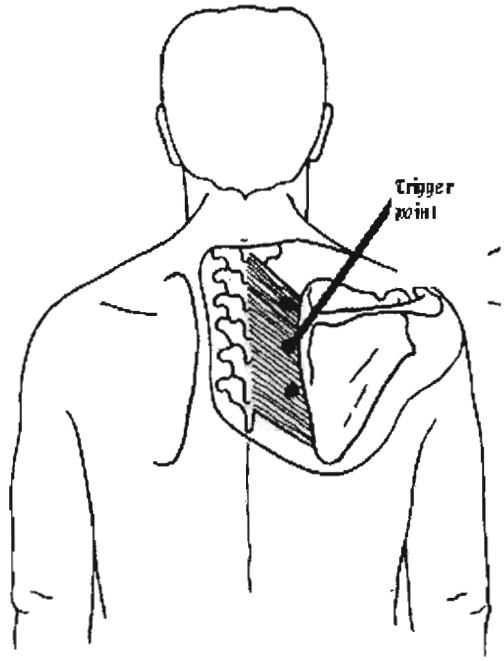

Figure 9: The rhomboids major trigger point location

(Adapted from Davies and Davies, 2004)

Posterior deltoid trigger point

The posterior fibers of the deltoid muscle trigger point location were found by locating the most lateral aspect of acromial cavicular joint. The athletic therapist then moved in a posterior and inferior direction to the upper 1/3 of the posterior fibers of the deltoid. The deltoid tuberosity of the humerus also served as a distal reference point for this landmark.

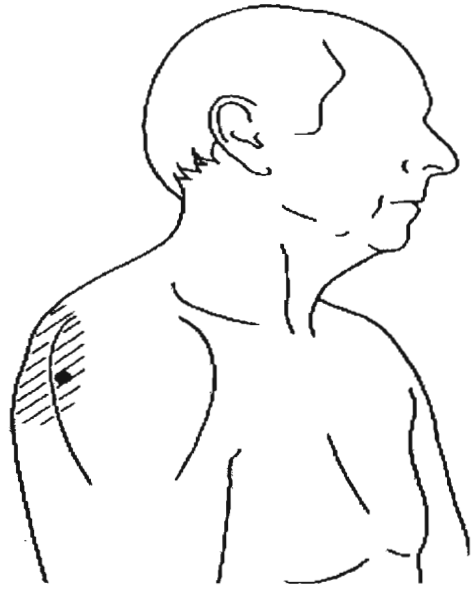

Figure 10: The posterior fibers on the deltoid trigger point location

(Adapted from Davies and Davies, 2004)

Supraspinatus trigger point (Davies C, Davies, 2004)

The trigger point location of the supraspinatus was identified, by locating the spine of the scapula and moving slightly superior. Identifying the medial border of the scapula and moving lateral. The location of the trigger point would be in the medial third of the muscle.

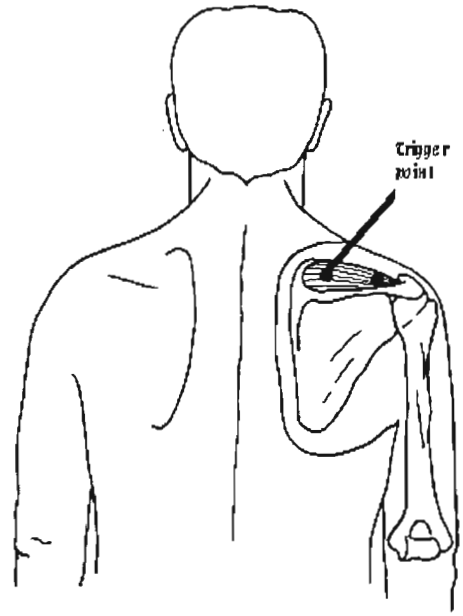

Figure 11: The supraspinatus trigger point location

(Adapted from Davies and Davies, 2004)

Upper fibers of the Trapezius trigger point

The trigger point of the trapezius was identified, by locating the spine of the scapula and moving in slightly superior and medial. The 6th and 7th cervical vertebrae were also located. To differentiate between the two structures the 6th cervical vertebrae moved anterior when the neck was moved into extension while the 7th cervical vertebrae stays fixed in position.

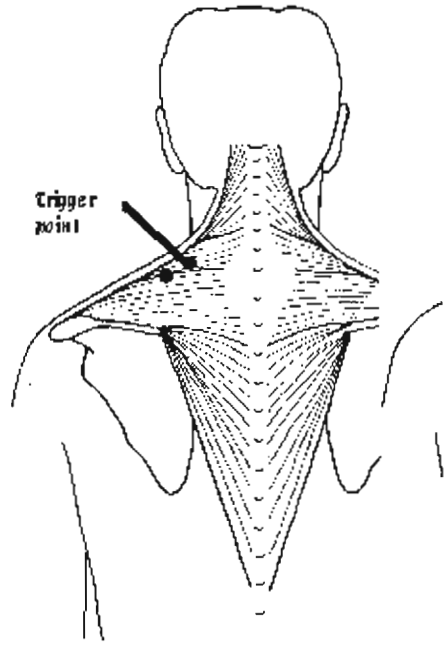

Figure 12: The trapezius trigger point location

(Adapted from Davies and Davies, 2004)

Infraspinatus trigger point

There are three different bony landmarks on the scapula to locate the appropriate trigger point on the infraspinatus. The trigger point of the infraspinatus was identified by locating the spine of the scapula and moving inferior and lateral from the medial border of the scapula and slightly superior from the inferior angle of the scapula. The trigger point was marked as being in the middle of the muscle in close proximity to the inferior angle.

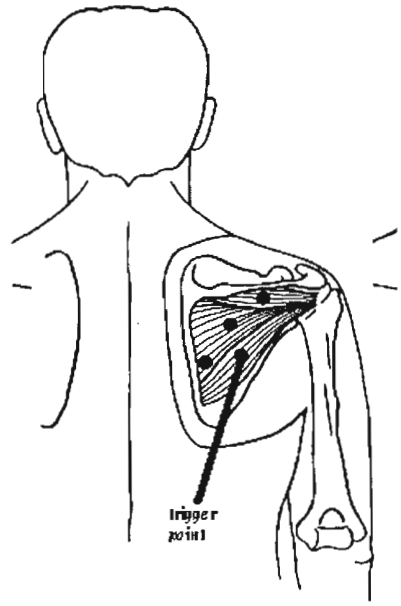

Figure 13: The infraspinatus trigger point location

(Adapted from Davies and Davies, 2004)

2.07 The use of bony land marks as reference points

The use of bony landmarks as anatomical reference points was thought be the most appropriate method to identify the locations in the upper extremity and torso region. The use of a bony reference point is a common technique used by clinicians to locate anatomical structures due to the tremendous variability in body composition. Students enrolled in athletic therapy and physical therapy classes at Universities are taught this skill in their first year and expected to become competent in this area throughout their academic study. The two athletic therapists who were used for this project presently work at Concordia University in the Department of Exercise Science teaching these manual skills to students.

In some studies the use of callipers and tape measures may be appropriate to assess body composition. For this project it would have been impractical to measure a specific distance with a tape measure because of the number of locations in and around the scapula. The scapula thoracic region is often referred to as the fourth joint in the shoulder (Mcgee, 2002), because of the significant amount of movement that takes place. In a resting position, the scapula's position relative to the spinal column is quite variable, this may include it being adducted, abducted elevated, depressed, the inferior angle being lateral rotated, the inferior angle being medially rotated as well as combinations of the previously mentioned positions (Kendall, McCreary and Provance, 2005). Using a tape measure to a specific distance on

individuals with different body types and various scapular thoracic positions would have lead to a significant increase in errors.

A second method used by Messing and Kilbom 2001, would have involved taking an impression of the joint surface. This technique has been used very effectively on the palmar surface of hands and the plantar aspect of the feet. The limitation with this technique for our project is the shape of the area being evaluated. Testing locations anterior and posterior on the torso and upper extremity would have required some form of marking solution placed on a very large portion of the skin surface of the subject. This would have required the subjects to disrobe to expose the upper back and the arm shoulder region. This would have increased the difficulty in recruiting subjects and when the subject had been recruited, potentially soiling the subjects clothes with the marking solution. It was thought that this approach would not have added significantly to the testing procedure except for an additional mess to clean up, eventually making the methodology more cumbersome.

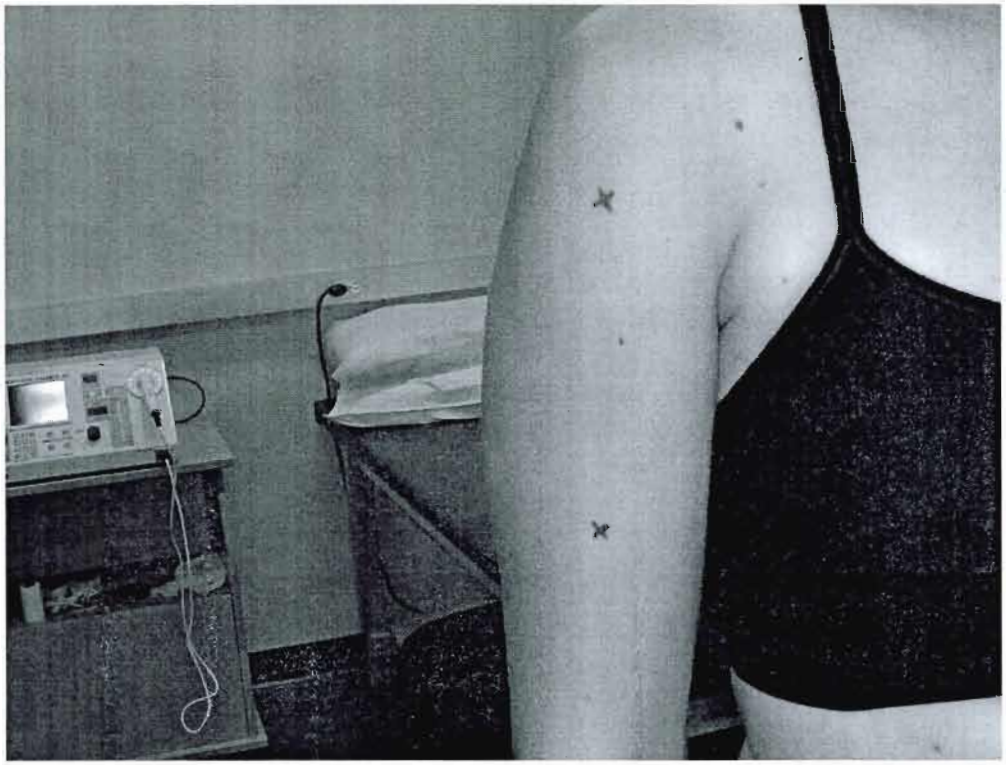

Figure 14: Testing locations identified by pen marks (X) on the anterior surface of the upper arm and shoulder.

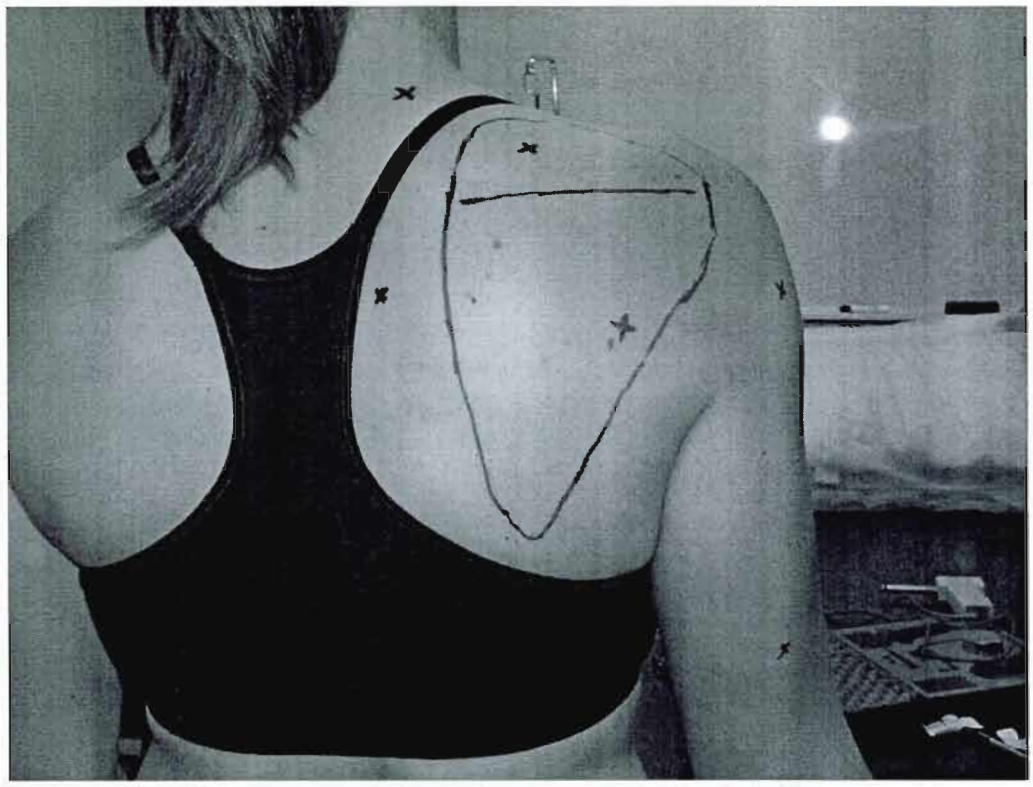

Figure 15: Testing locations identified by pen marks (X) on the posterior surface of the upper arm and shoulder.

Please note from the angle the picture (Figure 15) was taken it may appear that the indelible mark is over the middle portion of the deltoid when in fact the mark is over the posterior fibres of the deltoid. The subject in the photo also has a slight rounding of the shoulders which may also lead to a misperception of the testing location.

2.08 Skin fold measures

Within one week of the algometer testing, skin-fold measures were taken on each of the subjects to note the body fat thickness at each of the eight testing locations. The skin fold measures were applied following the American College of Sports Medicine guidelines (2006). Two data collectors were required to correctly apply the skin calipers because of the unique locations being assessed. One data collector would pre-fold the skin location to be measured, with the ink mark being in the mid point of the fold. The second data collector would apply the skin fold caliper.

Measures for the skin-folds were taken following the same sequence as with the algometer. Following the American College of Sports Medicine guidelines (2006), two complete sets of skin fold measures were obtained at each location. The second set of values obtained at each location had to be within 10% of the first measure. If the difference between the first and second measures was greater than 10% then a third measure at that location would be taken. At that point, the first set of data obtained at that location would be discarded.

2.09 The skin-fold measures for the eight locations

The locations that were selected for this project are not sites that are commonly used when assessing body composition. Therefore it was considered important to include a detailed outline of the procedure at each site.

The skin fold for the long head of the biceps required that a pre-fold of the skin be made in a cranial-caudal direction (superior-inferior direction). The ink mark, indicating the place where the algometer had been applied, was at the mid point of the fold.

The skin-fold for anterior deltoid required that a pre-fold of the skin be made following the direction of the muscle, moving in a medial superior direction to a lateral inferior direction. The ink mark, indicating the place where the algometer had been applied, was at the mid point of the fold.

The skin fold for lateral head of the triceps required that a pre-fold of the skin be made in a cranial-caudal direction (superior-inferior direction). The ink mark, indicating the place where the algometer had been applied, was at the mid point of the fold.

The skin fold for rhomboids major required that a pre-fold of the skin be made in a cranial-caudal direction (superior-inferior direction). The ink mark, indicating the place where the algometer had been applied, was at the mid point of the fold.

The skin fold for posterior deltoid required that a pre-fold of the skin be made following the direction of the muscle moving in a medial superior direction to a lateral inferior direction. The ink mark, indicating the place where the algometer had been applied, was at the mid point of the fold.

Supraspinatus required that a pre-fold of the skin be made following the direction of the muscle; moving in a medial direction to a lateral direction. The subject was advised to maintain their posture in an anatomically neutral position. If the head was in a forward flexed position then the tissue was under to much tension to secure the tissue. The ink mark, indicating the place where the algometer had been applied, was at the mid point of the fold.

Trapezius a pre-fold of the skin was required, crossing to the opposite side of the spinal column moving in a medial direction to a lateral direction and pre-folding the right and left portions of the upper trapezius. The subject was advised to maintain their posture in an anatomically neutral position. If the head was in a forward flexed position then the tissue

was under to much tension to secure the tissue. The ink mark, indicating the place where the algometer had been applied, was at the mid point of the fold.

Testing of the infraspinatus required that a pre-fold of the skin be made following the direction of the muscle in a cranial-caudal direction (superior- inferior direction). The ink mark, indicating the place where the algometer had been applied, was at the mid point of the fold.

It was speculated that with the tissue adherence to the underlying fascia, that with repeated pre-folding and measuring of the tissue that each of the testing location would be less adherent and would eventually loosen up making it easier to apply the test. No subject was measured more than 3 times at any location.

2.10 Break down of tasks performed by individuals in the research project

Three additional individuals were required to help the M.Sc. candidate complete the project. It is important to briefly summarize what their tasks entailed.

The two athletic therapists

1. Identified and marked the eight different locations on each subject.
2. Palpated each location for the presence or absence of a nodule associated with a trigger point, before the algometer was applied on day 1 and after the algometer had been applied on day 4.

Data collector number 2

1. Applied the skin fold calipers to each of the testing locations of each subject.

Data collector number 1, the M.Sc. candidate

1. Recruited subjects, secured signed consent forms from each subject, and organized the appropriate starting times for each subject.
2. Calibrated the algometer before each testing period.
3. Applied the algometer to each of the locations on all subjects over the 4 days of testing, as well as recorded all measures.
4. During the skin fold measurements, prefolded the skin at each location so that the skin-fold calipers could be applied correctly, as well as recorded all measures.
5. Performed the analysis of all data.
6. Wrote up the thesis and papers that were submitted

2.11 Statistical analysis:

Descriptive analysis of all data was performed using Microsoft Excel (Microsoft, Redmond, WA) to report results as mean ± S.D. Significant differences between means were detected by using SPSS version 11.5 (SPSS Inc., Chicago IL). A repeated measures analysis of variance was performed evaluating the absolute changes in PPT at each location throughout the 4 consecutive days of testing. A post hoc analysis was performed using a Tukey test. The criterion for significance was set at $p \leq 0.05$. Inter class correlation (ICC) scores were calculated for the PPT values collected at each location on each day of testing.

A repeated measures analysis of variance was performed evaluating the differences in skin fold values obtained at each location. A post hoc analysis was performed using a Tukey test. The criterion for significance was set at $p \leq 0.05$.

A regression analysis was performed between the skin fold values and the PPT values obtained at each location. The criterion for significance was set at $p \leq 0.05$.

Interclass correlation was performed on the consistency of the two athletic therapists determining whether a nodule was present at of each of the 8 locations. The interclass

correlation evaluated the status before and after testing. The criterion for significance was set at $p \leq 0.05$.

CHAPTER III

MANUSCRIPT NUMBER 1

3.01. Overview of the accepted manuscript

What follows is a copy of the manuscript that was accepted in the Journal of Pain and published in August 2007, Volume 8, number 8

Following the department of kinanthropologie guidelines concerning publications and graduate students, Dr. Alain Comtois, PhD and supervisor to the M.Sc. candidate is listed as the corresponding author with the editor to the Journal of Pain. The work submitted to the Journal of Pain is the work of Mr. David H. Jones. Both Dr. Comtois and Dr. Kilgour made significant comments on the manuscript.

The results of this paper were a surprise to the candidate and to his supervisors. It was expected that there would be little or no change in pressure pain threshold values over the 4 days of testing. When deciding to submit this paper for publication it was felt that the results would be of interest to fellow researchers, because it is contrary to what has been seen in other studies.

3.02 Methodology paper - Letter of acceptance

-----Message d'origine-----
De : The Journal of Pain [mailto:jpain@jpain.us]
Envoyé : April 20, 2007 8:02 AM
À : Comtois, Alain Steve
Objet : Your Submission JPAIN-D-06-00253R1

Ms. Ref. No.: JPAIN-D-06-00253R1
Title: Test-retest reliability of pressure pain threshold measurements of the upper limb and torso in young healthy women The Journal of Pain

Dear Professor Comtois,

Thank you for submitting "Test-retest reliability of pressure pain threshold measurements of the upper limb and torso in young healthy women" to The Journal of Pain. I am pleased to say your manuscript has been accepted for publication.

Prior to publication, you will receive page proofs from Elsevier Science, which publishes The Journal for the American Pain Society. Proofs are made available to you electronically, in PDF file format. You will receive notification via e-mail.

Thank you for submitting this interesting paper.

Sincerely yours,

GF Gebhart, PhD
Editor-in-Chief
The Journal of Pain

3.03 Letter to the editor concerning revisions to manuscript

March 14, 2007

Dear Dr. GF Gebhart, PhD
Editor-in-Chief
The Journal of Pain

RE: JPain-D-06-00253

Dear Dr. Gebhart,

Thank you for assigning the 2 reviewers to examine and to comment on our manuscript entitled "Test-retest reliability of pressure pain threshold measurements of the upper limb and torso in young healthy women " I have made all the recommended changes/corrections/clarifications that have been suggested by the reviewers. I have included the reviewer's comments and have highlighted where the changes have been made.

Major comments and replies: Reviewer # 1

1) It is not clear why only one evaluator is used. If the authors planned to show the intra-tester reliability of PPT measurement, blinded multiple evaluators should be used to increase its reliability.

Reply to comment #1: The goal of our study was to measure PPT stability over 4 days. Hence, the importance of having one single evaluator performing all of the measurements, at this moment we are not interested in inter-tester reliability, which has been well established by others (e.g., Persson et al, 2004).

This is now stated clearly in the abstract on **page 2** where the opening sentence has been changed to: *The goal of this study was to test re-test the intra and inter day reliability.* It is also stated clearly in the introduction on at the bottom of page 3 under the heading **objectives** and reads as follows: *Thus, the **objectives** of this study are 1) establish the intra-tester reliability and reproducibility measures of PPTs with the use of a hand-held algometer by a single evaluator; and 2) to evaluate the reliability of the algometer in determining the PPT values in women over 4 consecutive days of testing.* This should clarify for the reader that we are looking at the reliability over a number of days.

Reference: Persson AL, Brogargh C, Sjolund BH: Tender or not Tender: Test –Retest repeatability of pressure pain thresholds in the Trapezius and the Deltoid muscles of healthy women, J Rehabil Med 36:17-27, 2004

2) Why the order of PPT measurements at 8 points was not randomized?
Randomization is only possible method to reduce order bias in this case.

Reply to comment #2: We agree with the reviewer that perhaps randomizing the order of application would have made for a stronger research design. However, logistically or clinically randomization would complicate performing measurements. The rationale for not randomizing in our study is as follows: The order of application of the algometer to the 8 locations was based on minimizing the amount of unnecessary movement. It is expected that this template will be used on groups of women who have neck, shoulder and upper arm problems. It was decided that testing of all of the anterior locations should be done first and then the subject would turn over to a prone position for all the posterior location measurements. With 4 trials of measurements at each location the subjects were required to turn from supine to prone or prone to supine 8 different times during the testing period. Randomization would have made the measurements extremely tedious for the subjects. Also, by randomizing the location sites, we would lose control of the time taken between PPT measurements on any particular day.

A paragraph in the **methods section** was added to outline this rationale in the **3rd paragraph on page 6** and reads as follows: *All subjects were placed in a supine position for the measurement of the bicep and anterior deltoid and then moved to the prone position for the measurement of the remaining sites. These two positions allowed for better stabilization of the arm, shoulder and torso compared to the seated position. We elected to follow this sequential order of measurement as opposed to randomizing the locations for PPT measurements in order to eliminate repeated movements between the supine to prone positions. Thus, with the subject in the supine position, the algometer was applied to the anterior aspect of the shoulder and arm for the PPT measurement over the marks located on the anterior deltoid and bicep. With the subject in a prone position, the algometer was applied to the posterior aspect of the arm (triceps), shoulder (posterior deltoid) and torso (infraspinatus, supraspinatus, rhomboids and the trapezius) for the measurement of PPTs. Pillows and padding*

were used to support the subject's shoulder and arm when appropriate. The total time required to collect three complete sets of data for each subject (4 trials total) was approximately 20 minutes.

3) What is measured by the algometer and what is expressed by the PPT value?

Reply to comment #3: In the introduction, on **page 3**, we have clarified what is an algometer and what is being measured.

The following sentences have been added and read as follows: *...within the algometer. The progressive development of pressure, by the application of the algometer head, produces a gradual displacement/ depression of the local skin surface. The PPT is the point where the amount of pressure being applied produces a local sensory shift from pressure to pain. According to Nie et al...*

4) Some loci (S4, S12) clearly decreased (Figure 6) and they strongly affect the mean value, so regional difference should be more stressed in the discussion.

Reply to comment #4: We now stress this issue in **both** the **results** and **discussion** sections. In the **results** section, **page 9**, the last paragraph before the discussion, we have indicated that there are at least 3 non-followers (S1, S13 and S15) that do not conform to the general trend of the 19 subjects.

The text in the **results section** now reads as follows: *Figure 4 represents all PPT values obtained at location 4 (rhomboids) for all 19 subjects. The thick line and points represent the mean ± SD for each trial and every subject and is in fact the line of location 4 presented in Figure 3. The data trend and dispersion shown in Figure 4 is representative of data collected at all 8 locations. Note, however, that there are three subjects (S1, S13 and S15) that do not follow the overall trend. In the remaining 16 subjects, four subjects follow the overall trend except on day 4 where the PPT values continued to decrease. The individual PPT values are illustrated in Fig 4 and are expressed numerically as means and standard deviations in Table 3.*

The **discussion** section on **page 13, paragraph 1,** has been modified to stress this regional difference and now reads as follows: *This repeated noxious stimulation has been shown to cause central nervous system changes [14]. In fact, Treede et al[32] have investigated brain cortical processing of pain by using both PET scan and fMRI imaging and have shown the involvement of the thalamus, the primary somatosensory cortex (S1), the secondary somatosensory cortex (S2), the insula, forebrain and the cingulate cortex (GC). These areas have been suggested to encode affective motivational pain aspects (GC and forebrain), whereas the lateral system (S1 and S2) is more likely to account for the sensory discriminative pain dimension[32]. It is clear that in our study a painful response was being provoked repeatedly not only on one day, but over 4 consecutive days. It is unclear whether there was sufficient stimulation to cause some form of physiological adaptation. Nonetheless, this*

may account for some of the variability that takes place as shown by the non-followers (S1, S13, and S 15) in figure 4.

Please note that chart listed as **figure 6** is now listed as **figure 4**

5) In conclusion, the author assumed the reduction of PPT due to local micro trauma or central response, however it is not well explain the data that the changes of PPT were different in each points and not uniformly reduced (Figure 6).

Reply to comment #5: In the results section we have indicated that 3 of the subjects did not follow the trend of decreased PPT values over 4 consecutive days of testing. In the remaining 16 subjects 4 of the subjects had an increase in PPT values between days 3 and days 4. Page 9 last paragraph in the results section

Page 9 last paragraph in the **results section**

The following section has been changed:

Changes in absolute PPT measurements over 4 consecutive days

The data outlined in Table 2 show a significant main effect of time ($F_{2,77}$ $p<0.05$) between days 1 and 4 over all eight locations.

With reference to chart 1, a significant lowering of PPT values is seen from day 1 to ay 2, across all 8 locations. The PPT values remain significantly lower across all 8 locations on day 3, when compared to day 1. On day 4, there was a general trend toward the increase in PPT values across all 8 locations; however they all remained significantly lower than day 1 values.

Chart 2 is a graphic representation of all the PPT values obtained at location 4 (rhomboids) for all 19 subjects. The thicken line and points represents the mean value for each trial. The data shown in chart 2 is typical of the data collected at all 8 locations.

This section now reads

Changes in absolute PPT measurements over 4 consecutive days

The data outlined in Table 2 show a significant main effect of time ($F_{2,77}$ $p<0.05$) between days 1 and 4 over all eight locations.

Figure 3 shows a significant lowering of PPT values seen on days 2, 3, and 4 across all 8 locations when compared to day 1. On day 4, there was a general trend towards an increase in PPT values across all 8 locations; however they all remained significantly lower than day 1.

Figure 4 represents all PPT values obtained at location 4 (rhomboids) for all 19 subjects. The thick line and points represent the mean ± SD for each trial and every subject and is in fact the line of location 4 presented

in Figure 3. The data trend and dispersion shown in Figure 4 is representative of data collected at all 8 locations. Note, however, that there are three subjects (S1, S13 and S15) that do not follow the overall trend. In the remaining 16 subjects, four subjects follow the overall trend except on day 4 where the PPT values continued to decrease. The individual PPT values are illustrated in Fig 4 and are expressed numerically as means and standard deviations in Table 3.

6) Figures 1-4 are not so much informative so it is better to give schematic illustration in one figure including the algometer.

Reply to comment #6: We have removed figures 1 and 2 from the previous version and we have retained figures 3 and 4, which give an accurate representation of many of the testing locations as well as how the algometer was applied. The charts that were **previously listed as figures 3 and 4** are presently listed as **figures 1 and 2.** We have also retained **figures 5 and 6** from the previous version and listed them as **figures 3 and 4.**

Minor comments and replies: Reviewer 1:

1) The significant digit should be considered in all expression of values (ages, ICC, etc).

Reply to comment #1: All age, height, weight values are represented as whole numbers with one decimal place. The ICC values have been changed to have two decimal places.

2) The authors stated that 1 kilogram weight was put on the head of algometer and confirmed the value between 98 to 102 kilopascals. Is this description correct? The linearity of algometer is also important information. It is better to add some data of its linearity if it is available.

Reply to comment #2: Additional detail has been included in the **methods sections** that outlines the manufactures recommended calibration guidelines. This detail is presented at the bottom of **page 4 and at the top of page 5**

The following section has been changed Calibration: The algometer was calibrated at the onset of each day of testing, before being applied to the subject. The algometer (Somedic Sales AB; Model type 2, Sweden) was calibrated using a standard protocol recommended by the manufacturer. The algometer was placed on to a stable surface, with the handle of the algometer on a table top with the nozzle surface facing upwards. A one kilogram weight was applied to the 0.5cm diameter applicator head attached to the end of the nozzle. Values were obtained and recorded from an LCD display. The acceptable calibration values ranged from 98 to 102 kilopascals.

This section now reads *The algometer was calibrated at the onset of each day of testing, before being applied to the subject. The algometer (Somedic Sales AB; Model type 2, Sweden) was calibrated using a standard protocol that was described and recommended by the manufacturer. The protocol required that the algometer be placed on to a stable surface; we used a table top, with the nozzle surface facing upwards. A one kilogram weight that was provided by the manufacturer was applied to the 0.5cm diameter applicator head attached to the end of the nozzle. Values were obtained and recorded from an LCD display. The acceptable calibration values ranged from 98 to 102 kilopascals. When the values did not fall within this acceptable range (± 2 kilopascals) the algometer was restarted and the calibration process was repeated.*

Unfortunately there is no available data on the linearity of the application of the algometer.

3). A 2cm applicator head was used but the details were not clear. Its material and shape are important and the reason why 2cm was used instead of usual 1cm head in the previous literatures should be mentioned.

Reply to comment #3: The project used the 2cm applicator head. We used the larger applicator head in the project because we were concerned about future projects working with patients undergoing adjuvant therapy for breast cancer. We felt that a smaller applicator may place these subjects (dealing with breast cancer) at an increased risk of bruising and localized tissue trauma, increasing their concern for developing lymphedema.

The following section has been changed Application: The 0.5cm applicator head was replaced following calibration with the 2cm applicator head to measure PPT's at the locations described below.

This change has been made on page **5 paragraph 2 in the methods section**

This section now reads: ***Application:*** *The 0.5cm applicator head* (circular disc with a rubberize tip) *was replaced following calibration with the 2.0cm applicator head to measure PPT's. The 2.0cm applicator head* (circular disc with a rubberize tip) *was used as opposed to the smaller head because we were concerned about an increased risk of bruising and localized tissue trauma. In addition, there is evidence that the 2.0 cm applicator appears to give indication of local pain sensation when compared to smaller applicator heads* [31].

The Takahashi article suggested by this reviewer actually recommends using larger application heads with the algometer. A larger applicator head gives a better indication of pain for the subjects (compared to smaller applicator heads). We thank the reviewer for this insight.

4) Sites of PPT measurements are important. Inter-subject variation might be large if there are any tender points or trigger points. There was no description of the nature of the loci used.

Reply to comment #4: The locations that were selected for the testing template were chosen because they were identified as possibility having a trigger point nodule at the site. The locations were referred to in several texts that are popular with clinicians. The muscles selected were areas that were used in previous studies. The location on the muscle was chosen based on the possibility of a trigger point nodule at the site. Some muscles had multiple locations where a trigger point nodule maybe located. We tried to have 8 distinct locations to avoid any confusion in the testing protocol. Confusion may have arisen if the sites were in to close proximity with each other such as with location 8 infraspinatus and location 4 on the rhomboids.

We have clarified this in the **methods section** of **page 6, 2nd paragraph**

This section has now been added: *The locations on the muscle were chosen based on the possibility of a trigger point nodule on the different sites. We recognized that a potential trigger point nodule maybe at the locations and we will be presenting that data in a companion paper. We can report that no location tested on the 19 subjects had an active trigger point. An active trigger point being defined as causing pain and restricting mobility [reference]. Any subject with an active trigger point nodule would have been removed from this study.*

5) The measurements were done in sequential manner. PPT measurement might be affected by the previous measure. It should be stated why the order of measurements did not randomized.

Reply to comment #5: Randomizing the order of application would have made for a stronger research design. The order of application of the algometer to the 8 locations was based on minimizing the amount of unnecessary movement. It is expected that this template will be used of groups of women who have neck, shoulder and upper arm problems. It was decided that testing of all of the anterior locations should be done, then the subject would turn over to a prone position and all of the posterior locations were tested. With 4 trials at each location the subjects were required to turn from supine to prone or prone to supine 8 different times or the testing period.

A paragraph in the **methods section** has been add outlining this rational, **3rd paragraph on page 6**

This section has now been added: *All subjects were placed in a supine position for the measurement of the bicep and anterior deltoid and then moved to the prone position for the measurement of the remaining sites. These two positions allowed for better stabilization of the arm, shoulder and torso compared to the seated position. We elected to follow this sequential order of measurement as opposed to randomizing the locations for PPT measurements in order to eliminate repeated movements between the supine to prone positions.*

6) The intervals of each measure were also important information but it did not mention.

Reply to comment #6: It would take approximately 5 minutes to go through one complete set, considering set up, movement and recording of data. It would have taken a total of 20 minutes to collect the 3 sets of data; the first set of data was not recorded. (300sec/8 locations =37.5sec per location)

This inform has been added to the **methods section** at the top of **page 7**, it took appropriately 20 minutes to complete all of the testing of 3complete data sets (4 sets total).

This sentence has now been added: *The total time required to collect three complete sets of data for each subject (4 trials total) was approximately 20 minutes.*

7) They stated cut-off of 400 kilopascal but several data indicate over 400 kilopascal.

Reply to comment #7: Actually only one individual had values over 400 kilopascals, actually all of her values were over 400 kilopascals

This termination point was used as a safety precaution as outlined in the **methods section**, at the top of **page 8**

The following section has been changed The experimenter explained to each subject that the trial at a specific location would end if and when the readings went beyond 400 kilopascals. This cut-off served to avoid any unnecessary pain or damage to the skin and underlying structures.

This section now reads: *The tester explained to each subject that the trial at a specific location would end if and when the readings went beyond 400 kilopascals. This precautionary measure served to avoid any unnecessary pain or damage to the skin and underlying structures.*

8) Citation of ref.19 was inadequate as it is rat allodynia model.

Reply to comment #8: This **reference** has been removed from the reference section.

9) PPT increase (ref 23) was accounted by smoking as a factor. You need to add reference that smoking increase PPT thresholds.

Reply to comment #9: The reference for smoking altering PPT values has been included with the following

Pauli P, Rau H, Zhuang P, Brody S, Birbaumer N: Effects of smoking on thermal pain threshold in deprived and minimally-deprived habitual smokers. Psychopharmacology 111:472-6, 1993

The two references listed below were recommended by reviewer 1 and have been included in the reference section,

References

1 Takahashi K, Taguchi T, Itoh K, Okada K, Kawakita K, Mizumura K: Influence of surface anesthesia on the pressure pain threshold measured with different-sized probes. Somatosens Mot Res 2:299-305: 2005

2 Itoh K, Okada K, Kawakita K: A proposed experimental model of myofascial trigger points in human muscle after slow eccentric exercise Acupunct Med 22:2-12; 2004

Major comments and replies: Reviewer # 2

****

Reviewer 2: comment #1. This paper studies the stability of the PPT determined by an electronic algometer when measured over 4 consecutive days. The authors carefully controlled for such variables as gender and hormonal variation in the menstrual cycle. The study was well thought out and conducted. The result is unexpected and one that must be considered in short term studies, although one that would be expected to be addressed by a control group in clinical studies. Nevertheless, the result is one to be considered by researchers doing studies over several days. There is one point that the authors do not address. Figure 6 shows that not all subjects had a decrease in the PPT over 4 days. In some subjects, the decrease was quite striking. They should address this variability in the response in the results section and in the discussion.

It appears from figure 6 that the drop in PPT in some subjects was dramatic. Did that drop affect the outcome for the whole group. Were there subpopulations, those with large decreases, those with small decreases, and those with no decrease? If so, was there any identifiable reason for the differences?

Figure 6 is so crowded that it is difficult to follow the course of individual subjects. Perhaps that data would be better displayed in a table.

Reply to Reviewer 2 comment #1. In the results section we have indicated that 3 of the subjects did not follow the trend of decreased PPT values over 4 consecutive days of testing.

This information has been added on **page 9**, last paragraph of the **results section** and now reads as follows: *Figure 4 represents all PPT values obtained at location 4 (rhomboids) for all 19 subjects. The thick line and points represent the mean ± SD for each trial and every subject and is in fact the line of location 4 presented in Figure 3. The data trend and dispersion shown in Figure 4 is representative of data collected at all 8 locations. Note, however, that there are three subjects (S1, S13 and S15) that do not follow the*

overall trend. In the remaining 16 subjects, four subjects follow the overall trend except on day 4 where the PPT values continued to decrease. The individual PPT values are illustrated in Fig 4 and are expressed numerically as means and standard deviations in Table 3.

We also address this issue of non followers and followers in the discussion.

We have added a sentence (last sentence) to the first paragraph on **page 13** of the **discussion section** that at reads as follows: *This may account for some of the variability that takes place as shown by the non-followers (S1, S13, and S 15) in figure 4.*

Reviewer 2: comment #2. The authors considered the psychological issue of pain perception to some extent. Could some of the patients simply have refined their sense of when pain began, and become more certain of onset at day 2. The major change appears to be between day 1 and day 2. The authors address this in the discussion, but perhaps they should emphasize that more in relationship to other mechanisms such as central sensitizatione, particularly since the PPT was more stable between days 2-4. The authors should address the remarkable drop in PPT between day 1 and days 2-4 in more detail in the discussion section. In future studies, a break-in or training period of testing before a clinical trial might address this specific issue, similar to the authors' suggestion to discard the day 1 results.

Reply to Reviewer 2 comment #2. We agree with the reviewer that some subjects may have refined their sense of when pain began. We address this issue beginning on page 11 under the heading: **Factors possibly contributing to the decrease in PPT values**. In addition, we specifically address central sensitization in the first paragraph on **page 13** where we have added the following sentences: *In fact, Treede et al [reference] have investigated brain cortical processing of pain by using both PET scan and fMRI imaging and have shown the involvement of the thalamus, the primary somatosensory cortex (S1), the secondary somatosensory cortex (S2), the insula, forebrain and the cingulate cortex (GC). These areas have been suggested to encode affective motivational pain aspects (GC and forebrain), whereas the lateral system (S1 and S2) is more likely to account for the sensory discriminative pain dimension [reference].*

****

Stylistic concerns:

*1) Please add page numbers to your manuscript.

Reply to comment #1: Done

* 2) We noticed that there is no "acknowledgment' information that provides sources of research support. As stated in the Journal's Instructions for Authors, authors are required to disclose sources of research support. This would include grants or departmental funding. You should also include any other information as set forth in our Instructions. To recap: "All authors must disclose any potential conflicts of interest. This includes honoraria, travel to conferences, consultancies, stock ownership (excluding publicly-owned mutual funds), equity interests and patent-licensing arrangements, (particularly if a commercial product is noted in the article), and sources of research support. Support staff may also be recognized in this section."

Reply to comment #2: There was no additional funding or grants to run this project. All the individuals who participated in the project volunteered their time and energy. The algometer was lent to the project by Dr. Karen Messing.

* 3) Please pay attention to the punctuation used in the references. There is no need to place periods after the initials of the authors' first names, or after the abbreviated names of the journals cited. Journal citations should appear as: Doe J, Jones S, White K: New directions in pain management. J Pain 1:10-16, 2004

Reply to comment #3: We have listed all of the Journal citations as indicated by the above example.

*4) Table 3 does not appear to be called out in the text. Please make sure Table 3 is cited.

Reply to comment #4: Table 3 has been cited. Table 3 has been linked to Figure 4(previously figure 6) as the mean and standard deviation values of location 4 over the 4 days of testing.

* 5) Some of your references are formatted incorrectly. For more information on the Journal's reference style, scroll to the bottom of this letter.

Reply to comment #5: We have gone back over each reference to make sure that they are formatted correctly.

* 6) Please note that the Journal has recently instituted a length limit of 600 words for the Introduction, and a limit of 1,500 words to the Discussion. Check those sections to be sure they do not exceed the word limits.

Reply to comment #6: We have made sure that the word limit in the introduction and the discussion has not been exceeded

Yours truly,

3.04 Revised manuscript-

Test-retest reliability of pressure pain threshold measurements of the upper limb and torso in young healthy women

David H. Jones, B.Sc., CAT (C), CSCS[1], Robert D. Kilgour, Ph.D., FACSM[1],

Alain S. Comtois Ph.D., FACSM[2].

[1]Department of Exercise Science

The Richard J. Renaud Science Complex

Concordia University

7141 Sherbrooke Street West

Montreal, QC

H4B 1R6

[2]Département de kinanthropologie

Université du Québec à Montréal

CP 8888, Succursale centre-ville

Montreal, QC

H3C 3P8

Address of correspondence:

Alain S. Comtois Ph.D., FACSM

Associate Professor,

Département de kinanthropologie

Université du Québec à Montréal

CP 8888, Succursale centre-ville

Montreal, QC, H3C 3P8

Tel: 514-987-3000 ext 1506,

Fax: 514-987-6616,

E-mail: comtois.alain-steve@uqam.ca

Abstract

The goal of this study was to determine the intra- and inter-day reliability of pressure pain thresholds (PPT) in the upper extremity and torso of asymptomatic women. Nineteen healthy women (20-39 yrs) with no underlying musculoskeletal problems had three PPT trials performed on 8 different locations in the upper extremity and torso over four consecutive days. The test-retest reliability of PPT values was robust and highly consistent over the four days. The PPT intra-class correlations (ICC) were highly consistent and repeatable over the four days of testing (Day 1: ICC = 0.94; Day 2: ICC = 0.96; Day 3: ICC = 0.97 and Day 4: ICC = 0.96). When compared to baseline measurements obtained on Day 1, the PPT values were significantly lower ($p<0.05$) on Days 2, 3 and 4 at all eight locations. Although the PPT test-retest reliability is robust and consistent throughout the four days, there appears to be a similar overall decline in the magnitude of the absolute PPT response at each of the eight locations. A specific explanation for this greater overall sensitivity in PPTs at all eight locations is lacking; however, a centrally-mediated alteration in pressure/pain sensation could contribute to the overall trend observed in this study.

Perspective:

PPT measurements of the upper limb and torso will be significantly lower with repeated measures over a short period time. a standardized evaluation grid should be included in baseline so as to accurately evaluate the progression in shoulder rehabilitation in women with shoulder dysfunction.

Introduction

The concept of pressure pain threshold (PPT) and the measurement of the onset of pain sensation using the algometer have been the focus and attention of much research and interest among clinicians and researchers. Over the last 25 years, the algometer has become widely used and accepted in the research literature [11] as well as the clinical environment [17], as a valid tool to evaluate one aspect of pain. The gradual application of pressure on a section of skin/muscle is detected by a force displacement transducer within the algometer. The progressive development of pressure, by the application of the algometer head, produces a gradual displacement/depression of the local skin surface. The PPT is the point where the amount of pressure being applied produces a local sensory shift from pressure to pain. According to Nie et al [20], the PPT serves as a useful index for discriminating tenderness of musculoskeletal structures in problems such as fibromyalgia [17,25], post surgery pain [13] and pain related to multiple sclerosis [30]. This algometer has been shown to be an effective tool in the determination of PPT [26, 28], with a number of the studies focusing on the consistency in measures between multiple examiners [1]. Thus, it has been hypothesized that PPT values would remain constant over time in a healthy population. Unfortunately, there is a paucity of information regarding the test-retest reliability of the algometer and the intra-tester reliability over time. In fact, two studies that did evaluate intra-tester reliability over time came up with conflicting results. A study by Nussbaum et al. [21] found reliable and consistent measures over time with no difference between the first, second or third day of testing, whereas, a study by Sand et al [27] did find a lowering of PPT values over the measurement time periods. Thus, the **objectives** of this study are 1) establish the intra-tester reliability and reproducibility measures of PPTs with the use of a hand-held algometer by a single evaluator; and 2) to evaluate the

reliability of the algometer in determining the PPT values in women over 4 consecutive days of testing.

Materials and Methods

Subject selection:

Nineteen female subjects [3] with a mean (± SD) age of 23.9 ± 5.2 yrs, mean height of 1.7 ± 0.1 m, average weight of 64.6 ±10.3 kg and a mean body mass index of 23.6± 3.5 kg/m² were recruited from the University and local community. All subjects were non-smokers[23] who were involved in some form of regular physical activity. The forms of physical activity varied and included dance, running, swimming and martial arts. None of the subjects experienced any shoulder pain or significant musculoskeletal pain that required medical review over the last 6 months. All subjects were right hand dominant [22]. Subjects were recruited for this study following approval of the University Human Research Ethics Committee. Each subject was explained the risks of participating in this study and voluntarily gave their written informed consent.

The subjects were asked not to undertake any new physical activity over the four day testing period. Subjects were also asked to avoid ingesting any caffeine products for at least 4 hours prior to each testing period. Subjects were asked to avoid any analgesic medication throughout the entire 4-day experimental period.

The calibration and application of the algometer:

Calibration: The algometer was calibrated at the onset of each day of testing, before being applied to the subject. The algometer (Somedic Sales AB; Model type 2, Sweden) was calibrated using a standard protocol that was described and recommended by the manufacturer. The protocol required that the algometer be placed on to a stable surface; we

used a table top, with the nozzle surface facing upwards. A one kilogram weight that was provided by the manufacturer was applied to the 0.5cm diameter applicator head attached to the end of the nozzle. Values were obtained and recorded from an LCD display. The acceptable calibration values ranged from 98 to 102 kilopascals. When the values did not fall within this acceptable range (± 2 kilopascals) the algometer was restarted and the calibration process was repeated. Identifying marks were placed on the skin, of the upper limb figure 1 and torso figure 2, so that the tester could repeat the PPT measurements over the same locations.

Application: The 0.5cm applicator head (circular disc with a rubberized tip) was replaced following calibration with the 2.0cm applicator head to measure PPT's. The 2.0cm applicator head (circular disc with a rubberized tip) was used as opposed to the smaller head because we were concerned about an increased risk of bruising and localized tissue trauma. In addition, there is evidence that the 2.0 cm applicator appears to give indication of local pain sensation when compared to smaller applicator heads [31].

The testing locations were identified through the placement of pen marks on the skin; over two (2) anterior locations and six (6) posterior upper torso locations were selected (see Figures 1- and 2). The marks served to identify the appropriate location in which to place the nozzle of the algometer. The experimenter applied the algometer to each of the eight locations in the following sequential manner (i.e., location1 through location 8): 1) the mid-point of the muscle fibers of the long head of biceps, 2) the mid-point of the anterior fibers of the deltoid, 3) the mid-point of the muscle fibers of the lateral head of the triceps, 4) the upper half of the fibers of the rhomboids major, 5) the mid-point of the posterior fibers of the deltoid, 6) the proximal one-third of the fibers of the supraspinatus (the location closest to the medial border of the scapula), 7) the upper fibers of the trapezius (medial to the superior angle of the scapula)

and 8) the distal one-third of the muscle fibers of the infraspinatus. The specific locations were selected for one of the three following reasons. Several of the locations have been used in previous studies such as the trapezius, deltoid and infraspinatus [15, 0, 34]. Other locations have often been identified in a clinical setting as being problematic such as the rhomboid and supraspinatus [4, 5, 17]. Finally, the biceps and triceps were selected because these regions have been found to be frequently painful especially in women who have had breast surgery with an axillary node dissection for the determination of breast cancer [18].

The locations on the muscle were chosen based on the possibility of a trigger point nodule on the different sites. We recognized that a potential trigger point nodule maybe at the locations and we will be presenting that data in a companion paper. We can report that no location tested on the 19 subjects had an active trigger point. An active trigger point being defined as causing pain and restricting mobility[4, 19]. Any subject with an active trigger point nodule would have been removed from this study.

All subjects were placed in a supine position for the measurement of the bicep and anterior deltoid and then moved to the prone position for the measurement of the remaining sites. These two positions allowed for better stabilization of the arm, shoulder and torso compared to the seated position. We elected to follow this sequential order of measurement as opposed to randomizing the locations for PPT measurements in order to eliminate repeated movements between the supine to prone positions. Thus, with the subject in the supine position, the algometer was applied to the anterior aspect of the shoulder and arm for the PPT measurement over the marks located on the anterior deltoid and bicep. With the subject in a prone position, the algometer was applied to the posterior aspect of the arm (triceps), shoulder (posterior deltoid) and torso (infraspinatus, supraspinatus, rhomboids and the trapezius) for the measurement of PPTs. Pillows and padding were used to support the subject's shoulder

and arm when appropriate. The total time required to collect three complete sets of data for each subject (4 trials total) was approximately 20 minutes.

Experimental Procedures

Pilot study: We completed a pilot project in order to test the 8 different locations on 5 subjects. The goal of the pilot project was to familiarize the evaluator with the algometer and to establish the protocol and experimental procedures for this study.

Time of testing: The subjects' first day of testing occurred within four days of the last day of the subject's menstrual cycle. The subjects were tested over four consecutive days. Each testing session took place in the morning at approximately the same time of day, over each of the four days.

Order of testing: An initial trial was performed at the outset of each testing session to familiarize the subject to the testing procedure. The data from this trial was discarded. Thereafter, three complete sets of data were collected on the subject. A complete set of data included applying the algometer to each location (1 through 8 in sequence) and recording the values obtained from the location. This order of measurement was done two more times. Each trial (of all 8 locations) was recorded on a single data sheet. When the data sheet was completed, the sheet was removed from view of the tester, so that subsequent data sets were collected without bias. This procedure was repeated for each trial over the four consecutive days.

Determination of the pressure pain thresholds (PPTs): At the beginning of each testing session, the subject was reminded that the PPT was defined as the "instant or moment that the pressure on the skin surface changed from the sensation of pressure to the sensation/perception of pain". The tester explained to each subject that they would feel a gradual increase in pressure on the skin. The pressure would continue to increase until the subject experienced a sensory transition from pressure to pain. The tester explained to each subject that the trial at a specific location would end if and when the readings went beyond 400 kilopascals. This precautionary measure served to avoid any unnecessary pain or damage to the skin and underlying structures. The tester applied the nozzle of the hand-held algometer at each landmark location at an approximate rate of 30 kilopascals per second [5]. The increase in the force applied to the skin surface was viewed by the experimenter, via the digital output display on the algometer. The tester continued to apply pressure until the subject pressed the button on hand-held switch indicating that they perceived a sensory transition from pressure to pain. The subject never viewed the recorded values.

Statistical analysis:

Descriptive analysis was performed using Microsoft Excel (Microsoft, Redmond, WA) to report results as mean $\pm$ S.D. Significant differences between means were detected by using SPSS version 11.5 (SPSS Inc., Chicago IL). A repeated measures analysis of variance was performed evaluating the absolute changes in PPT at each location throughout the 4 consecutive days of testing. A post hoc analysis was performed using a Tukey test. The criterion for significance was set at $p \leq 0.05$.

Results

Determination of intra-tester reliability (Day 1 of testing)

The analysis outlined in Table 1 gives an overview of the consistency of PPT measurements. The intra-tester reliability was highly correlated for the 3 trials performed at the 8 locations. The intra class correlation coefficient (ICC) for day 1 ranged from 0.92 to 0.98.

Determination of intra-test day reliability (Days 2, 3, and 4 of testing)

As well, as shown in Table 1, the ICC scores were calculated for the 3 trials performed at the 8 locations for days 2, 3 and 4. The ICC for days 2, 3, and 4 varied from 0.90 to 0.99. PPT intra-class correlations (ICC) were highly consistent and repeatable, and 0.93 to 0.98, respectively.

Changes in absolute PPT measurements over 4 consecutive days

The data outlined in Table 2 show a significant main effect of time ($F_{2.77}$ $p<0.05$) between days 1 and 4 over all eight locations.

Figure 3 shows a significant lowering of PPT values seen on days 2, 3, and 4 across all 8 locations when compared to day 1. On day 4, there was a general trend towards an increase in PPT values across all 8 locations; however they all remained significantly lower than day 1.

Figure 4 represents all PPT values obtained at location 4 (rhomboids) for all 19 subjects. The thick line and points represent the mean $\pm$ SD for each trial and every subject and is in fact the line of location 4 presented in Figure 3. The data trend and dispersion shown in Figure 4 is representative of data collected at all 8 locations. Note, however, that there are three subjects (S1, S13 and S15) that do not follow the overall trend. In the remaining 16 subjects, four subjects follow the overall trend except on day 4 where the PPT values

continued to decrease. The individual PPT values are illustrated in Fig 4 and are expressed numerically as means and standard deviations in Table 3.

Discussion

The main findings of this study demonstrate that there is a high level of consistency among the 3 trials for all 8 locations; that the PPT measures are reliable over consecutive days of testing; and that there is a significant lowering of PPT values observed over consecutive days of testing when compared to the day 1 baseline measures. This general trend was observed at each of the eight locations indicating that the subjects experienced a greater sensitivity in PPT in the upper arm and torso over time. In fact, the greatest decline in PPT values took place between day 1 and day 2, afterwards the rate of decline in PPT values diminished (between days 2 and 3)and by day 4 the PPT values started to increase but still remained significantly lower than the day 1 values.

Although reductions in PPT over time have been observed in subjects experiencing migraine/chronic headaches [5, 27], to the best of our knowledge there are no other studies that showed a similar trend in a non-clinical population. In fact, our cohort was obtained from a normal healthy subject population and we hypothesized that the PPT values would be either consistent [21] or demonstrate an increase over time [0].

A study by Nussbaum et al[21] showed no difference in PPT values over consecutive days of testing. There are several differences between the Nussbaum study and the present study that could possibly explain the differential findings. For example, Nussbaum et al (1997) used both males and female subjects, did not consider a women's menstrual cycle [2] in the testing protocol, tested one location the biceps brachii and used a manual algometer with

verbal feedback tested. We had only female subjects, coincided the first day of testing with the subject's menstrual cycle, tested 8 different locations and used an electronic algometer. Electronic algometers have been shown to be more sensitive in defining PPT values compare to manual algometers, with electronic algometers indicating significantly lower PPT values when compared to manual algometers at the same location [9].

We show that over 4 consecutive days of testing there is a decrease in PPT values. In contrast, a study by Persson et al [0] having a similar design of repeated measures but not on consecutive days (day 1, 3, 28 and 30) showed a significant increase in PPT values. The major differences between our study and Persson's study involve the subjects used in the project and the testing periods. The subjects in our study were in a more defined age range (20-39 years) compared to Persson et al [0] where 24 women (24-59 years) were evaluated on 4 separate days (1, 3, 28, 30). All of the women in our study had regular menstrual cycles and were non smokers, while in the Persson [0] study, several women (n= 6) were menopausal and some of the women were smokers. In fact, a study has shown that smoking influences PPT measurements [23]. We tested 8 locations on the right side of the upper arm and torso, while Persson et al bilaterally tested 3 locations on the trapezius and 4 locations on the deltoid for a total of 14 locations. Thus, all of these combined factors may account for the differences observed between our study and Persson et al's.

Factors possibly contributing to the decrease in PPT values

The decline in PPTs over the 4 days of testing may be due to one or more of the following factors: 1) A learned behaviour whereby the subject anticipates the PPT and depresses the button; 2) Tissue trauma or bruising of the location creating a more sensitive

area; and 3) A more complex central mechanism that elicits an earlier activation of the superficial and deep nociceptors.

It is possible that some form of learned behavioral response or anticipatory cue influenced or guided the subjects to respond sooner to the pressure of the algometer head on days 2, 3, and 4 when compared to baseline (day1). It is conceivable that the subjects began to anticipate when the PPT was approaching. This may have allowed the subject to be more aware of when the PPT level had been reached. This learning response did not occur on any one day; if it had then the ICC values would have been affected. A significant difference would have been seen between trials at the same location on the same day. This is in contrast to Persson et al [0] where a gradual increase in PPT values was noted in between trials on the same day.

The raw PPT scores on each day show little variation between trials at each location. But there was significant difference in PPT values obtained on day 1 and the PPT values obtained on the subsequent days of testing for each location. If a learning effect actually occurred, then it took place in between each day of testing and included the whole testing period, it is less likely to have taken place between each trial on any specific day of testing.

A second probable factor that may have accounted for the lowering of PPT values over time is the increase in sensitization of localized nerve receptors and local tissue trauma possibly brought on by the repeated pressure of the algometer head. If there was trauma around the affected area, it probably involved more superficial pain receptors embedded in the skin. It is possible that a small trauma occurred at each of the 8 location and thereby lowering the PPT value at each site. In a few instances, a faint discoloration at the selected testing locations was observed on the skin over the bicep brachii in five subjects. Discoloration is

often associated with tissue trauma or the onset of a hematoma [7]. A second factor associated with tissue trauma is an increase in the subject's sensitivity. It is foreseeable that some of the subjects may have experienced a change in sensitivity over some of the locations. Work by Treede et al [33] has shown that cutaneous analgesia does not have a significant influence on PPT values, thus a change in sensitivity is an unlikely outcome to explain the decrease in PPT values that we have observed.

A third possibility in the lowering of the PPT values may involve some form of central response which may have included components of both the learning on the part of the subject and very mild tissue trauma. The central and peripheral nervous systems are thought to have certain plasticity when it comes to learning [7, 14], being able to adapt and change rather quickly. A good example of this is in the area of pain, where free nerve endings, (nociceptive neurons) have been shown to not only respond to a single stimulus but have been shown to increase their readiness to fire during repeated stimulation [16]. This repeated noxious stimulation has been shown to cause central nervous system changes [14]. In fact, Treede et al[32] have investigated brain cortical processing of pain by using both PET scan and fMRI imaging and have shown the involvement of the thalamus, the primary somatosensory cortex (S1), the secondary somatosensory cortex (S2), the insula, forebrain and the cingulate cortex (GC). These areas have been suggested to encode affective motivational pain aspects (GC and forebrain), whereas the lateral system (S1 and S2) is more likely to account for the sensory discriminative pain dimension[32]. It is clear that in our study a painful response was being provoked repeatedly not only on one day, but over 4 consecutive days. It is unclear whether there was sufficient stimulation to cause some form of physiological adaptation. Nonetheless, this may account for some of the variability that takes place as shown by the non-followers (S1, S13, and S 15) in figure 4.

A possibility of a central response being elicited at all 8 locations may have been related to the presence of trigger points. Trigger points are known to be hypersensitive locations in the muscle and have been implicated in causing referred pain [19]. Referred pain is thought to have a central mechanism [8] which is believed to be bidirectional and modality specific to either a single or repeated response.

Limitations:

One of major limitation with our study is the lack of information on the physiological responses (i.e. change in cytokine levels) that may have taken place in the tissue at each of the testing sites. Another limitation was the failure to ask subjects if they perceived a lowering in their PPT value. Did the subjects notice that the location was becoming more sensitive or that they were aware of when the PPT value had been achieved at each site?

Conclusion:

In conclusion, we have shown a decrease in PPT values over 4 consecutive days, especially between Day 1 and Day 2 of testing. The nature of the decrease in PPT values is unknown but may involve local micro trauma over the measurement site or a central response.

Acknowledgement

The authors are indebted to all the volunteers at Concordia University and in particular to Ron Rehel, Tracy Griffiths and Christina Grace. As well, the authors express gratitude to Dr. Karen Messing for her constructive criticism and access to the hand-held algometer.

References

1. Antonaci F, Sand T, Lucas GA:Pressure algometry in healthy subjects: inter-examiner variability. Scand J Rehabil Med 30:3-8, 1998
2. Bajaj P, Arendt-Neilson L, Bajaj P: Madsen H. Sensory changes during the ovulatory phase of the menstrual cycle of healthy females. Europ J Pain 5:135-144, 2001
3. Chesterton LS, Barlas P, Foster NE, Baxter GD, Wright CC: Gender differences in pressure pain threshold in healthy humans Pain 101:259-66, 2003
4. Davies C, Davies A: The Trigger point Therapy Workbook, Oakland, CA, New Harbinger, 2004, pp 57-103
5. Defrin R, Ronat A, Ravid A Peretz C: Spatial summation of pressure pain: effect of body region. Pain 106 471-480, 2003
6. Galeotti N, Ghelardini C, Grazioli I, Uslenghi C: Indomethacin, caffeine and prochlorperazine alone and combined revert hyperalgesia in vivo models of migraine. Pharmacol Res 46: 245-50, 2002
7. Garell PC, McGillis SL, Greenspan JD: Mechanical response properties of nociceptors innervating feline hairy skin. J Neurophysiol 75:1177-89, 1996
8. Giesecke T, Gracely RH, Grant MA, Nachemson A, Petzke F, Williams DA, Clauw DJ: Evidence of augmented central pain processing in idiopathic chronic low back pain. Arthritis Rheum 50:613-23, 2004
9. Gracely RH, Grant MA, Giesecke T: Evoked pain measures in fibromyalgia. Best Pract Res Clin Rheumatol 17:593-609, 2003

10. Greenspan JD, McGillis SL: Thresholds for the perception of pressure, sharpness, and mechanically evoked cutaneous pain: effects of laterality and repeated testing. Somatosens Mot Res 11: 311-7, 1994

11. Itoh K, Okada K, Kawakita K: A proposed experimental model of myofascial trigger points in human muscle after slow eccentric exercise Acupunct Med 22(1):2-12, 2004

12. Kosek E, Ekholm J, Nordemar R : A comparison of pressure pain thresholds in different tissues and body regions. Long-term reliability of pressure algometry in healthy volunteers. Scand J Rehabil Med 25: 117-24, 1993

13. Kosek E, Ordeberg G: Lack of pressure pain modulation by hetertopic noxious conditioning stimulation in patients with osteoarthritis, before but not following surgical pain relief. Pain 88: 69-78, 2000

14. Leite JP, Neder L, Arisi GM, Carlotti CG Jr, Assirati JA, Moreira JE : Plasticity, synaptic strength, and epilepsy: what can we learn from ultrastructural data? Epilepsia 46 Suppl 5: 134-41, 2005

15. Lundberg U, Dohns IE, Melin B, Sandsjo L, Palmerud G, Kadefors R, Ekstrom M, Parr D: Psychophysiological stress responses, muscle tension, and neck and shoulder pain among supermarket cashiers. J Occup Health Psychol 4:245-55 , 1999

16. Maihofner C, Forster C, Birklein F, Neundorfer B, Handwerker HO : Brain processing during mechanical hyperalgesia in complex regional pain syndrome: a functional MRI study. Pain 114:93-103, 2005

17. Maquet D, Croisier JL, Demoulin C, Crielaard JM: Pressure pain thresholds of tender point sites in patients with fibromyalgia and in healthy controls. Eur J Pain 8:111-7, 2005

18. McCredie MR, Dite GS, Porter L, Maskiell J, Giles GG: Phillips KA, Redman S, Hopper JL. Prevalence of self-reported arm morbidity following treatment for breast cancer in the Australian Breast Cancer Family Study. Breast 10(6):515-22, 2001

19. Mense S, Simons DG. Muscle pain Understanding is nature, diagnosis and treatment. Lippincott, Williams and Wilkins, Philadelphia 2001 pp 205-281

20. Nie H, Arendt-Nielsen L, Andersen H, Graven-Nielsen T: Temporal summation of pain evoked by mechanical stimulation in deep and superficial tissue. J Pain 6:348-55, 2005

21. Nussbaum EL, Downes L: Reliability of clinical pressure-pain algometric measurements obtained on consecutive days. Phys Ther 78:160-9, 1998

22. Ozcan A, Tulum Z, Pinar L, Baskurt F: Comparison of pressure pain threshold, grip strength, dexterity and touch pressure of dominant and non- dominant hands within and between right-and left-handed subjects. J Korean Med Sci 19: 874-8, 2004

23. Pauli P, Rau H, Zhuang P, Brody S, Birbaumer N: Effects of smoking on thermal pain threshold in deprived and minimally-deprived habitual smokers. Psychopharmacology 111:472-6,1993

24. Persson AL, Brogargh C, Sjolund BH: Tender or not Tender: Test –Retest repeatability of pressure pain thresholds in the Trapezius and the Deltoid muscles of healthy women, J Rehabil Med 36:17-27, 2004

25. Petzke F, Harris RE, Williams DA, Clauw DJ, Gracely RH: Differences in unpleasantness induced by experimental pressure pain between patients with fibromyalgia and healthy controls. Eur J Pain 9: 325-35, 2005

26. Rolke R, Magerl W, Campbell KA, Schalber C, Caspari S, Birklein F, Treede RD : Quantitative sensory testing: a comprehensive protocol for clinical trials. Eur J Pain 10: 77-8, 2006

27. Sand T, Zwart JA, Helde G, Bovim G: The reproducibility of cephalic pain pressure thresholds in control subjects and headache patients. Cephalalgia 17: 748-55, 1997

28. Scoitti VM, Mittack VL, Dimarco LM,Ford LM, Plezbert J, Santipadri E, Wigglesworth J, Ball K: Clinical precision of myofascial trigger point location in the trapezius muscle. Pain 93: 259-266, 2001

29. Stohr T, Krause E, Selve N : Lacosamide displays potent antinociceptive effects in animal models for inflammatory pain. Eur J Pain 10: 241-9, 2006

30. Svendsen KB, Jensen TS, Hansen HJ, Bach FW :Sensory function and quality of life in patients with multiple sclerosis and pain. Pain 114: 473-81, 2005

31. Takahashi K, Taguchi T, Itoh K, Okada K, Kawakita K, Mizumura K:. Influence of surface anesthesia on the pressure pain threshold measured with different-sized probes. Somatosens Mot Res 2:299-305, 2005

32. Treede RD, Kenshalo DR, Gracely RH, Jones AK: The cortical representation of pain. Pain 79: 105-111,1999

33. Treede RD, Rolke R, Andrews K, Magerl W: Pain elicited by blunt pressure: neurobiological basis and clinical relevance. Pain 98: 235-40, 2002

34. Vanderweeen L, Oostendorp RA, Vaes P, Duquet W: Pressure algometry in manual therapy. Man Ther 1:258-265, 1996

Table 1: Consistency of repeated trials over the 4 days of testing- Reliability

Intra class Correlation Coefficients (Consistency Definition)

	Day 1	Day 2	Day 3	Day 4
Location	ICC	ICC	ICC	ICC
Location 1	0.96	0.97	0.97	0.96
Location 2	0.98	0.98	0.96	0.98
Location 3	0.96	0.97	0.99	0.98
Location 4	0.92	0.97	0.97	0.96
Location 5	0.94	0.95	0.97	0.98
Location 6	0.93	0.90	0.96	0.93
Location 7	0.92	0.97	0.97	0.96
Location 8	0.93	0.94	0.97	0.94

Confidence Interval ICC= 95%, IIC= Intra Item correlation of the 3 trials

Table 2 Average means and standard deviations across 4 days of testing

	Day 1 (Baseline)	Day 2	Day 3	Day 4	F & p values	
Location	x SD	x SD	X SD	x SD	F	p
Location 1	150.09 ± 77.15	123.37 ± 79.44 *	123.61 ± 81.50 *€	136.83 ± 81.60 *¦	7.22	< **0.05**
Location 2	160.28 ± 72.39	138.00 ± 73.91 *	131.24 ± 76.81 *	145.00 ± 77.29 *¦	7.65	< **0.05**
Location 3	174.95 ± 73.40	146.46 ± 77.94 *	139.37 ± 80.42 *	146.33 ± 81.40 *¦	11.13	< **0.05**
Location 4	246.53 ± 78.01	219.77 ± 75.97 *	208.27 ± 76.30 *	220.57 ± 78.51 *¦	6.64	< **0.05**
Location 5	232.19 ± 77.77	191.21 ± 74.11 *	187.18 ± 73.55 *	201.67 ± 76.06 *¦	11.94	< **0.05**
Location 6	228.79 ± 80.90	195.18 ± 75.18 *	180.78 ± 82.75 *£	190.57 ± 80.92 *	12.54	< **0.05**
Location 7	244.70 ± 78.34	213.56 ± 76.01 *	207.16 ± 79.93 *	210.36 ± 78.34 *	7.30	< **0.05**
Location 8	211.18 ± 76.48	180.70 ± 72.34 *	171.57 ± 78.85 *	181.93 ± 72.16 *	8.69	< **0.05**

Abbreviation **F =2.77, p≤ 0.05**

* Significant difference between day 1 and day 2, day 3 and day 4(P<0.35 to P<0.00)

€ The variance for day 2 = 6310.95, the variance for day 4 = 6658.58 leading to a P = 0.07,indicating no significant difference between the 2 days, the variance for day 3 = 6642.36 and day 4 = 6658.58 leading to a P = 0.02 indicating a significant difference between the 2 days

£ Significant difference between day 2 and day 3 (P=0.02)

¦ Significant difference between day 3 and. day 4(P<0.05 to P<0.01)

Table 3: Mean PPT values of repeated daily trials over 4 days of testing at location 4

	Trial 1	Trial 2	Trial 3
Day 1	252.95 ± 74.34	244.84 ± 87.06	241.79 ± 73.58
Day 2	218.37 ± 79.97	223.05 ± 72.29	217.89 ± 78.84
Day 3	211.47 ± 81.46	203.71 ± 76.98	209.65 ± 73.26
Day 4	214.64 ± 80.65	227.00 ± 80.03	220.07 ± 78.25

Figure legend

Figure 1. Location of marks (X) on the anterior surface of the upper arm and shoulder. An indelible ink mark was placed on the anterior fibers of the deltoid muscle and on to the long head of the biceps brachii muscle. The hand-held algometer is being applied to a location on the upper arm on the anterior surface of the subject, with the subject lying in a supine position

Figure 2. Location of marks (X) on the posterior surface. An indelible ink mark was placed on the posterior fibers of the deltoid muscle (not shown), lateral head of the triceps brachi muscle (not shown), supraspinatus muscle, rhomboids muscle, trapezius muscle and the infraspinatus muscle. The hand-held algometer is being applied to a location on the torso of the posterior surface of the subject, with the subject lying in a prone position.

Figure 3. Time course of PPT changes over 4 days of consecutive measurements over 8 locations. The data presented for each location are mean values. SDs have been omitted for sake of clarity. SDs are provided in Table 2. The text in the parentheses indicates the location number.

Figure 4. Time course of location 4 (rhomboid) PPT changes for all 19 subjects over 4 days of consecutive measurements for each three trials per day. The thick grey line in the background represents the group average ± SD. The figure in the inset represents the time course for location 4, which is taken from Figure 3. The text in the figure legend represents the corresponding subject number.

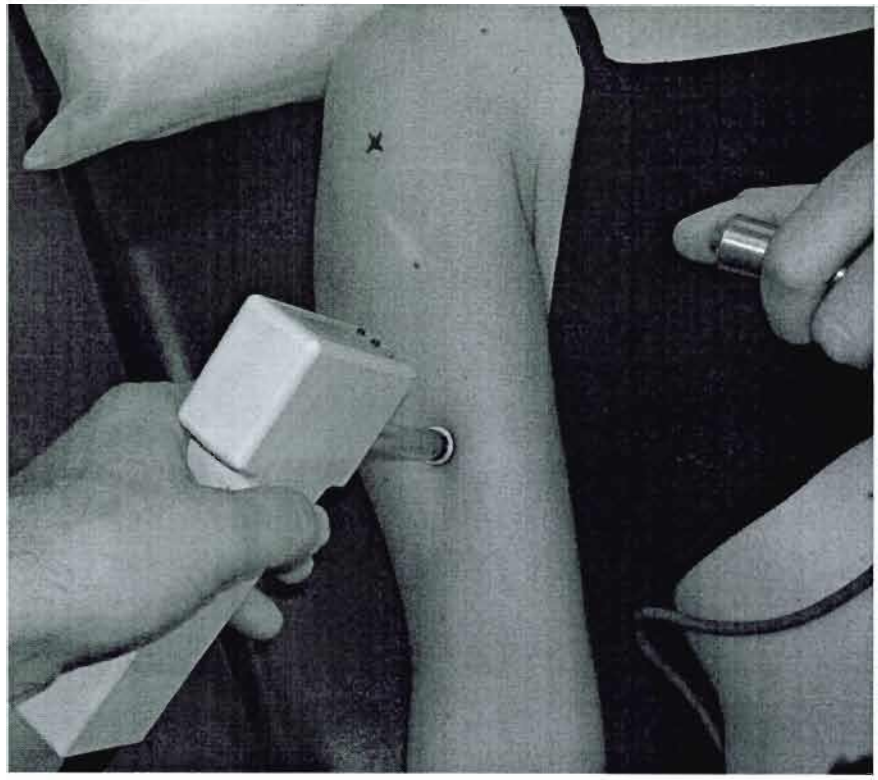

Figure 1

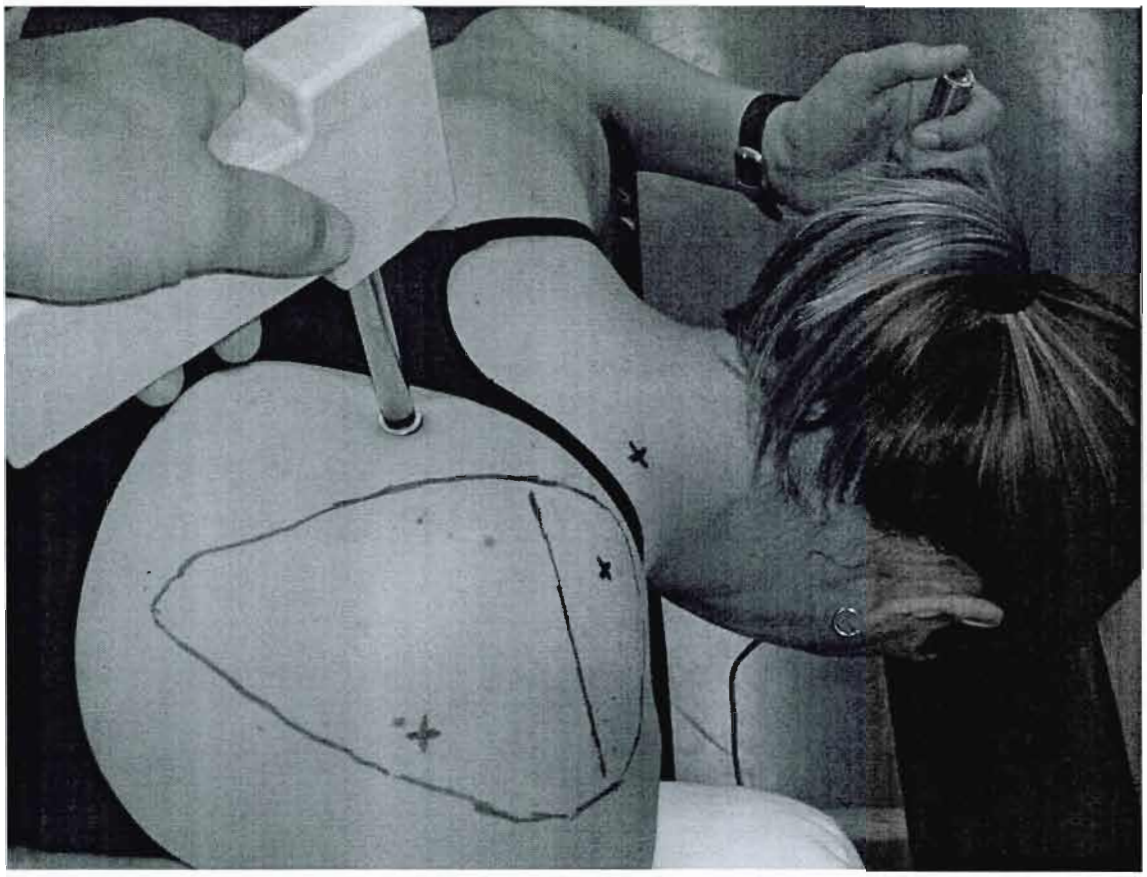

Figure 2

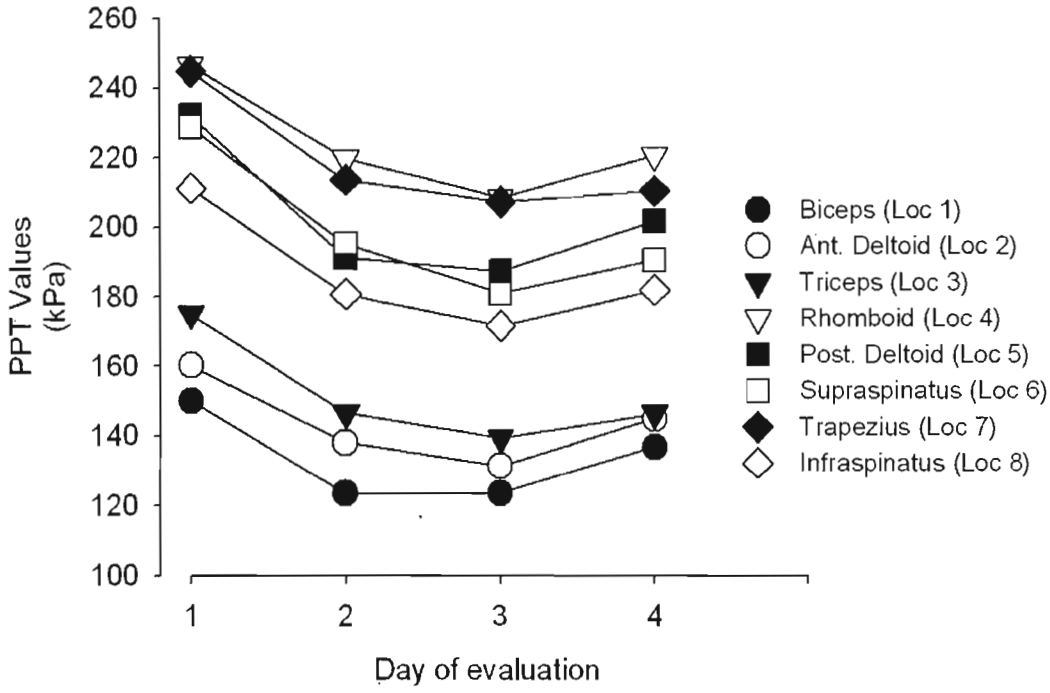
260
240
220
200
180
160
140
120
100
PPT Values (kPa)
1
2
3
4
Day of evaluation
Biceps (Loc 1)
Ant. Deltoid (Loc 2)
Triceps (Loc 3)
Rhomboid (Loc 4)
Post. Deltoid (Loc 5)
Supraspinatus (Loc 6)
Trapezius (Loc 7)
Infraspinatus (Loc 8)

Figure 3

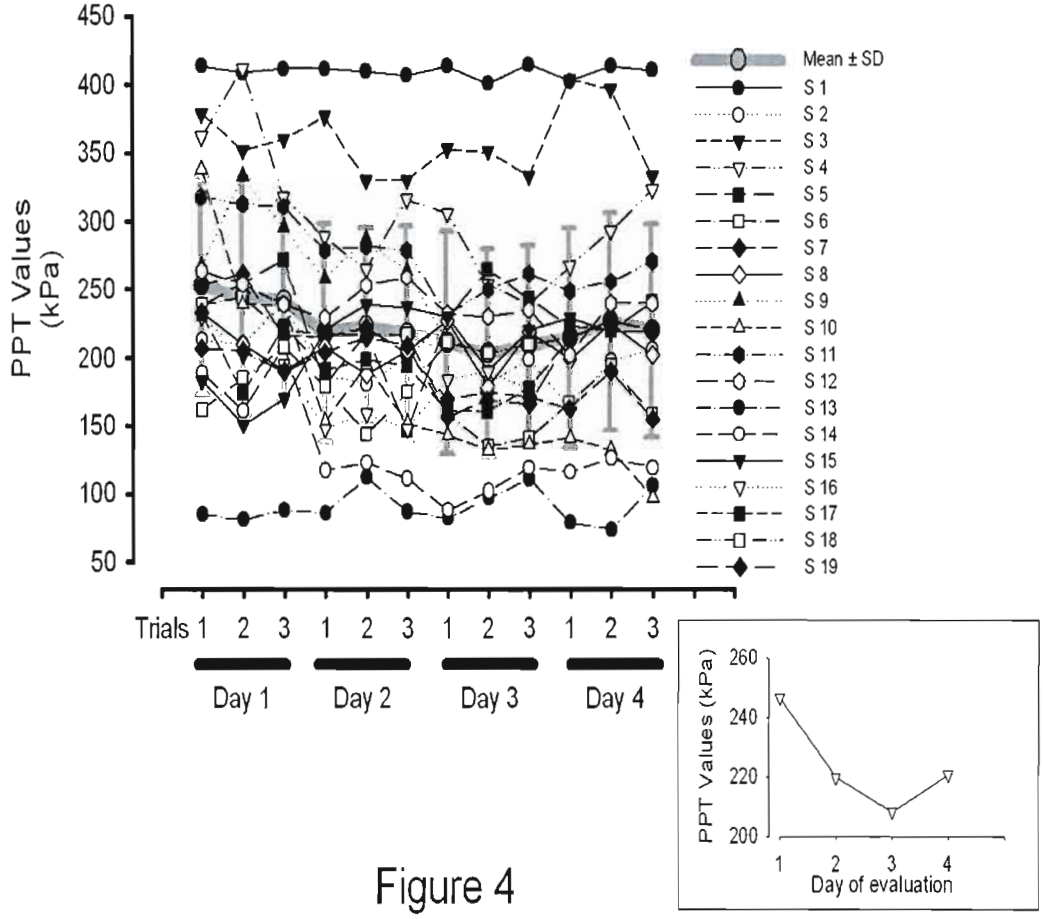
PPT Values (kPa)
450
400
350
300
250
200
150
100
50
Trials 1 2 3 1 2 3 1 2 3 1 2 3
Day 1
Day 2
Day 3
Day 4
Mean ± SD
S 1
S 2
S 3
S 4
S 5
S 6
S 7
S 8
S 9
S 10
S 11
S 12
S 13
S 14
S 15
S 16
S 17
S 18
S 19
PPT Values (kPa)
260
240
220
200
1 2 3 4
Day of evaluation

Figure 4

CHAPTER IV

MANUSCRIPT NUMBER 2

4.01 Overview of the second manuscript

This manuscript deals the original hypothesis concerning variation in the pressure pain threshold at the eight different locations. This manuscript was also presented as part of the research poster presentations at the annual Canadian Athletic Therapy association conference in Winnipeg in May, 2007.

Again the correspondence is between the journal's editor and Dr. Alain Comtois supervisor of the M.Sc candidate. All work has been done by Mr. David H. Jones both Dr. Comtois and Dr. Kilgour have made significant comments on the manuscript.

4.02 Letter of acceptance for poster presentation competition from the CATA conference committee 2007

4.03 Submitted manuscript 2

Regional variation in pressure pain threshold measurements of the upper arm and torso in young healthy women

David H. Jones, M.Sc., CAT (C), CSCS, [1,2] Robert D. Kilgour Ph.D., FACSM, [1]

Alain S. Comtois Ph.D., FACSM, [2]

[1]Department of Exercise Science
The Richard J. Renaud Science Complex
Concordia University
7141 Sherbrooke Street West
Montreal, QC
H4B 1R6

[2]Département de Kinanthropologie
Université du Québec à Montréal
CP 8888 Succursale, centre-ville
Montreal, QC
H3C 3P8

Address for reprints:

David H. Jones, M.Sc., CAT (C), CSCS,
Department of Exercise Science
The Richard J. Renaud Science Complex
Concordia University
7141 Sherbrooke Street West
Montreal, QC, H4B 1R6

Tel: 514-848-2424 ext 3318

Fax: 514-848-8681

E-mail: dhjones@alcor.concordia.ca

Abstract:

The purpose of this study was to evaluate the variation in pressure pain threshold (PPT) values in eight different locations of the upper arm and torso over four consecutive days of testing. Nineteen college-aged women (20-39 yrs) with no underlying musculoskeletal problems participated in the study. Over the testing period, the upper arm and anterior shoulder regions were found to have significantly lower PPT values ($P < 0.05$) when compared to PPT values on the posterior shoulder and torso. Four locations on the torso had PPT values that were consistently higher than the grand PPT mean of all eight locations. Of all the locations measured, the PPT on the infraspinatus muscle was found to be consistently around the grand mean over the four days of testing.

Perspective:

PPT measurements performed on the upper arm and anterior shoulder have been shown to be significantly lower compared to the posterior shoulder and torso in normal healthy women. These differences should be recognized and included in baseline values so as to accurately evaluate the progress in women, especially those with shoulder dysfunction.

Introduction

Over the last four decades, researchers have taken a significant interest in determining the incidence of musculoskeletal pain that develops in the neck, shoulder and arm regions of people working at various jobs requiring repetitive movements for extended periods of time [3,8,11]. Those considered to be at risk for developing pain in the neck, shoulder and arm regions include musicians[30], dental hygienists[24,25], cashiers[11]and people who work at computer terminals[19]. In the majority of these positions, the high incidence of pain is associated with tasks that have low biomechanical demands that are performed for extended periods of time[27]. A second observation is the significantly greater percentage of women than men who are affected by this problem[4, 8]. These individuals not only endure pain and dysfunction but also a diminished quality of life[17].

Many protocols and measurement devices have been used to assess the efficiency of different therapeutic interventions of the upper arm and torso[12,17]. Among the measurement devices used is the algometer. The algometer is a valid and reliable tool that is commonly used to assess the subject's pressure pain threshold (PPT)[18,21].

The algometer has been used to gain an understanding of muscle tissue sensitivity on single [29] and multiple site locations[6] in the upper and lower regions of the body. These and other different models have been tested [21, 22] but none to our knowledge has been designed to assess and evaluate specific regions that may eventually be implemented in a clinical setting.

A recent study from our laboratory (Jones et al. 2007) established the test-re-test reliability of a protocol that evaluated PPT sensitivity in a group of healthy asymptomatic young women. In establishing the test-re-test reliability in the eight sites over the four days, we discovered an interesting trend in PPT values according to the regions and locations tested. In this paper, we reported the regional differences in PPT and the significance that these presented in a normal population of women. . We observed that not all locations had the same PPT values and that some locations are more sensitive than others as evidenced by the consistent differences at specific locations on the upper body and torso.

Materials and Methods

Subject selection:

Nineteen female subjects with a mean (± SD) age of 23.9 ± 5.2 yrs, height (1.7 ± 0.1 m), weight (64.6 ±10.3 kg) and body mass index (23.6± 3.5 kg/m^2) were recruited from the University and local community following approval of the University Human Research Ethics Committee. Each subject was explained the risks of participating in this study and voluntarily gave their written informed consent. All subjects were non-smokers[20] who were involved in some form of regular physical activity including dance, running, swimming and martial arts. None of the subjects experienced any shoulder pain or significant musculoskeletal pain that required medical attention over the last 6 months. All subjects were right hand dominant[18].

The subjects were asked not to undertake any new physical activity over the testing period of four consecutive days. Subjects were also asked to avoid ingesting any caffeine

products for at least 4 hours prior to each testing period. Subjects were asked to avoid taking any analgesic medication throughout the entire 4-day experimental period.

Test locations

The algometer (Somedic Sales AB; Model type 2, Sweden) calibration and application in this study are discussed in detail in Jones et al (2007).

The testing locations were identified through anatomical reference landmarks on the skin surface. The placement of pen marks on the skin over two (2) anterior locations and six (6) posterior upper torso locations served to identify the anatomical landmarks and location of where the nozzle head of the algometer was placed (see Figure 1). The experimenter applied the algometer to each of the eight locations in the following sequential manner (i.e., location1 through location 8): 1) the mid-point of the muscle fibers of the long head biceps (Bb), 2) the mid-point of the anterior fibers of the deltoid (AD), 3) the mid-point of the muscle fibers of the lateral head of the triceps (Tri), 4) the upper half of the fibers of the rhomboids major (RhM), 5) the mid-point of the posterior fibers of the deltoid (PD), 6) the proximal one-third of the fibers of the supraspinatus (Sup) (the location closest to the medial border of the scapula), 7) the upper fibers of the trapezius (Trap) (medial to the superior angle of the scapula) and 8) the distal one-third of the muscle fibers of the infraspinatus (Inf). The specific locations were selected for one of the three following reasons. Several of the locations have been used in previous studies such as the trapezius, deltoid and infraspinatus [11, 28]. Other locations such as the rhomboid and supraspinatus [5, 6,14] have often been identified in a clinical setting as being problematic.. Finally, the biceps and triceps were selected because these regions have been found to be frequently painful especially in women who have had breast surgery with an axillary node dissection for the determination of breast cancer [13].

The specific locations on the muscle were chosen based on the probability of the existence of a trigger point nodule on the different sites (refs). We recognized that a potential trigger point nodule may be at these locations and we will be presenting those data in a follow-up companion paper. We can report that none of the 19 subjects tested had an active trigger point. An active trigger point being defined as causing pain at rest and restricting mobility[4, 14]. Any subject with an active trigger point nodule would have been released from this study.

All subjects were placed in a supine position for the PPT measurement of the bicep and anterior deltoid and then moved to the prone position for the measurement of the remaining sites. These two positions allowed for better stabilization of the arm, shoulder and torso compared to the seated position. We elected to follow this sequential order of measurement as opposed to randomizing the locations for PPT measurements in order to eliminate repeated and numerous movements of the subjects between the supine to prone positions. Thus, with the subject in the supine position, the algometer was applied to the anterior aspect of the shoulder and arm for the PPT measurement over the marks located on the anterior deltoid and bicep brachii. With the subject in a prone position, the algometer was applied to the posterior aspect of the arm (triceps), shoulder (posterior deltoid) and torso (infraspinatus, supraspinatus, rhomboids and the trapezius). Pillows and padding were used to support the subject's shoulder and arm when appropriate. The total time required to collect three complete sets of data for each subject was approximately 20 minutes.

Although randomizing the order of application would have made for a stronger research design, we decided for reasons of logistics and optimum experimental control to

specify the order of application. It is expected that this template will be used on groups of women who have neck, shoulder and upper arm problems. It was decided that testing all of the anterior locations should be done first and then the subject would turn over to a prone position for all the posterior location measurements. With 4 trials of measurements at each location the subjects were required to turn from supine to prone or prone to supine 8 different times during the testing period. Randomization would have made the measurements extremely tedious for the subjects.

Experimental Procedures

Time of testing: The subjects' first day of testing occurred within four days of the last day of the subject's menstrual cycle[1]. The subjects were tested over four consecutive days and each testing session took place at approximately the same time each morning.

Order of testing: An initial trial was performed at the outset of each testing session to familiarize the subject to the testing procedure. The data from this trial was discarded. Thereafter, three complete sets of data were collected on the subject at each location (1 through 8 in sequence). Each trial (of all 8 locations) was recorded on a single data sheet. When the data sheet was completed, the sheet was removed from view of the tester, so that subsequent data sets were collected without bias. This procedure was repeated for each trial over the four consecutive days.

Determination of the pressure pain thresholds (PPTs): At the beginning of each testing session, the subject was reminded to press the button on the hand-held switch the "instant or moment that the pressure on the skin surface changed from the sensation of

pressure to the sensation/perception of pain". Each subject was informed that they would feel a gradual increase in pressure on the skin when the nozzle of the algometer was applied. The pressure would continue to increase until the subject experienced a sensory transition from pressure to pain. Each subject was told that the trial would end if and when the algometer reading went beyond 400 kilopascals. This precautionary measure served to avoid any unnecessary pain or damage to the skin and underlying structures. The experimenter applied the nozzle of the hand-held algometer at each landmark location at an approximate rate of 30 kilopascals per second[6]. The increase in the force applied to the skin surface was viewed by the experimenter via the digital output display on the algometer. The experimenter continued to apply pressure until the subject pressed the button on hand-held switch indicating that they perceived a sensory transition from pressure to pain. The subjects never viewed nor were they informed of the recorded values.

Statistical analysis:

Descriptive analysis was performed using Microsoft Excel (Microsoft, Redmond, WA). All values are reported as mean ± S.D. Significant differences between means were detected using SPSS version 11.5 (SPSS Inc., Chicago IL). A repeated measures ANOVA was performed evaluating the mean changes in PPT at each location throughout the 4 consecutive days of testing. A post-hoc analysis was performed using a Tukey test. The criterion for significance was pre-set at $p \leq 0.05$.

Results

The main effect of an analysis of variance indicated that there was a significant difference in PPT values obtained at the 8 different locations over the 4 days of testing. Post hoc analysis showed that location 1, 2 and 3 had significantly lower PPT values compared to all other locations over all 4 days of testing (Table 1). The critical F= 2.08, over the 4 days of testing with; F=38.83 on day 1; F= 39.90 on day 2; F= 26.18 on day 3 and F= 15.76, $P < 0.05$ on all 4 days.

What follows is a detailed breakdown of the post hoc analysis at each location (Table 1).

Differences per location over the 4 days of testing

Locations 1 biceps brachii, 2 anterior deltoid and 3 triceps brachii

The PPT values obtained at these 3 locations were significantly lower than the PPT values obtained at the other 5 locations ($p<0.00$) over all 4 days of testing. There was a significant difference between location 1 (Bb) and location 2 (AD) ($p=0.02$) and 3 (Tri) ($p=0.00$) on day 1 of testing. There was no difference between the 3 locations on days 2, 3 and 4 of testing.

Locations 4 rhomboids major, 5 posterior deltoid and 7 trapezius.

The PPT values obtain at locations 4 (RhM), 5 (PD) and 7 (Trap) were significantly greater ($p<0.00$) than the PPT values obtained at the other 4 locations; 1 (Bb), 2 (AD), 3 (Tri) and 8(Inf), over the 4 days of testing.

Location 6 the supraspinatus

The ppt values for location 6 (Sup), were significantly greater than the PPT values of locations 1, 2, 3, ($p<0.00$) over the 4 days of testing. Over the 4 days of testing location 6 (Sup) showed the same variation in ppt values as locations 4 (RhM), 5 (PD) and 7 (Trap). On day 1 the ppt values for location 6 (Sup) were significantly different from location 8 (Inf) ($p=0.04$). On day 2 ppt values for location 6 (Sup) were significantly from location 4 (RhM) ($p<0.00$). On day 3 the PPT values of location 6 supraspinatus, were significantly different to the PPT values from 5 of the 7 locations, the exceptions being location 5 (PD) ($p=0.34$) and 8 (Inf) $p=0.11$). On day 4 the PPT values of location 6 (Sup), were significantly different to the PPT values from 6 of the 7 locations, the exception being location 8 (Inf) ($p=0.14$).

Location 8 the infraspinatus

The PPT values for location 8 (Inf) were significantly different from PPT values recorded at all other locations on day 1. The difference between location 8 (Inf) and location 6 (Sup) was ($p=0.04$). The significant difference in PPT values, continued over all 4 days, across 6 of the 7 locations. At location 6 (Sup), there was no difference in PPT values on days 2($p=0.08$), 3($p=0.11$) and 4(p 0.14) when compared to location 8.

The following section is a comparison of the mean PPT values for each location to the Grand Mean of PPT values of all locations. Figures 2 a-2d, 3

Comparing mean PPT values to grand mean of PPT values

A comparison was performed, looking at the mean PPT values of one location and comparing it to the grand mean of the PPT values of all 8 eight locations, figure 2(Day 1). All location points were normalized to the overall mean value of the 8 location points. When examining Figure 2, three distinct trends are seen in the data collected over 4 days of testing. First, the PPT values of locations 1 (Bb), 2 (AD), 3 (Tri) were consistently below the mean (15%-29%) for all 3 trials. Secondly, the PPT values of locations 4 (RhM), 5 (PD), 6 (Sup) and 7 (Trap) were consistently above the mean (7%-29%) for all 3 trials. Thirdly, the PPT values at location 8 infraspinatus were consistently around the mean (1.00%- 1.04%) for all 3 trials. This can be seen in Figure 3. The variation in PPT values obtain for a location on each day remained significantly different over all four days of testing. Figures 2a-2d shows the variation between trials on each day.

Discussion:

The main findings of this study demonstrate a significant regional difference in the PPT values of the arm and upper torso. The PPTs of the arm and anterior shoulder (e.g., biceps, anterior deltoid and triceps) were similar to one another but were significantly lower than those measured in the torso (e.g., rhomboids, posterior deltoid, supraspinatus, trapezius, and infraspinatus). This indicates selective regional pressure/pain sensitivity in a group of asymptomatic women. The PPT values fell into one of three significantly different groups. In the first group the PPT values were lower than the grand mean; in the second group the PPT values were higher than the grand mean and in a third group the PPT values were close to the grand mean. The grand mean was the mean value of all eight locations across all 19 subjects.

When using an algometer as a diagnostic tool, the clinician/researcher should expect lower PPT values in the upper arm compared to the torso with the understanding that a lower PPT value does not necessarily indicate an underlying problem. It is possible that these 3 locations with the lower PPT values may have a greater density of free nerve ending compared to the other 5 locations, making them more sensitive to the perception of pressure pain. If the upper arm does become problematic, the clinician working with a patient to resolve this problem, should not expect PPT values in the upper arm to attain the same PPT levels in the torso, as the area is being rehabilitated[26].

The PPT values for the rhomboids major and the trapezius were approximately 20% greater than the mean. Both muscles have been frequently associated with neck and back pain and dysfunction in the upper extremity [8]especially the trapezius. It is possible that the locations with high pain thresholds only become problematic after some form of tissue damage has occurred, which may make them more difficult treat. If either of these locations were to become problematic, it is possible that the PPT values obtained at the rhomboids major and the trapezius may be at the same level or even slightly higher, than other test locations. This may give the false impression that the locations are not problematic, when in reality there is some form of dysfunction present[26]. The clinician/researcher must take this into consideration when analysing PPT values.

Location 8 infraspinatus had PPT values that were close to the grand mean, over all 4 days of testing. Location 6 supraspinatus did have PPT values that were similar to location 8 infraspinatus but had much more variation over the testing period. Using the infraspinatus (and possibly supraspinatus) as reference points, clinicians and researchers may be able to estimate the PPT values of the other 6 locations[26]. This approach may be appropriate as long as the infraspinatus itself does not become problematic and the same locations are used to evaluate PPT levels. This value would probably vary if more or less locations were to be used or if different locations were to be used.

In a previous study[9], we indicated that there was a significant decrease in PPT values over 4 consecutive days of testing. This decrease in PPT values over time did not affect the

differences between the testing locations. The same locations remained more sensitive or less sensitive over all four days of testing. The variation over time as well as detailed analysis of the ICC scores was described previously[9]

Why are there 3 distinct groupings of PPT values?

The subjects may have been influenced by seeing the application of the algometer being applied to their arm. Lying in a supine position, and the head in a neutral position the subjects may have been able to view the algometer being applied to their arm, even though the subject did not see the digital display, they may have been influenced by the site of the algometer being pushed down upon their upper arm and shoulder. This remains plausible except that the third location which had low PPT values was on the triceps. When testing the triceps, the subject was lying in a prone position and had limited view of the algometer when it was applied to this location. Future studies should look to blind folding subjects to diminish visual input as a confounding variable.

Another possible explanation for the differences in recorded PPT values maybe due to the difference in nervous innervation and the vascular supply of the locations being tested. Seven of the eight locations had a different nerve supply[16]; the only location that had the same nervous input was anterior and posterior deltoid. A comparison between location 2, the anterior deltoid and location 5, the posterior deltoid, show a significant difference in PPT values between the 2 locations. Where the anterior portion of the deltoid was significantly more sensitive and had lower PPT values than the posterior portion, even though both are

innervated by the same nerve (axillary) [16]. The brachial plexus is the nervous supply that innervates the arm and is positioned more superficial on the anterior surface of the upper body compared to the posterior surface [16]. With the brachial plexus being in close proximity to the anterior deltoid it may have lead to an increase in sensitivity which may account for the difference in PPT values [16].

In this study the locations being tested were the mid point of the anterior fiber and the mid point of the posterior fibers. In a study by Baker et al.[2] different areas of a muscle (rectus femoris) were found to have different values. The proximal and distal tendon bone junctions were shown to have increased sensitivity and lower PPT values when compared to the mid point of the muscle. In this study the mid point of the anterior fiber of the deltoid and the mid point of the posterior fibers were tested and fond to be significantly different.

A third reason why we observed differences in PPT values at the 8 locations maybe due the location of the muscles. Posterior muscles maybe less sensitive than anterior muscles, with the upper back being considered less sensitive than other areas that were tested. In one study [6]the back and torso region was found to have higher PPT values when compared to other locations[6]. This is consistent with our results and maybe related to free nerve ending density [16].

A fourth and possible final reason for the differences in the 8 locations, maybe related to the order in which the PPT values were assessed. As outlined in the methods section we did not randomize the order in which the locations were tested. We wanted to

avoid excessive movement of the subject, which may have compromised stabilization of the subject's torso or shoulder. This may have influenced the values obtained. If the order of application was a factor then a follow up study randomizing the locations would be appropriate. Moreover, if the order of application was a significant factor then we should have seen a gradual increase or decrease in PPT values based on the order the algometer was being applied to the testing locations. This would have meant that location 1 should have had either the lowest or the highest PPT value and location 8 should have had the corresponding inverse, with the highest or lowest PPT values. This did not take place. Looking at table 1 we see a progressive increase in PPT values at the first 4 locations, followed by a drop at location 5,PD, a drop in location 6,Sup, an increase in location 7 , Trap and a final drop in location 8,Inf.

Application:

In the work force individuals whom are at risk of developing repetitive movement syndrome have become very interested in finding solutions to overuse problems for these individuals. The financial cost from lost man hours and the increased work required to hire competent replacement workers [15]has had a negative impact on a company's bottom line. To determine if an individual is ready to return to work, individuals and companies have looked to the medical community for guidance, with the return to work being based on the attending physician's recommendations[23]. Studies have shown that the physician/surgeon's recommendations for return to work after surgery maybe highly variable[23], with

recommendations being based less on objective measures and more on the perceived patient readiness to return to work [23]. Physicians, through the help of ergonomists (whom are the eyes in the work place setting) maybe able to combine the template with additional objective tools to determine when it is appropriate for someone to safely return to work without aggravating problems in the neck, upper torso and arm.

A patient experiencing pain in the trapezius location was able tolerate x amount pressure at the initial evaluation. The values on the trapezius were close to the values obtained while testing locations on the upper arm. After a number of weeks of rehabilitation the patient is now able to y amount of pressure, which is significantly greater than the values on the upper arm and is closer to the ratio values we would anticipate for the individual, approximately 15-20 % greater than the grand mean of the 8 locations.

Limitations:

The template for this study was used on healthy individuals who did not have any musculoskeletal problems at present. Moving the template to a group that has underlying problems in the neck, upper back, shoulder, arm and region may lead to different findings. Individuals with chronic and acute pain are shown to have very different responses[7,8]. Individuals with chronic pain associated with repetitive movement syndromes have both physiological and psychological adaptations, which are not accounted for with this model.

Future Projects:

Moving the template to a population that is at risk of developing upper arm torso problems is the next logical step. This would entail doing a pre-test evaluation on specific groups such as females who perform repetitive tasks for sustained periods of time or women who are undergoing some type of medical intervention that has been known to adversely affect the shoulder, such as adjuvant therapy associated with breast cancer. Then following up with the group 4-6 months later to see if anything has changed at the testing sites or whether different therapeutic interventions have improved the situation and made the locations less sensitive.

Conclusion:

There was a significant difference between the 8 different locations that were evaluated over the 4 days of testing. Locations on the arm and anterior shoulder were more sensitive and had lower PPT values than locations on the upper torso and posterior shoulder. The PPT values of one location, on the infraspinatus, were consistently around the grand mean of all 8 locations. Before the infraspinatus could be considered representative of the 8 locations, many more tests need to be performed.

REFERENCES

1. Bajaj P, Arendt-Neilson L, Bajaj P: Madsen H: Sensory changes during the ovulatory phase of the menstrual cycle of healthy females Europ J Pain.2001: 5: 135-144

2. Baker SJ, Kelly NM, Eston RG: Pressure pain tolerance at different sites on the quadriceps femoris prior to and following eccentric exercise. Eur J Pain.1997: 1: 229-33

3. Brandt LP, Andersen JH, Lassen CF, Kryger A, Overgaard E, Vilstrup I, Mikkelsen S: Neck and shoulder symptoms and disorders among Danish computer workers. Scand J Work Environ Health 2004: 30(5): 399-409

4. Chesterton LS, Barlas P, Foster NE, Baxter GD, Wright CC: Gender differences in pressure pain threshold in healthy humans Pain: 2003 101: 259-66

5. Davies C, Davies A: The Trigger point Therapy Workbook, Oakland, CA, New Harbinger, 2004, pp 57-103

6. Defrin R, Ronat A, Ravid A Peretz C: Spatial summation of pressure pain: effect of body region, Pain 2003: 106: 471-480

7. Greenspan JD, McGillis SL: Thresholds for the perception of pressure, sharpness, and mechanically evoked cutaneous pain: effects of laterality and repeated testing. Somatosens Mot Res 11994: 311-7

8. Johansson H, Windhorst U, Djupsjobacka M, Passatore M: Chronic work-related Myalgia, Neuromuscular mechanisms behind work-related chronic muscle pain syndromes, University of Gavle, Umea, Sweden, 2003

9. Jones DJ, Kilgour RD, Comtois AS: Test-retest reliability of pressure pain threshold measurements of the upper limb and torso in young healthy women. J Pain. 2007: 8: 650-656

10. Kosek E, Ekholm J, Nordemar R : A comparison of pressure pain thresholds in different tissues and body regions. Long-term reliability of pressure algometry in healthy volunteers. Scand J Rehabil Med 1993: 25: 117-24

11. Lundberg U, Dohns IE, Melin B, Sandsjo L, Palmerud G, Kadefors R, Ekstrom M, Parr D: Psychophysiological stress responses, muscle tension, and neck and shoulder pain among supermarket cashiers. J Occup Health Psychol 1999: 4: 245-55

12. Luime JJ, Kuiper JI, Koes BW, Verhaar JA, Miedema HS, Burdorf A, Work-related risk factors for the incidence and recurrence of shoulder and neck complaints among nursing-home and elderly-care workers. Scand J Work Environ Health 2004: 30: 279-86

13. McCredie MR, Dite GS, Porter L, Maskiell J, Giles GG: Phillips KA, Redman S, Hopper JL. Prevalence of self-reported arm morbidity following treatment for breast cancer in the Australian Breast Cancer Family Study. Breast 2001: 10(6): 515-22

14. Mense S, Simons DG. Muscle pain Understanding is nature, diagnosis and treatment. Lippincott, Williams and Wilkins, Philadelphia 2001 pp 205-281

15. Miller P, Murphy S: Demonstrating the economic value of investments in health at work: not just a measurement problem. Occup Med 2006: 56: 3-5

16. Moore KE, Dalley AF: Clinically oriented Anatomy, 4th edition, Lippincott, Williams and Wilkins, Philadelphia 1999

17. Murphy PL, Sorock GS,Courtney TK, Webster BS, Leamon TB: Injury and illness in the American workplace: a comparison of data sources. Am J Ind Med 1996: 30: 130-41

18. Ozcan A, Tulum Z, Pinar L, Baskurt F: Comparison of pressure pain threshold, grip strength, dexterity and touch pressure of dominant and non- dominant hands within and between right-and left-handed subjects. J Korean Med Sci 2004: 19: 874-8

19. Pascarelli EF, Hsu YP: Understanding work-related upper extremity disorders: clinical findings in 485 computer users, musicians, and others, J Occup Rehabil 2001: 11(1): 1-21

20. Pauli P, Rau H, Zhuang P, Brody S, Birbaumer N. Effects of smoking on thermal pain threshold in deprived and minimally-deprived habitual smokers. Psychopharmacology 1993: 111(4): 472-6

21. Persson AL, Hansson GA, Kalliomaki A, Moritz U, Sjolund BH: Pressure pain thresholds and electromyographically defined muscular fatigue induced by a muscular endurance test in normal women. Clin J Pain 2000: 16 (2): 155-63

22. Petzke F, Harris RE, Williams DA, Clauw DJ, Gracely RH: Differences in unpleasantness induced by experimental pressure pain between patients with fibromyalgia and healthy controls. Eur J Pain 2005: 9: 325-35

23. Ratzon N, Schejter-Margalit T, Froom P: Time to return to work and surgeons' recommendations after carpal tunnel release. Occup Med 2006: 56: 46-50

24. Rice VJ, Nindl B, Pentikis JS: Dental Workers, Musculoskeletal Cumulative Trauma, and Carpal Tunnel Syndrome, Who is at Risk? A Pilot Study Int J Occup Saf Ergon 1996: 2(3): 218-233

25. Rising DW, Bennett BC, Hursh K, Plesh O: Reports of body pain in a dental student population. J Am Dent Assoc 2005: 136(1): 81-6

26. Travell J ,Simons D G, Myofascial pain and Dysfunction: The Trigger point manual , Volume 2 Williams and Wilkins, Baltimore,1999, pp 30-85

27. Westgaard RH, Winkel J: Guidelines for occupational musculoskeletal load as a basis for intervention: a critical review. Appl Ergon 1996: 27: 79-88

28. Vanderweeen L, Oostendorp RA, Vaes P, Duquet W: Pressure algometry in manual therapy, Man Ther 1996: 1: 258-265

29. Vatine JJ, Tsenter J, Nirel R : Experimental pressure pain in patients with complex regional pain syndrome, Type I (reflex sympathetic dystrophy). Am J Phys Med Rehabil 1998 77(5):382-7

30. Zaza C, Farewell VT: Musicians' playing-related musculoskeletal disorders: an examination of risk factors. Am J Ind Med 1997: 32(3): 292-300

List of Figures

Figure 2c: Day 3 Repeated measures of Pressure pain threshold values at 8 locations. The figure shows that 3 trials were repeated at each location. The standard deviation is shown for each trial.

Figure 2d: Day 4 Repeated measures of Pressure pain threshold values at 8 locations. The figure shows that 3 trials were repeated at each location. The standard deviation is shown for each trial.

Figure 3: The ratio between the 8 locations and the Grand Mean (1) over 4 days of testing. The mean PPT values expressed as a ratio of 3 trials obtained for each location over 4 consecutive days of testing. Values above and below "1" identifies the ratio between a location and the over all mean for that day.

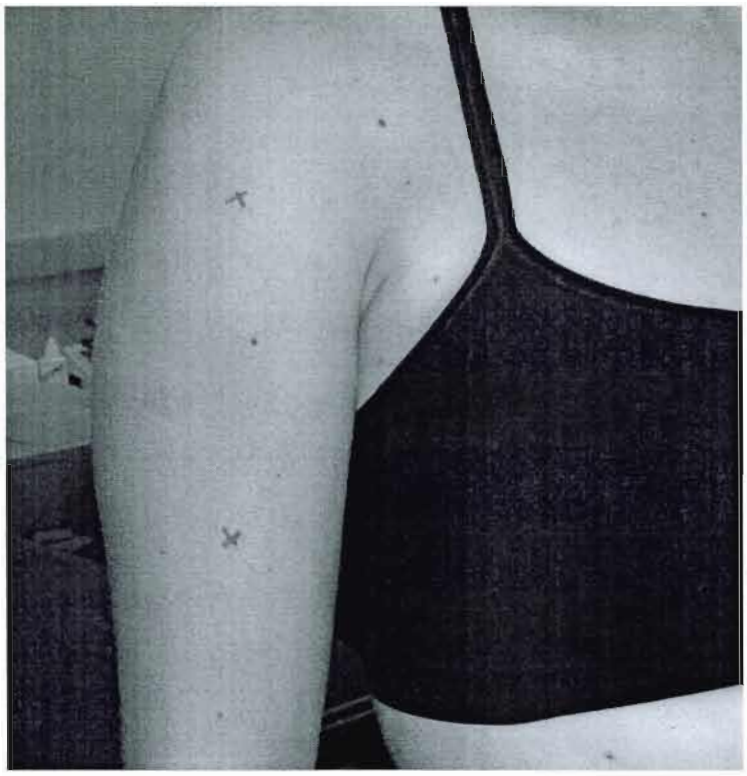

Figure 1A

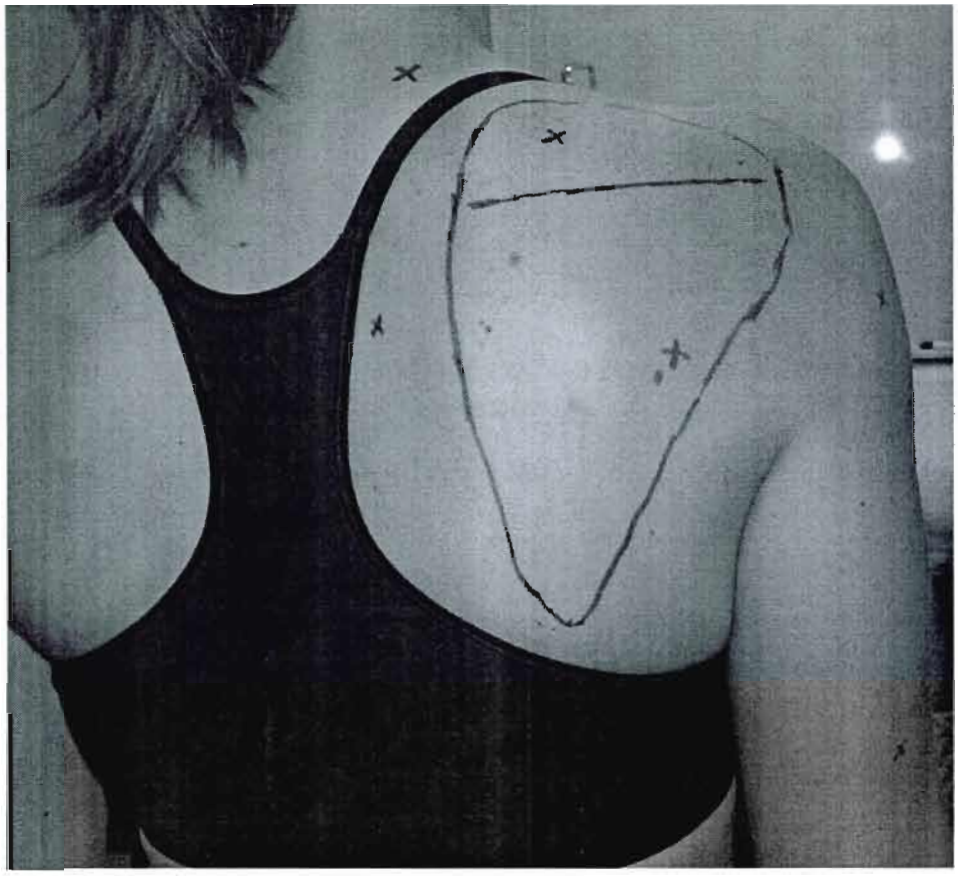

Figure 1B

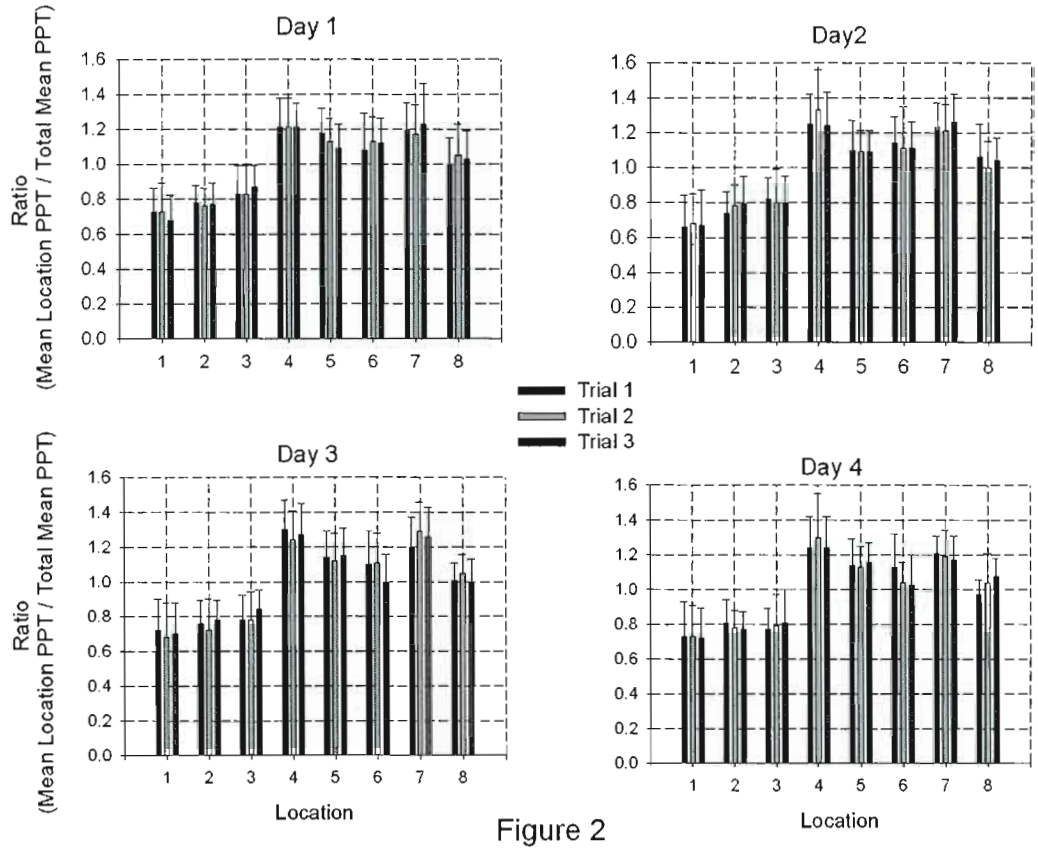
Day 1
Day2
Day 3
Day 4
Ratio
(Mean Location PPT / Total Mean PPT)
Location
Trial 1
Trial 2
Trial 3
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1 2 3 4 5 6 7 8

Figure 2

Figure 3: The ratio between the 8 locations and the Grand Mean (1) over 4 days of testing

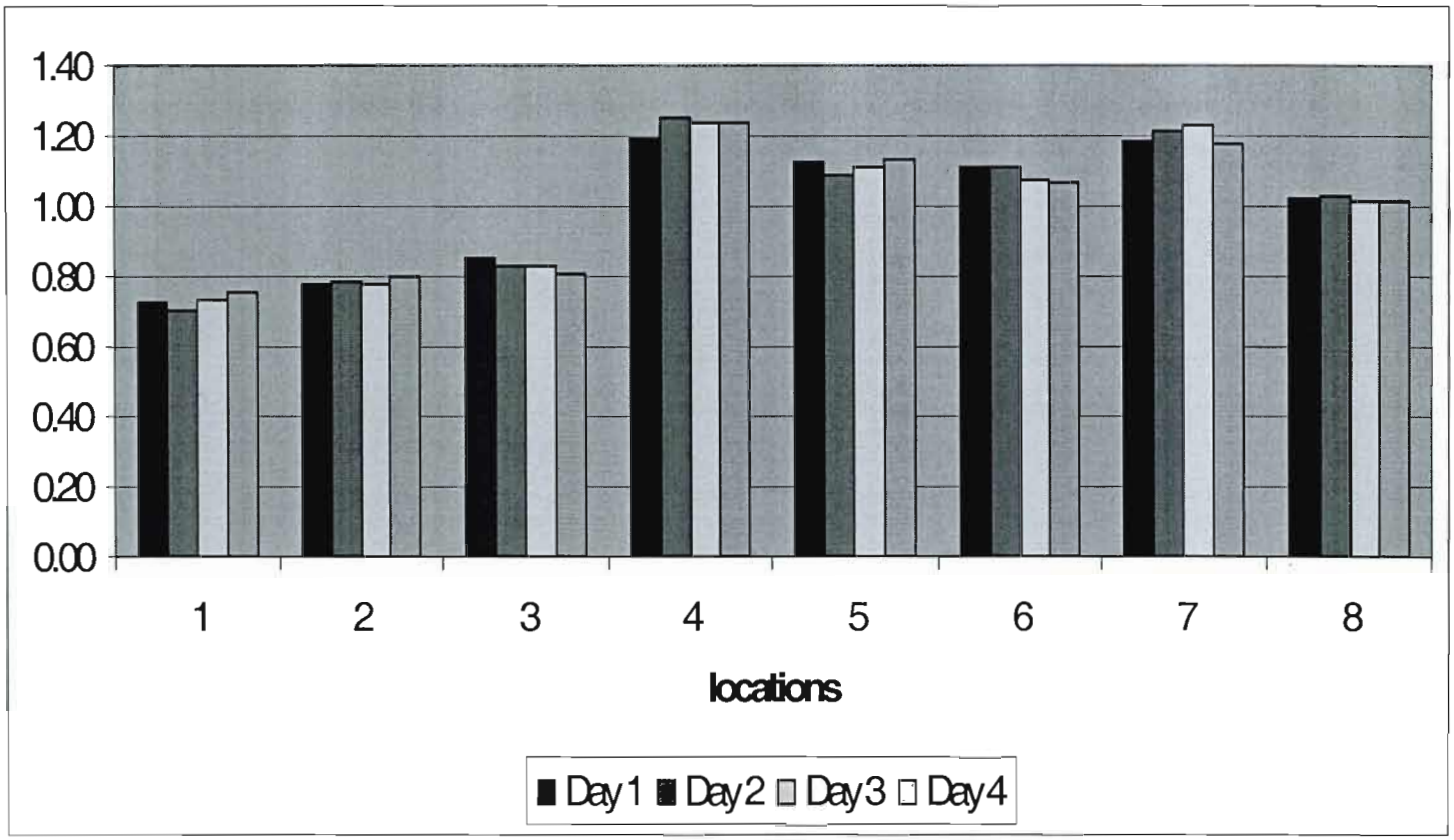

Table legend

Table 1: Mean PPT values of 8 locations over 4 days of testing: This table outlines the mean PPT values obtained at each location over the 4 days of testing. Underneath the table is the significant difference between locations on each day of testing.

Table 1 Mean PPT values of 8 locations over 4 days of testing

Location	Day 1 (x ± SD)	Day 2 (x ± SD)	Day 3 (x ± SD)	Day 4 (x ± SD)
Location 1	150.09 ± 77.15 *	123.37 ± 79.44*	123.61 ± 81.50 *	136.83 ± 81.60 *
Location 2	160.28 ± 72.39 *	138.00 ± 73.91 †	131.24 ± 76.81 *†	145.00 ± 77.29 *
Location 3	174.95 ± 73.40 *	146.46 ± 77.94 †	139.37 ± 80.42 †	146.33 ± 81.40 *
Location 4	246.53 ± 78.01 †	219.77 ± 75.97 ¥	208.27 ± 76.30 ¥	220.57 ± 78.51 †
Location 5	232.19 ± 77.77	191.21 ± 74.11	187.18 ± 73.55 £	201.67 ± 76.06 ¥
Location 6	228.79 ± 80.90 †	195.18 ± 75.18	180.78 ± 82.75 £ €	190.57 ± 80.92 €
Location 7	244.70 ± 78.34	213.56 ± 76.01	207.16 ± 79.93 ¥	210.36 ± 78.34 ¥
Location 8	211.18 ± 76.48 *	180.70 ± 72.34 €	171.57 ± 78.85 €	181.93 ± 72.16 €

Day 1

*Significantly Different from the 7 other locations (P=0.000 - P< 0.034)

†Significant Difference (P=0.045)

Day 2

* Significant difference across all 8 locations (P=0.000 - P= 0.023)

†Significant difference between all other locations (P=0.000- P= 0.027) no difference between location 2 and 3 (P= 0.112)

¥ Significant difference between all other locations (P=0.000- P= 0.003) no difference between location 7 (P=.259)

€ Significant difference between all other locations (P=0.000- P= 0.034) except locations 5(P=0.150) and location 6 (P=0.076)

Day 3

* Significant difference between all other locations (P=0.000 – P=0.031), no difference between location 1 and 2 (P=.229)

† Significant difference between all other locations (P=0.000- P=0.027) no difference between location 2 and 3 (P= 0.118)

¥ Significant difference between all other locations (P=0.000- P=0.003) no difference between location 4 and 7 (P=.754)

£ Significant difference between all other locations (P=0.000- P=0.022) no difference between location 5 and 6 (P=.342)

€ Significant difference between all other locations (P=0.000- P= 0.034) except between location 8 and 6 (P=0.109)

Day 4

* Significant difference between all other locations (P=0.000) no difference between location 1 and 2 (P= 0.123)

or location 1 and 3(P=0.156) or location 2 and 3 (P= 0.766)

† Significant difference between all other locations (P=0.000- P=0.018)

¥ Significant difference between all other locations (P=0.000- P=0.022) no difference between location 5 and 7 (P=0.175)

€ Significant difference between all other locations (P=0.000) except between location 8 and 6 (P=0.141)

CHAPTER V

RESULTS FROM ADDITIONAL QUESTIONS

5.01 Additional question 1: Relationship between skin fold values and PPT values

An analysis of variance was performed on the skin values collected at the 8 locations. The main effect showed that there was a significant difference in skin fold value between the 8 different sites (F= 10.29, p<0.05, critical F= 2.11), Table 1 Post hoc analysis showed a significant difference (0<0.05) between locations T1 and T2 on the one hand and all other testing locations except for T8 where T1-T8 (0.26) and T2-T8 (0.07).

Table 1: Skin-fold values of the 8 different locations

Location 1	Location 2	Location 3	Location 4	Location 5	Location 6	Location 7	Location 8	Mean of all sites
μ=9.73 ± 4.74	μ=8.94 ± 4.24	μ=17.38 ± 6.05 1, 2,3,4	μ=12.36 ±3.40 1,2	μ=15.20 ± 7.39 1,2,3	μ=13.76 ±4.05 1,2,3	μ=14.61 ± 3.84 1,2,3,4	μ=11.15 ± 4.41 1,2	μ=12.89 ± 3.79

ANOVA: F=10.29, critical F=2.11, P< 0.05

Post Hoc analysis

1 Significant difference from location 1(P< 0.05)

2 Significant difference from location 2(P< 0.05), note Post Hoc analysis between location 2 and location 8(p=0.07)

3 Significant difference from location 8(P< 0.05)

4 Significant difference from location 4(P< 0.05), note Post Hoc analysis between location 4 and location 5(p=0.08)

Location 2 on the anterior deltoid was found to have the lowest skin fold values with a mean of 8.94 and a SD± 3.60. Location 1 on the biceps was found to have the second lowest skin fold values with a mean of 9.73 and a SD± 4.02. Location 3 on the triceps was found to have the highest skin fold values with a mean of 17.38 and a SD± 5.14. The mean for all 8 locations was 12.89.

An Analysis was performed on the relationship between all PPT values and all skin fold values. No statistical correlation was found between skin fold thickness and PPT values obtained at the same location as seen in figure 16. Locations 1 on the biceps and location 2 on the anterior deltoid recorded the lowest skin fold values along with some of the lowest PPT values. Location 3 on the triceps had the highest skin fold values but had some of the lowest PPT values. When location 3 is removed from the group analysis, again no correlation was found between the skin thickness of a location and the PPT of the same location.

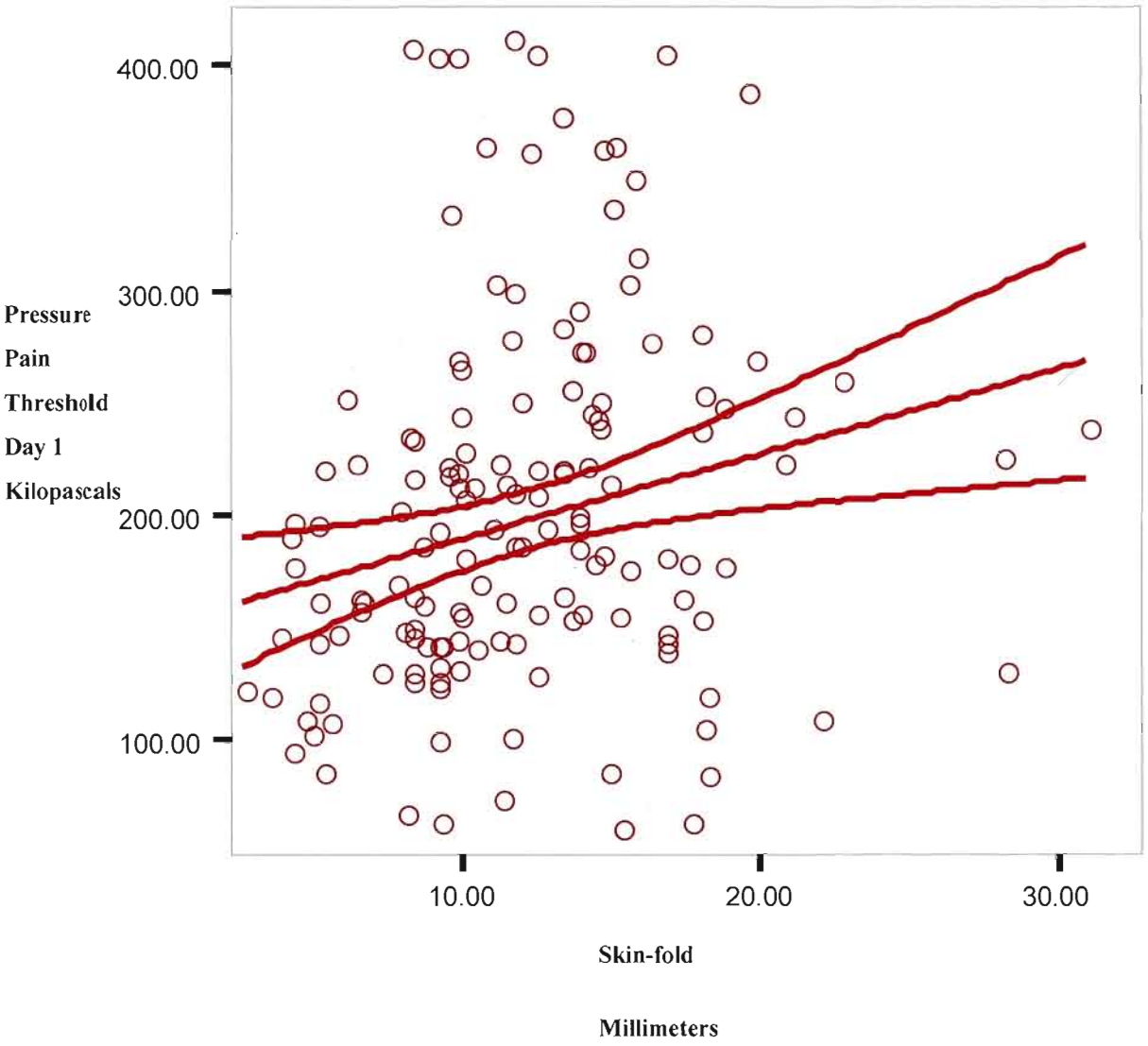

Figure16. PPT values correlated to skin fold values

Linear Regression with 95.00%Mean Prediction Interval

Pressure pain threshold of day 1 = 3.79(skin-fold) +157.27 * R-Square = 0.05

5.02 Additional question number 2: Consistency in determining nodule status

Table 2 shows the interclass correlation analysis that was performed on the agreement between the 2 athletic therapists on determining whether a nodule was present at the testing location for all 8 eight locations on all 19 subjects. The interclass correlation was 0.54, which is considered low but consistent with other studies of similar design (Shultz et al., 2006).

A comparison between the two athletic therapists was performed on the pre algometer- testing data and on the post algometer testing data. An Intraclass correlation was also done comparing what each athletic therapist's found pre algometer- testing and compared to what was found after completion of the algometer testing stage. We do recognize the possibility that the nodule status may change over the testing period.

Table 2 also lists the pre-test to post test ICC scores for each athletic therapist. The ICC scores for athletic therapist number 1, was 0.47 for her agreement between the pre-test nodule status and the post test nodule status. The ICC scores for athletic therapist number 2, was 0.36 for her agreement between the pre-test nodule status and the post test nodule status.

Table 2

The interclass correlation scores of the two athletic therapists, evaluating the nodule status at the 8 different locations.

Evaluation	ICC value	Critical F	Actual F
Both athletic Therapists pretest - post test score	0.537	2.156	1.634
Athletic Therapist 1 Pretest- post test score	0.465	1.868	1.530
Athletic Therapist 2 Pretest- post test score	0.357	1.552	0.095

ICC (p=0.05) 95% Confidence Interval

Figures 17 and 18 give a percent breakdown of the pre test and post test agreement between the two athletic therapists as to the nodule status. In figure 17, titled "Pre test agreement on nodule status at each location", location 2 anterior deltoid and location 8 the infraspinatus were found to have the highest levels of agreement (94.74 and 84.21%), location 5, the posterior deltoid, was found to have the lowest amount of agreement at 36.84. Location 5, the posterior deltoid, was also found to have the second highest skin fold value. This may have been a factor in the amount of disagreement found at this location. The other 5 locations varied from 57.89% to 68.42%. To verify this statement a correlation analysis will be performed between skin fold thickness and the interclass correlation between the athletic therapists in a follow up paper.

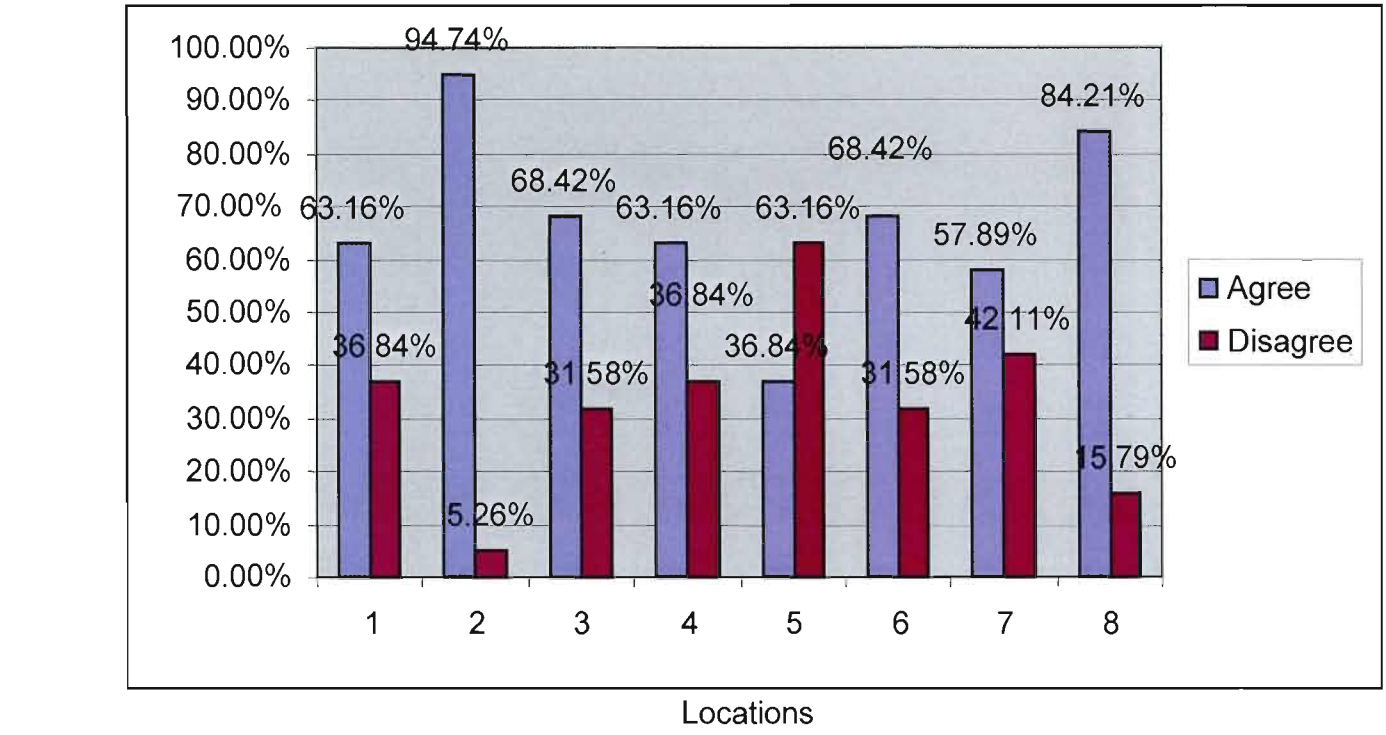

Figure 17. Pre test agreement on nodule atatus at each location

Figure18 shows the "Post agreement on nodule status at each location. There was some change between pre-test and post-test agreement. There was an increase in agreement across 6 of the 8 locations with the exceptions of locations 2, anterior deltoid, and 8, the infraspinatus, which showed a decrease in agreement levels. Location 2, anterior deltoid is still the location with the highest agreement between the 2 athletic therapists. The greatest change was observed at location 5, the posterior deltoid, where agreement changed from 36.84% to 64.71%. There was a small change at location 1 biceps brachii pre test to post test, 63.16% to 64.71%.

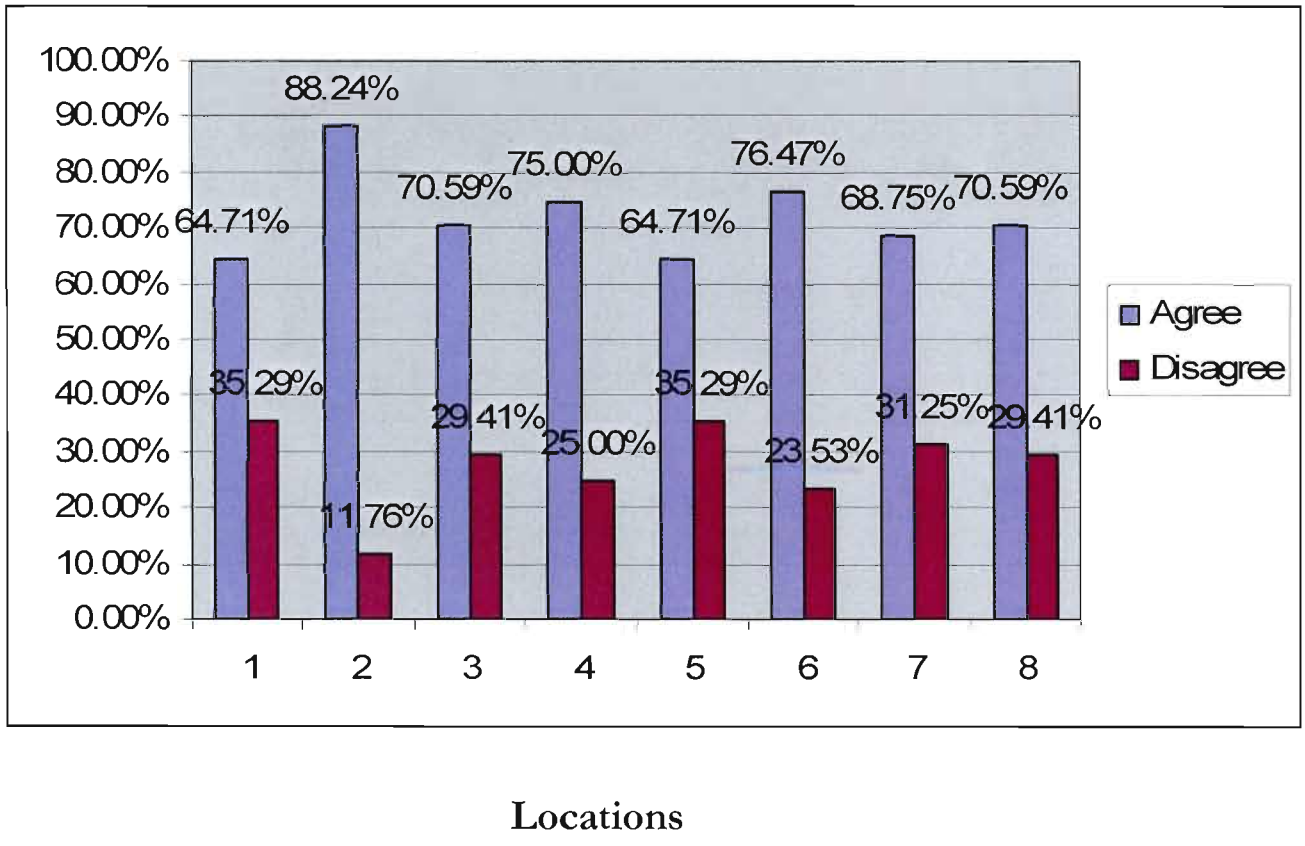

Figure 18. Post test agreements on nodule status at each location

Figure 18 shows the Pre-test to Post-test comparison of nodule status for athletic therapist number 1. Nodule status was defined as being either the presence or absence of a trigger point nodule at the testing location. Locations 1, bicep brachii and 2, anterior deltoid, had the highest levels of agreement at 82.35 and 94.12 respectively. Location 4, rhomboids major, had the lowest level of agreement at 50.00% Locations 3tricep brachii, 5 posterior deltoid, 6 supraspinatus, 7 trapezius and 8 the infraspinatus had agreement percent varying between 68.75 and 76.47%

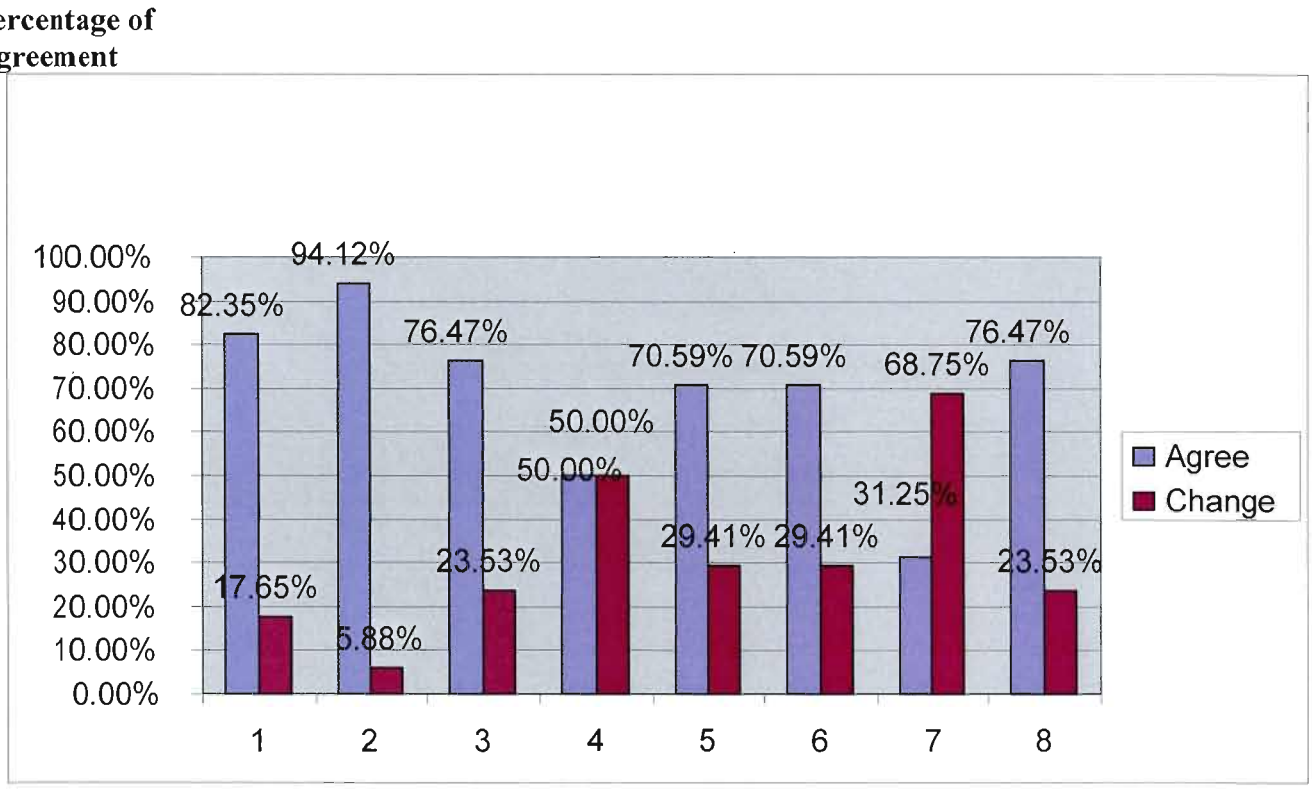

Figure 19. Pre-test to post-test comparison of nodule status for Athletic Therapist number 1

Figure 19 illustrates the pre-test to post-test comparison of nodule status for Athletic Therapist 1. Locations 1 biceps brachii and 2 anterior deltoid had the highest levels of agreement 82.35-94.12%, while location 4(rhomboids major) had the lowest level of agreement 50.00% Locations 3 triceps brachii, 5 posterior deltoid,6 supraspinatus, 7 trapezius and 8 the infraspinatus had agreement percent varying between 70.58 and 76.47%.

Figure 20 shows the pre-test to post-test comparison of nodule status for athletic therapist 2. Locations 1 biceps brachii and 2 anterior deltoid had the highest levels of agreement 94.12-100.00%, while location 3(posterior deltoid) had the lowest level of agreement52.94% Locations 4 rhomboid major, 5 posterior deltoid,6 supraspinatus, 7 trapezius and 8 the infraspinatus had agreement percent varying between 58.82 and 62.50%

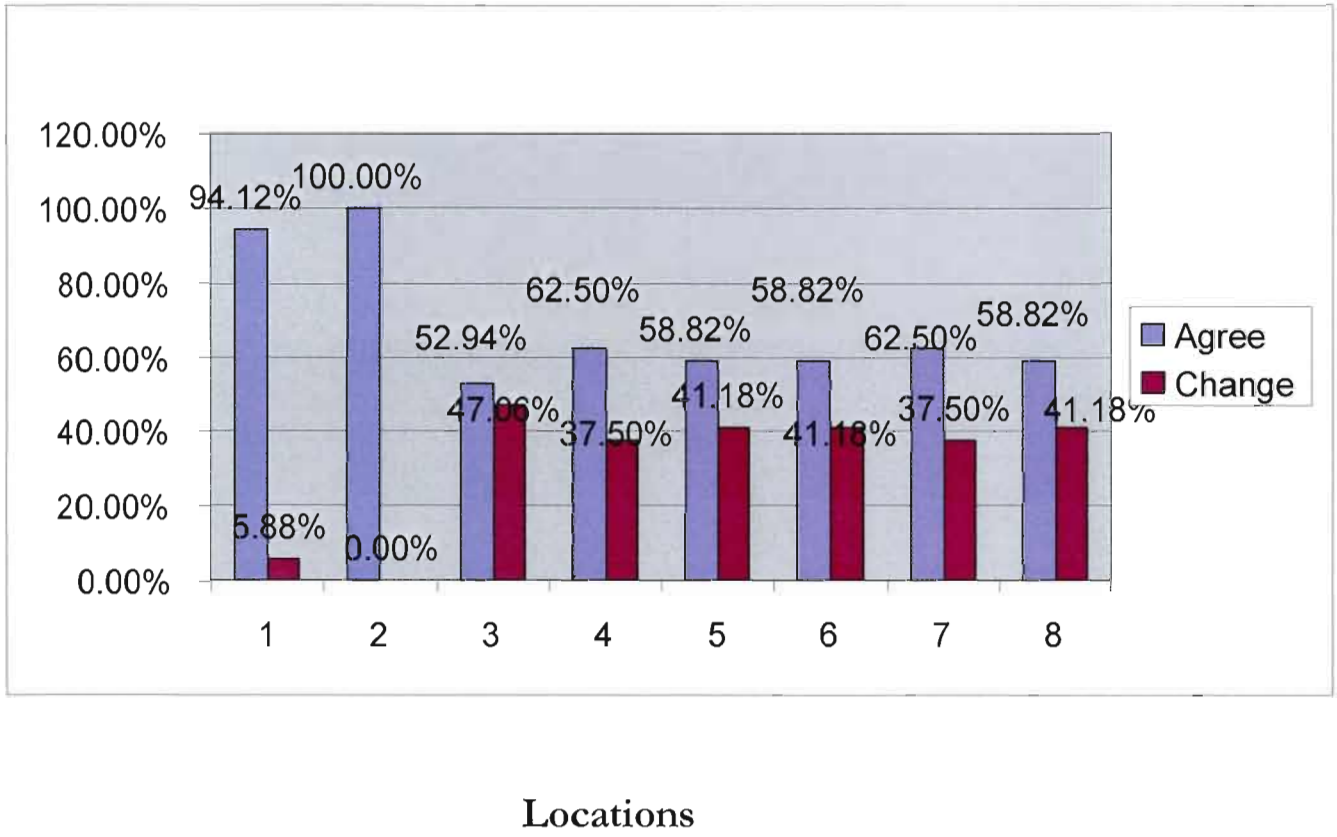

Figure 20. Pre-test to post-test comparison of nodule status for Athletic Therapist number # 2

5.03 Additional question number 3: Presence of a nodule and the pressure pain threshold values

Figures 21 and 22 give some qualitative information regarding the athletic therapists agreement on the presence or absence of a nodule at the 8 locations. In figure 21 locations 2, anterior deltoid, and 8, the infraspinatus, had the most agreement and location 5 the posterior deltoid had the most disagreement in regards to nodules at the locations. Locations 1 biceps brachii (12), 2 anterior deltoid (17), 6 supraspinatus (12) and 8 the infraspinatus (15) were suspected of having the greatest number of nodules. Location 3, triceps brachii (7) was found to have the fewest number of nodules presence.

In figure 22, looking at the post evaluation locations 1 biceps brachi (11), 2 anterior deltoid (15), 3, triceps brachii (10), 6, supraspinatus (10) and 8 the infraspinatus (10) were suspected of having the greatest number of nodules. Location 5 posterior deltoid (8) was found to have the fewest number of nodules presence.

The one location that both examiners agreed had a high probability of having a trigger point nodule also had one of the lowest PPT values, which was location number 2 on the

anterior deltoid. The location that was the least likely have a trigger point nodule was location 5- posterior deltoid and was also shown to have the second highest PPT values.

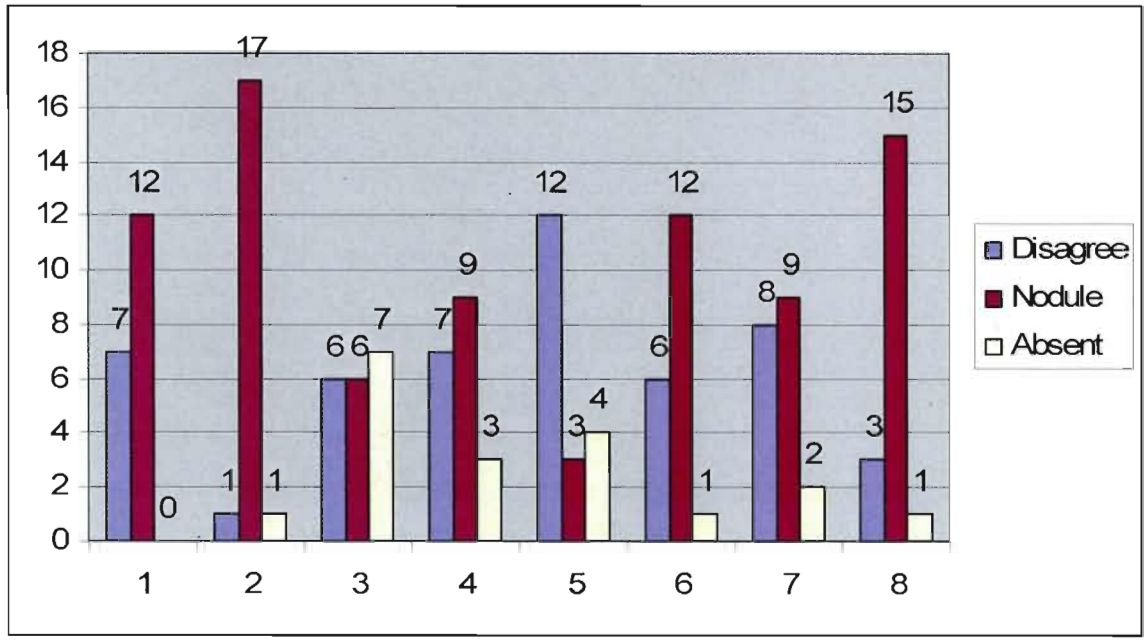

Figure 21. Pre-test evaluations of the 8 locations for nodule status

Series1 Disagreement between 2 athletic therapists on whether a nodule is present on or not present at the location

Series 2 Agreement between 2 athletic therapists that a nodule is present at the location

Series 3 Agreement between 2 athletic therapists that no nodule is present at the location

Number of nodules

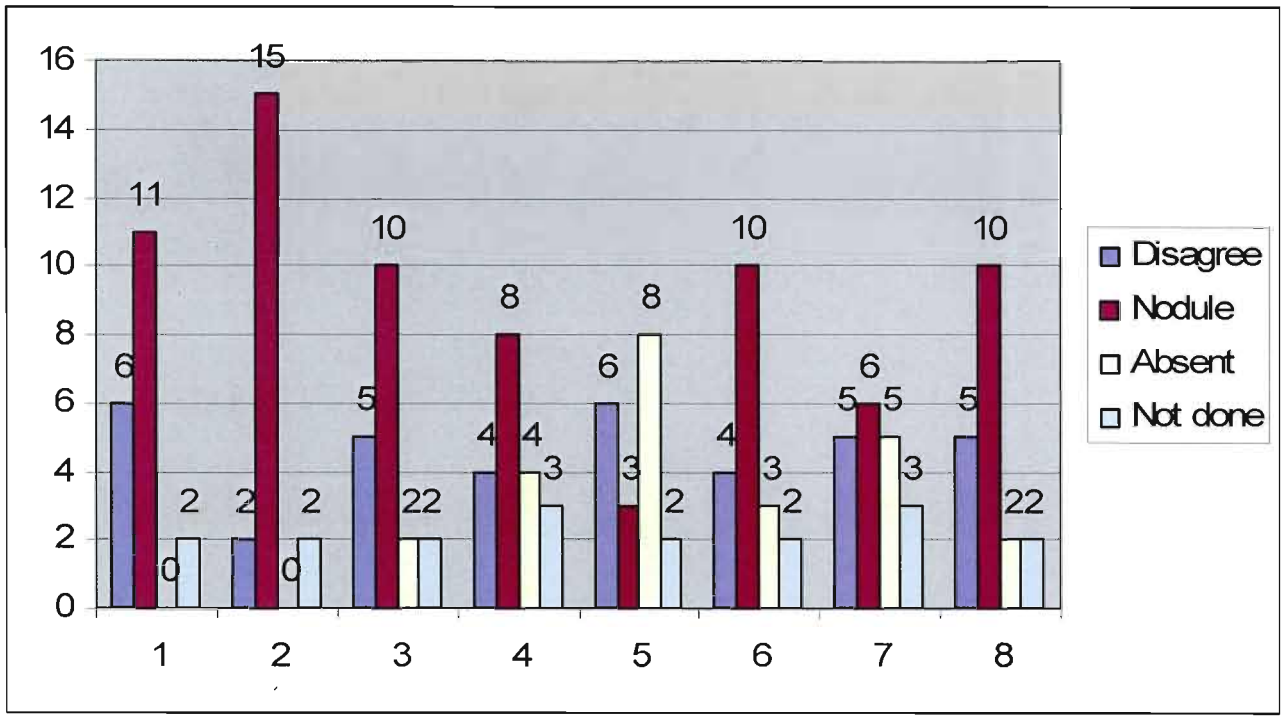

Figure 22. Post test evaluation of the 8 locations for nodule status

Series1 Disagreement between 2 athletic therapists on whether a nodule is present on or not present at the location

Series 2 Agreement between 2 athletic therapists that a nodule is present at the location

Series 3 Agreement between 2 athletic therapists that no nodule is present at the location

Series 4 Location was not tested

5.04 Additional question number 4: Variation in PPT values

Figures 22 through 24 show considerable variation between subjects in PPT values obtained at the lateral head of the triceps muscle (figure 23), trapezius (figure 24) and the infraspinatus (figure 25). The variation between subjects was present for all 8 locations over the 4 consecutive days of testing.

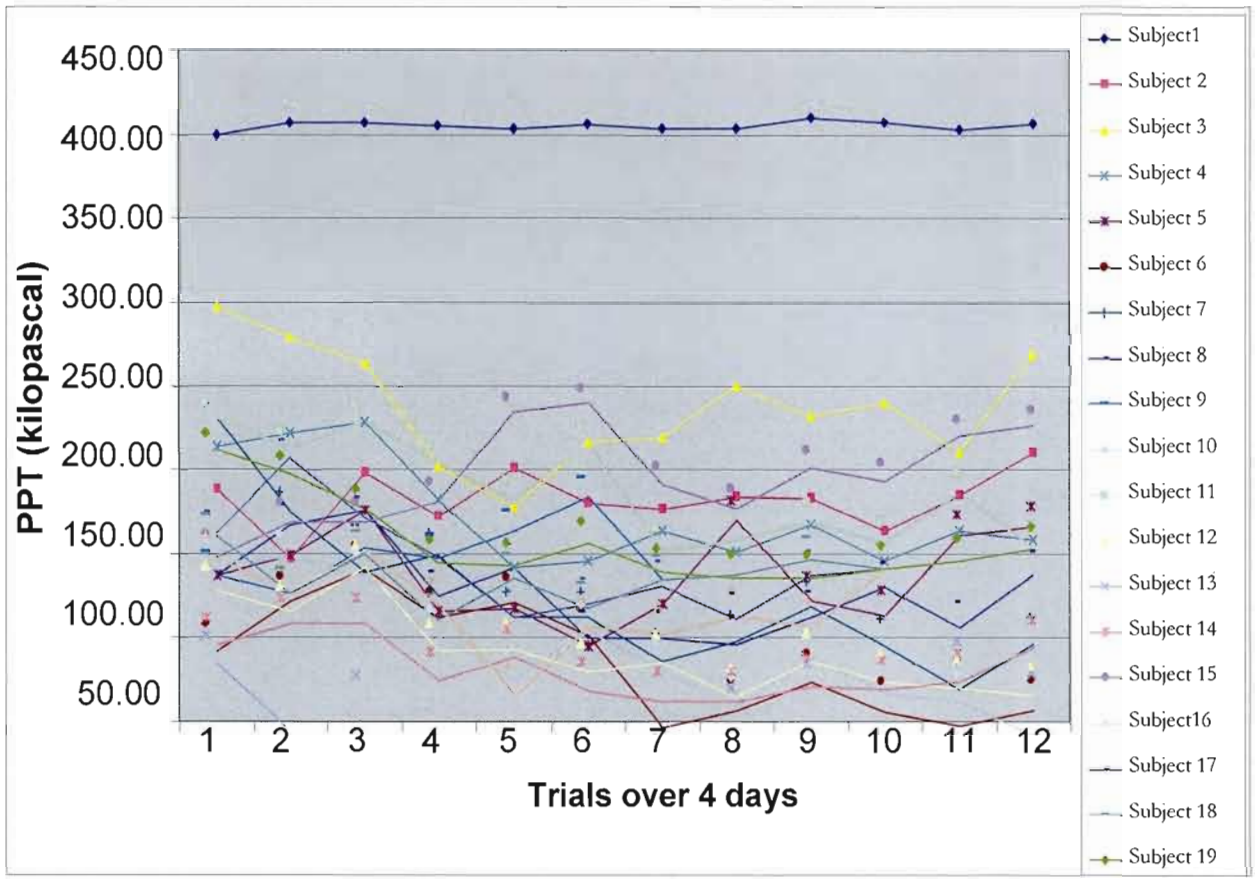

Figure 23. PPT values obtained at location 3, the triceps

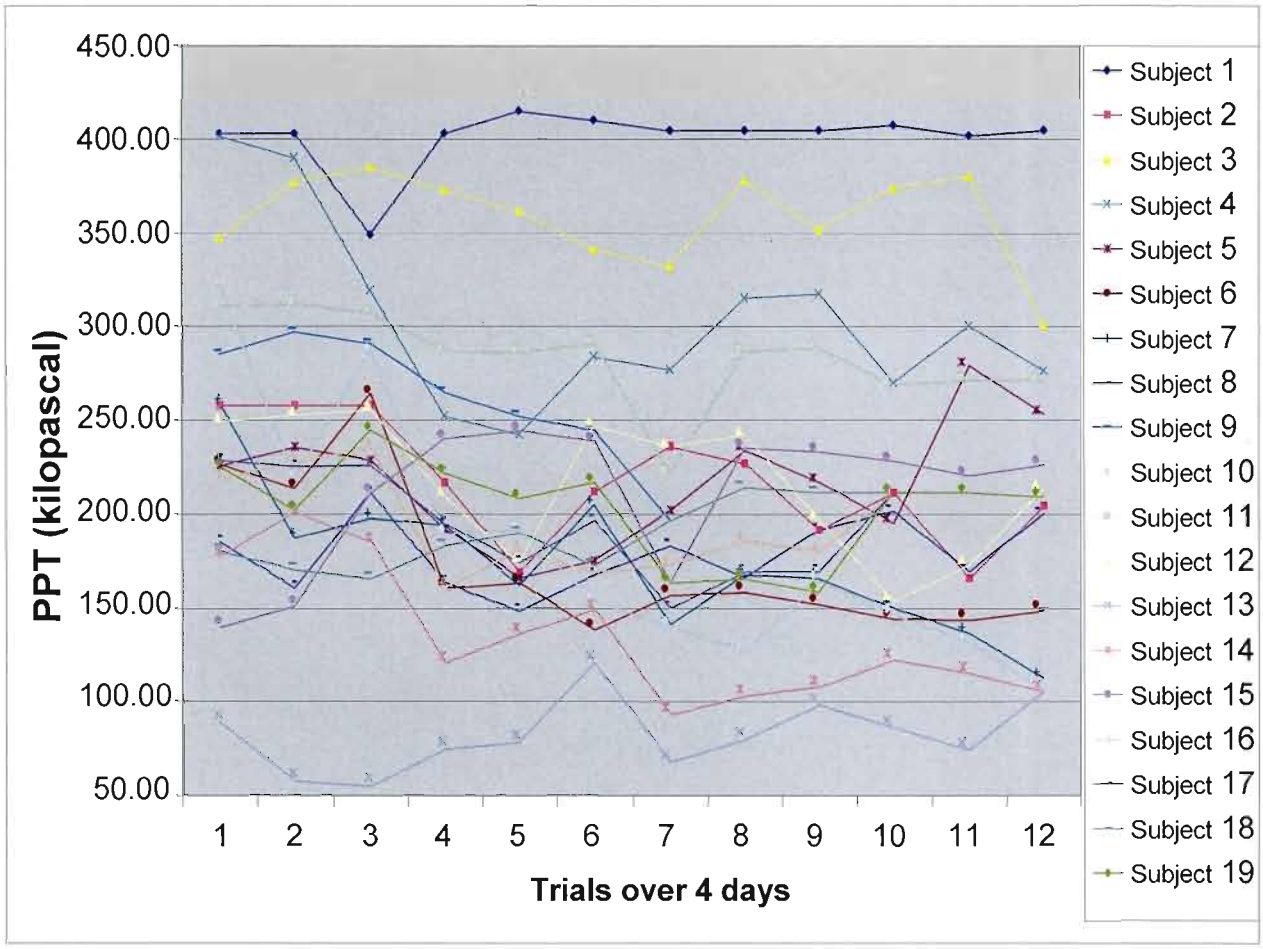

Figure 24. PPT values obtained at location 7, the trapezius

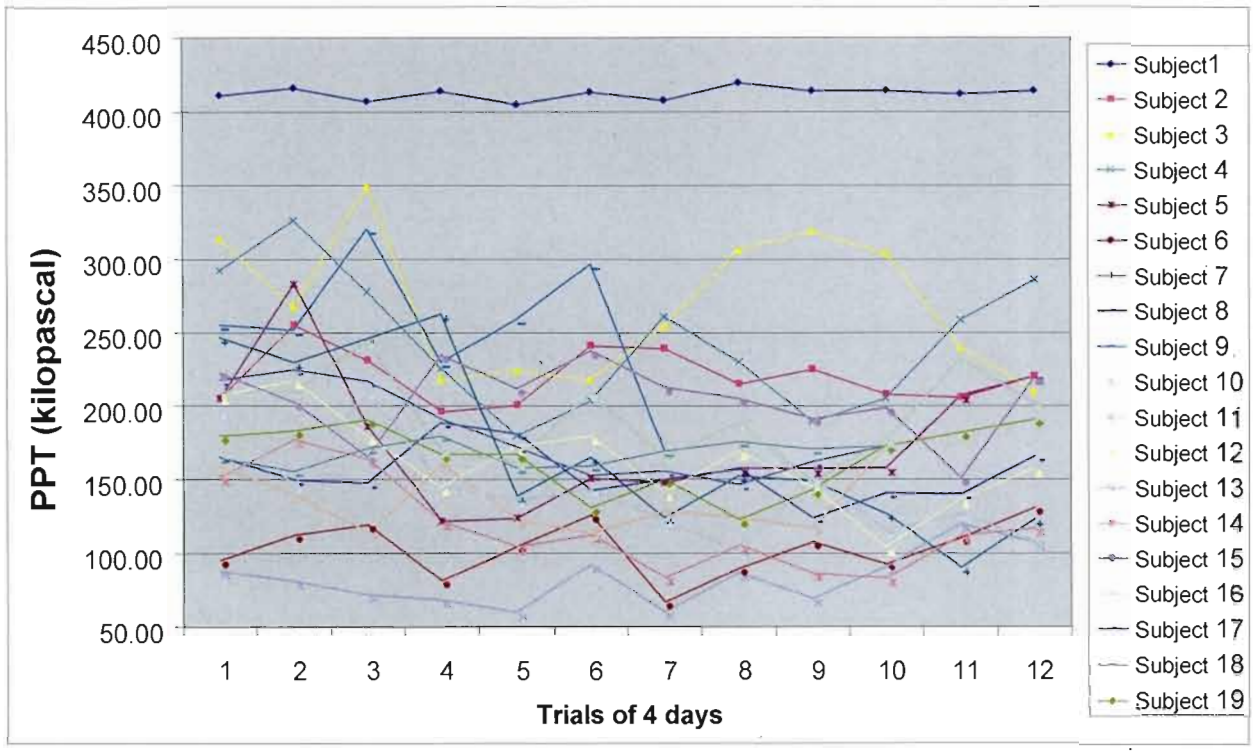

Figure 25. PPT values obtained at location 8, the infraspinatus

CHAPTER VI

DISCUSSION ON ADDITIONAL QUESTIONS

6.01 Additional question 1: **Relationship between skin fold values and PPT values**

It was expected that women with higher skin fold values (greater amounts of adipose tissue) would have higher PPT values and that women with lower skin fold values (lower amounts of adipose tissue) would have lower PPT values. This turned out to be not true. There appeared to be no correlation (Figure 16) between skin fold thicknesses at a location and how high or low were the associated PPT values.

An Analysis was performed on the relationship between all PPT values and all skin fold values. There was no statistical correlation between skin fold thickness and pressure pain threshold as seen in Figure16. When individual locations were evaluated, some of the locations came close to having a correlation. A good example of this was shown at locations 1, biceps brachii, and 2, anterior deltoid; both locations had some of the lowest recorded skin fold values along with some of the lowest PPT values. However, location 3 on the triceps had the highest skin fold values but had some of the lowest PPT values.

Even though this aspect of the project did not support our original hypothesis it is very useful information that other researchers may want to evaluate. There is an assumption (Glickman-Weiss et al., 1999), that the larger the amount of adipose tissue "the more padding" an individual has and the more likely he/she is able to tolerate greater levels of pain and discomfort. This theory appears to hold true when looking at how higher skin fold values help insulate an individual to tolerate colder climates (Glickman-Weiss et al., 1999; Prisby et al., 1999). This insulation effect does not appear to be factor when tolerating mechanical pressure; if it did, we would have seen higher PPT values closely correlated to higher skin fold measures. This did not take place. This information will be presented in greater detail in a research paper outlining the methodology and results on the relationship between PPT and skin fold.

One subject who did have a higher than average body mass index also had high PPT values. In fact, all PPT values were recorded at 400 kilopascals, which was our cut off point for the application of the algometer. It is possible that the subject's PPT values may have been much higher than what was registered. This individual appeared to have little variation in PPT values at the 8 locations and appeared to have a very high PPT. This subject had been previously in the Canadian military for several years, which may have been a contributing factor to her high PPT values.

6.02 Additional question 2: Consistency in determining nodule status

It was expected that there would be a high level of consistency between the two athletic therapists at determining whether a nodule was present or absent at each of the 8 different locations. Table 2: shows that the intertester correlation score between the two athletic therapists was 0.54, which is considered low (Shultz et al., 2006). The score is lower than (0.45-0.80) observed in other studies (Al-Shenqiti and Oldham, 2005; Shultz et al., 2006; Tunks et al., 1995) that have looked at the correlation between different clinicians' ability to locate structures using manual techniques, such as palpation. One significant difference between our study and many other studies (Al-Shenqiti and Oldham, 2005; Shultz et al., 2006; Tunks et al., 1995) is the subjects who are being evaluated. The subjects in our project were not experiencing any musculoskeletal problems at the time of testing. Subjects in other projects were patients being evaluated for musculoskeletal problems. Other studies did only try and feel for a nodule in the tissue (Al-Shenqiti and Oldham, 2005; Shultz et al., 2006) these studies also looked for a withdrawal response on the part of the subject, because of pain at the testing location.

A second thing that should be considered with the data from Table 2 is the restraints that were placed on the two athletic therapists. The subjects were not allowed to give either of the athletic therapists any verbal feedback while the palpation process was being performed. This is a more stringent protocol than in other studies (Al-Shenqiti and Oldham, 2005), where limited feedback by the subject was information therapists used to

determine nodule status. In this study no verbal feedback was given to the therapists by the subjects. This was done to avoid biasing the athletic therapists who were performing the evaluation.

In figure 17, titled "The pre test agreement on nodule status at each location", location 2, anterior deltoid, and location 8, the infraspinatus, were found to have the highest levels of agreement (94.74 and 84.21%), location 5 the posterior deltoid was found to have the lowest amount of agreement at 36.84%. Location 5 the posterior deltoid was also found to have the second highest skin fold value. The thickness in the location may have been a factor in the amount of disagreement found at this location. The other 5 locations varied from 57.89% to 68.42%.

In Figure18 titled "The post test agreement on nodule status at each location" we see the post agreement on nodule status at the 8 locations. There was some change between pre-test and post-test agreement. There was an increase in agreement across 6 of the 8 locations with the exceptions of locations 2, anterior deltoid, and 8, the infraspinatus, which showed a decrease in agreement levels. Location 2, anterior deltoid, was still the location with the highest agreement between the 2 athletic therapists. The greatest change took place at location 5, the posterior deltoid, where agreement changed from 36.84% to 64.71%. There was a small change at location 1, biceps brachi, pre test to post test,

63.16% to 64.71%. The overall improvement in agreement percentage maybe related to the athletic therapists starting to become more familiar with the locations being palpated on each subject.

Figures 19 and 20 looked at the pre-test to post-test agreement on nodule status for athletic therapist 1 and athletic therapist 2. It looked at whether the athletic therapist changed their opinion on whether a nodule was present at the location or whether it was absent. Subjectively looking at the 2 figures, it appears that athletic therapist 1 showed more consistency in determining nodule status compared to athletic therapist 2. This is because athletic therapist 1 did not have as much variation pre test to post test compared to athletic therapist 2.

The possible change in nodule status may have been related to the testing protocol of the project. The algometer was applied to each of the locations over 4 consecutive days. The repeated application of the algometer may have facilitated a change in the tissue of some of the subjects. Change may have been a reduction in a nodule that was present or the development of a nodule at the testing location where no nodule was previously present. This potential change would have influenced the results on the part of the Athletic Therapist.

Clinicians, who treat various forms of musculoskeletal disorders, place a significant emphasis on their ability to identify problem areas in soft tissue, such as being able to locate a nodule like structure associated with a trigger point. It is believed that the presence of a trigger point nodule may be contributing to the underlying problem of the patient. It is clear from the data collected from the two athletic therapists that actually knowing whether a nodule is present in the tissue is a challenge. Having verbal feedback from the patient, along with noting a withdrawal response would have made a significant difference in the interclass correlation scores (Scoitti et al., 2001).

The information collected on Interclass correlation and Intraclass correlation will comprise a separate paper, which will be of interest to clinicians.

6.03 Additional question 3: Presence of a nodule and PPT values

The third additional question that was asked concerned the relationship between the presence of a trigger point nodule and PPT values that would be obtained. It was hypothesised that locations where a trigger point nodule was found to be present that a lower PPT value would be obtained. This would be in comparison to a location where no trigger point nodule was located and a higher PPT value would be obtained.

Figures 21 and 22, gives some qualitative information regarding the athletic therapist's agreement on the presence or absence of a nodule at the 8 locations. In figure 21, locations 2, anterior deltoid, and location 8, infraspinatus, had the most agreement between the 2 athletic therapists while location 5, the posterior deltoid had the least amount of agreement in regards to the presence or absence of a trigger point nodule at the testing locations. Locations 1, biceps brachii (12), 2 anterior deltoid (17), 6 supraspinatus (12) and 8 infraspinatus (15) were suspected of having the greatest number of nodules. Location 3 triceps brachii (7) was found to have the fewest number of nodules presence.

In figure 22, looking at the post evaluation locations 1 biceps brachii (11), 2, anterior deltoid (15), 3, triceps brachii (10), 6, supraspinatus (10) and 8, infraspinatus (10), were suspected of having the greatest number of nodules. Location 5 posterior deltoid (8) was found to have the fewest number of nodules presence.

The one location that both examiners agreed had a high probability of having a trigger point nodule also had one of the lowest PPT values and this was location number 2 on the anterior deltoid. The location that was the least likely to have a trigger point nodule was location 5, posterior deltoid, and was also shown to have the second highest PPT values.

The information regarding nodule status and PPT will comprise a final paper.

6.04 Additional question 4: Variation in pressure pain threshold values

We hypothesised that the same location on different individuals would have different PPT values. This is consistent with the idea that PPT may be highly variable depending on the individual. This individual variation certainly adds to the challenge of evaluating pain. This information has been shown in other studies and gives the reader a better understanding of how subjective pain is to different people.

Figures 23 through to 25 give a graphic representation of the PPT of all 19 subjects at 3 of the 8 different locations over 4 consecutive days of testing. At least two observations may be readily noted from the 3 charts. The first observation is that subject number 1 had consistently high PPT values that were over 400 kilopascals for almost all of the recorded sessions. The subject rarely pressed the hand-held switch (red button in Figure 2) of the algometer to indicate her PPT had been reached. During the testing period, the data collector was frequently required to stop applying the algometer to the testing location because the 400 kilopascal mark had been reached on this subject. The 400 kilopascal mark was the predetermined point when the algometer was to be removed from the location to avoid tissue damage. It was important that this safeguard was in place and adhered by the data collector so as to protect the subjects from potential injury. It is actually unknown what the true PPT **is** for subject number 1.

There are some rare individuals who do not feel any pain. These subjects may go through their lives without experiencing any significant pain, which most of us experience to varying extents on a daily basis (Minde et al., 2004). These people have been found to be normal psychologically and physiologically but a genetic anomaly prevents them from feeling pain. These people have been known to walk around with major displaced fractures (tibia-fibula, etc.) and will feel more inconvenienced than uncomfortable (Minde et al 2006). Unfortunately these individuals end up dying at a rather young age (teenager to early twenties) often due to a major incident where a large volume of blood is lost and total system failure occurs (Danziger, Prkachin and Willer,2006; Minde et al., 2006).

The second observation concerning Figure 23 through 25 is that there was a lot of variation in the PPT values in 19 subjects, even though their may have been some similarity between individual subjects at certain locations, the values were different.

With the second observation, we expected to find variation in PPT values in the same location between each of the subjects. This does not take away from what we have outlined in Chapter IV, that different locations on the body have varying degrees of sensitivity, where some locations may be more sensitive than other locations. This does reinforce the fact that pain is a multidimensional problem and we have been able to

evaluate only one component. It is hoped that this information may be combined with other physiological, psychological, cultural and spiritual tools to address pain.

6.05 Conclusion and potential benefits of the project

Pain is a multi dimensional problem that afflicts large populations from many different disciplines. The goal of this project was to develop a diagnostic tool that may address one component of the problem with pain in the arm shoulder and neck regions. The hypothesis that the PPT values will vary in different locations has been shown to be valid. The unexpected finding in this project was the drop in an individual's PPT values from one day of testing to day two of testing. Taking both factors,1)the variation in PPT values between day 1 and day 2 and 2) the regional variation between testing locations, will allow the protocol to be used in the next stage of the project. The second stage being to work with women who are about to undergo breast surgery, related to breast cancer and to identify individuals who have greater predisposition to upper extremity problems, even though they are presently asymptomatic. We would expect variation at the 8 different testing locations. Locations on the upper arm and anterior shoulder will have lower PPT values, the posterior shoulder and posterior torso should have somewhat higher PPT values.

6.06 Precautions

In the medical field, diagnostic tools are used to identify pathologies so that appropriate treatment regimes maybe administered to people suffering from various disorders. Before you are able to effectively treat someone you should have an idea what it is you are treating.

The same tools that the medical profession use to help individuals may also be used by businesses and in particular, insurance companies for less than honourable reasons. This may include denying health insurance coverage to those who have had breast cancer or have been identified as having the BRAC1 or BRAC2 type gene.

This is certainly a problem in many countries including Canada.

Should we stop developing diagnostic tools to help reduce the suffering of patients? Definitely not, we need to continue to develop and implement ethical guidelines and the appropriate government regulatory bodies; to make sure that the misuse and abuse of diagnostic tools of does not occur.

BIBLIOGRAPHY

Al-Shenqiti AM and Oldham JA: Test-retest reliability of myofascial trigger point detection in patients with rotator cuff tendonitis. Clin Rehabil19:482-7, 2005

American college of Sports medicine: ACSM's guidelines for exercise testing and prescription seventh edition. Lippincot Williams and Wilkins, Philadelphia, 2006, pp 55-63

Antonaci F, Sand T and Lucas GA: Pressure algometry in healthy subjects: inter-examiner variability. Scand J Rehabil Med 30:3-8, 1998

Arnaud S, Houvenaeghel G, Moutardier V, Butarelli M, Martino M, Tallet A, Braud AC, Jacquemier J, Julian-Reynier C, Brenot-Rossi I : Patients' and surgeons' perspectives on axillary surgery for breast cancer. Eur J Surg Oncol 30:735-43, 2004

Atkins CJ, Zielinski A, Klinkhoff AV, Chalmers A, Wade J, Williams D, Schulzer M, Della Cioppa G An electronic method for measuring joint tenderness in rheumatoid arthritis. Arthritis Rheum 35(4):407-10, 1992

Bajaj P, Arendt-Neilson L, Bajaj P and Madsen H: Sensory changes during the ovulatory phase of the menstrual cycle of healthy females Europ J Pain 5:135-144, 2001

Baker SJ, Kelly NM and Eston RG: Pressure pain tolerance at different sites on the quadriceps femoris prior to and following eccentric exercise. Eur J Pain.1:229-33, 1997

Bendz I, Fagevik Olsen M: Evaluation of immediate versus delayed shoulder exercises after breast cancer surgery including lymph node dissection--a randomised controlled trial. Breast: 11(3):241-8, 2002

Brandt LP, Andersen JH, Lassen CF, Kryger A, Overgaard E, Vilstrup I and Mikkelsen S: Neck and shoulder symptoms and disorders among Danish computer workers. Scand J Work Environ Health. Oct; 30(5):399-409, 2004

Bunn WB 3rd, Baver RS, Ehni TK, Stowers AD, Taylor DD, Holloway AM, Duong D, Pikelny DB and Sotolongo D: Impact of a musculoskeletal disability management program on medical costs and productivity in a large manufacturing company. Am J Manag Care 12: SP27-32, 2006

Cella D, Land SR, Chang CH, Day R, Costantino JP, Wolmark N, Ganz PA: Symptom measurement in the Breast Cancer Prevention Trial (BCPT) (P-1): psychometric properties of a new measure of symptoms for midlife women. Breast Cancer Res Treat 13, 2007

Chen JT, Chen SM, Kuan TS, Chung KC, Hong CZ: Phentolamine effect on the spontaneous electrical activity of active loci in a myofascial trigger spot of rabbit skeletal muscle. Arch Phys Med Rehabil 79(7):790-4, 1998

Chesterton LS, Barlas P, Foster NE, Baxter GD and Wright CC: Gender differences in pressure pain threshold in healthy humans. Pain. 101:259-66, 2003

Chesterton LS, Foster NE, Wright CC, Baxter GD and Barlas P: Effects of TENS frequency, intensity and stimulation site parameter manipulation on pressure pain thresholds in healthy human subjects. Pain 106 (1-2):73-80, 2003

Danziger N, Prkachin KM and Willer JC: Is pain the price of empathy? The perception of others' pain in patients with congenital insensitivity to pain. Brain 129(Pt 9):2494-507, 2006

Davies C and Davies A: The Trigger point Therapy Workbook, Oakland, CA, New Harbinger, 2004, pp 57-103

Defrin R, Ronat A, Ravid A and Peretz C: Spatial summation of pressure pain: effect of body region, Pain.106 471-480, 2003

Dumontier C, Chaumeil G, Chassat R, Nourissat G : Arthroscopic treatment of dorsal wrist ganglia. Chir Main 25S1:S214-S220, 2006

Ellison LF, Gibbons L: Leading cancers--changes in five-year relative survival. Health Rep 15 (2):19-32, 2004

Falla D and Farina D: Muscle fiber conduction velocity of the upper trapezius muscle during dynamic contraction of the upper limb in patients with chronic neck pain. Pain 116(1-2):138-45, 2005

Farina D, Kallenberg LA, Merletti R and Hermens HJ: Effect of side dominance on myoelectric manifestations of muscle fatigue in the human upper trapezius muscle. Eur J Appl Physiol 90:480-8, 2003

Forsman M, Birch L and Zhang Q, Kadefors R: Motor unit recruitment in the trapezius muscle with special reference to coarse arm movements. J Electromyogr Kinesiol 11:207-16, 2001

Fredriksson K, Alfredsson L, Thorbjornsson CB, Punnett L, Toomingas A, Torgen M and Kilbom A: Risk factors for neck and shoulder disorders: a nested case-control study covering a 24-year period. Am J Ind Med 38: 516-28, 2000

Gajdos C, Tartter PI, Estabrook A, Gistrak MA, Jaffer S, Bleiweiss IJ: Relationship of clinical and pathologic response to neoadjuvant chemotherapy and outcome of locally advanced breast cancer. J Surg Oncol 80(1):4-11, 2002

Galeotti N, Ghelardini C, Grazioli I and Uslenghi C: Indomethacin, caffeine and prochlorperazine alone and combined revert hyperalgesia in vivo models of migraine. Pharmacol Res. 46: 245-50, 2002

Gardiner P: Neuromuscular aspects of Physical Activity, Human Kinetics, Windsor, Ontario pp 37-82, 2001

Garell PC, McGillis SL and Greenspan JD: Mechanical response properties of nociceptors innervating feline hairy skin. J Neurophysiol . 75:1177-89, 1996

Ge HY, Madeleine P and Arendt-Nielsen L: Gender differences in pain modulation evoked by repeated injections of glutamate into the human trapezius muscle. Pain.113 (1-2):134-40, 2005

Gerwin RD, Dommerholt J, Shah JP: An expansion of Simons' integrated hypothesis of trigger point formation. Curr Pain Headache Rep. 8:468-75, 2004

Giesecke T, Gracely RH, Grant MA, Nachemson A, Petzke F:Williams DA and Clauw DJ: Evidence of augmented central pain processing in idiopathic chronic low back pain. Arthritis Rheum 50:613-23, 2004

Giordano SH, Kuo YF, Freeman JL, Buchholz TA, Hortobagyi GN, Goodwin JS: Risk of cardiac death after adjuvant radiotherapy for breast, J Natl Cancer Inst 16;97(6):419-24,2005

Glickman-Weiss EL, Nelson AG, Hearon CM, Prisby R and Caine N: Thermal and metabolic responses of women with high fat versus low fat body composition during exposure to 5 and 27 degrees C for 120 min. Aviat Space Environ Med. 70:284-8, 1999

Greenspan JD and McGillis SL: Thresholds for the perception of pressure, sharpness, and mechanically evoked cutaneous pain: effects of laterality and repeated testing. Somatosens Mot Res. 11: 311-7, 1994

Guyton AC and Hall J.E.: Textbook of Medical Physiology, Tenth edition, W. B. Saunders Company, Philadelphia, 2000

Hägg G: Static work loads and occupational myalgia—a new explanation model. In: P.A. Anderson, D.J. Hobart and J.V. Danoff, Editors, Electromyographical Kinesiology, Elsevier Science, Amsterdam 141–143,1991

Harris JR, Lippman ME, Morrow M, Hellman S: Diseases of the Breast, Lippincott Raven, Philadelphia, 487-539,1996

Henneman E, Somjen G and Carpenter DO: Excitability and Inhibitability of motoneurons of different sizes, J Neurophysiol. 28(3):599-620 1965

Hooftman WE, van Poppel MN, van der Beek AJ, Bongers PM, van Mechelen W: Gender differences in the relations between work-related physical and psychosocial risk factors and musculoskeletal complaints. Scand J Work Environ Health. 30(4):261-78, 2004

Hou CR, Chung KC, Chen JT, Hong CZ: Effects of a calcium channel blocker on electrical activity in myofascial trigger spots of rabbits. Am J Phys Med Rehabil: 81:342-9, 2002

Itoh K, Okada K and Kawakita K: A proposed experimental model of myofascial trigger points in human muscle after slow eccentric exercise Acupunct Med. 22(1):2-12, 2004

Jatoi I and Miller AB: Why is breast-cancer mortality declining? Lancet Oncol (4):251-4, 2003

Johansson H, Windhorst U, Djupsjobacka M and Passatore M: Chronic work-related Myalgia; Neuromuscular mechanisms behind work-related chronic muscle pain syndromes, University of Gavle, Umea, Sweden, 2003

Karlqvist L, Leijon O, Harenstam A: Physical demands in working life and individual physical capacity. Eur J Appl Physiol 89(6):536-47, 2003

Kendall F, McCreary E, Provance P, Rodgers M and Romani W: Muscle Testing and function with posture and pain, 5th edition, Lippincott Williams and Wilkins, pp 51-117, 2005

Kilgour RD, Jones DH and Keyserlingk JR: Effectiveness of a self-administered, home-based exercise rehabilitation program for women following a modified radical mastectomy and axillary node dissection – a preliminary study. Breast Cancer Res Treat, (11), 2007

Kitahara T, Schnoz M, Laubli T and Wellig P, Krueger H: Motor-unit activity in the trapezius muscle during rest, while inputting data, and during fast finger tapping. Eur J Appl Physiol 83:181-9, 2000

Kosek E, Ekholm J and Nordemar R : A comparison of pressure pain thresholds in different tissues and body regions. Long-term reliability of pressure algometry in healthy volunteers. Scand J Rehabil Med 25: 117-24, 1993

Kosek E and Ordeberg G: Lack of pressure pain modulation by hetertopic noxious conditioning stimulation in patients with osteoarthritis, before but not following surgical pain relief. Pain 88: 69-78, 2000

Kuan TS, Chen JT, Chen SM, Chien CH, Hong CZ: Effect of botulinum toxin on endplate noise in myofascial trigger spots of rabbit skeletal muscle. Am J Phys Med Rehabil 81(7):512-20, 2002

Larsson L and Ansved T: Effects of age on the motor unit. A study on single motor units in the rat. Ann N Y Acad Sci 515:303-13, 1985

Lee TS, Kilbreath SL, Refshauge KM, Pendlebury SC, Beith JM, Lee MJ: Quality of life of women treated with radiotherapy for breast cancer. Support Care Cancer Sep 18, 2007

Leidenius M, Leppänen E, Krogerus L, von Smitten K: Motion restriction and axillary web syndrome after sentinel node biopsy and axillary clearance in breast cancer. Am J Surg; 185(2):127-30, 2003

Lindman R, Eriksson A and Thornell LE: Fiber type composition of the human male trapezius muscle: enzyme-histochemical characteristics. Am J Anat 189:236-44, 1990

Lindman R, Eriksson A and Thornell LE: Fiber type composition of the human female trapezius muscle: enzyme-histochemical characteristics. Am J Anat 190:385-92, 1991

Lindman R, Hagberg M, Angqvist KA, Soderlund K, Hultman E and Thornell LE: Changes in muscle morphology in chronic trapezius myalgia. Scand J Work Environ Health 17:347-55, 1991

Lundberg U, Dohns IE, Melin B, Sandsjo L, Palmerud G, Kadefors R, Ekstrom M and Parr D: Psychophysiological stress responses, muscle tension, and neck and shoulder pain among supermarket cashiers. J Occup Health Psychol 4: 245-55, 1999

Luime JJ, Kuiper JI, Koes BW, Verhaar JA, Miedema HS and Burdorf A, Work-related risk factors for the incidence and recurrence of shoulder and neck complaints among nursing-home and elderly-care workers. Scand J Work Environ Health: 30(4):279-86, 2004

Maihofner C, Forster C, Birklein F, Neundorfer B and Handwerker HO : Brain processing during mechanical hyperalgesia in complex regional pain syndrome: a functional MRI study. Pain 114:93-103, 2005

Maquet D, Croisier JL, Demoulin C and Crielaard JM: Pressure pain thresholds of tender point sites in patients with fibromyalgia and in healthy controls. Eur J Pain 8:111-7, 2005

Maunsell E, Brisson J and Deschenes L: Arm problems and psychological distress after surgery for breast cancer. Can J Surg; 36 (4): 315 - 320, 1993

McCredie MR, Dite GS, Porter L, Maskiell J, Giles GG: Phillips KA, Redman S and Hopper JL: Prevalence of self-reported arm morbidity following treatment for breast cancer in the Australian Breast Cancer Family Study. Breast 10(6):515-22, 2001

Mcgee DJ: Orthopaedic physical assessment, Fourth edition. Saunders, Philadelphia, Penn 2002, pp 207-234

Mcgee D, Zachazewski JE, Quillen W: Scientific Foundations and Principles of Practice in Musculoskeletal Rehabilitation. Saunders Elsevier, St Louis, MI 2007, pp 2-3

McPartland JM: Travell trigger points--molecular and osteopathic perspectives. J Am Osteopath Assoc 104:244-9, 2004

Melchior M, Imbernon E and Goldberg M: Epidemiologic surveillance of upper-extremity musculoskeletal disorders in the working population. Arthritis Rheum 55:765-78, 2006

Mense S and Simons DG: Muscle pain; Understanding is Nature, Diagnosis and Treatment. Lippincott, Williams and Wilkins, Philadelphia 2001 pp 205-281

Messing K and Kilbom A: Standing and very slow walking foot pain-pressure threshold, subjective pain experience and work activity. Appl Ergo 32: 81-90, 2001

Messing K, Punnett L, Bond M, Alexanderson K, Pyle J, Zahm S, Wegman D, Stock SR and de Grosbois S.: Be the fairest of them all: Challenges and recommendations for the treatment of gender in occupational health research. Am J Ind Med 43(6): 618-29, 2003

Miller AB, To T, Baines CJ, Wall C: The Canadian National Breast Screening Study-1: Breast cancer mortality after 11 to 16 years of follow-up. A randomized screening trial of mammography in women age 40 to 49 years. Ann Intern Med 3:137(5 Part 1):I28, 2002

Minde J, Toolanen G, Andersson T, Nennesmo I, Remahl IN and Svensson O, Solders G: Familial insensitivity to pain (HSAN V) and a mutation in the NGFB gene. A neurophysiological and pathological study. Muscle Nerve 30:752-60, 2004

Minde J, Svensson O, Holmberg M, Solders G and Toolanen G: Orthopedic aspects of familial insensitivity to pain due to a novel nerve growth factor beta mutation. Acta Orthop 77 (2):198-202, 2006

Nie H, Arendt-Nielsen L, Andersen H and Graven-Nielsen T: Temporal summation of pain evoked by mechanical stimulation in deep and superficial tissue. J Pain 6: 348-55, 2005

Nussbaum EL and Downes L: Reliability of clinical pressure-pain algometric measurements obtained on consecutive days. Phys Ther 78:160-9, 1998

Ozcan A, Tulum Z, Pinar L and Baskurt F: Comparison of pressure pain threshold, grip strength, dexterity and touch pressure of dominant and non- dominant hands within and between right-and left-handed subjects. J Korean Med Sci 19: 874-8, 2004

Pascarelli EF and Hsu YP: Understanding work-related upper extremity disorders: clinical findings in 485 computer users, musicians, and others, J Occup Rehabil 11(1):1-21, 2001

Pauli P, Rau H, Zhuang P, Brody S and Birbaumer N. Effects of smoking on thermal pain threshold in deprived and minimally-deprived habitual smokers. Psychopharmacology 111(4):472-6, 1993

Pilegaard M, Jensen BR, Sjogaard G and Sogaard K: Consistency of motor-unit identification during force-varying static contractions. Eur J Appl Physiol 83:231-4, 2000

Persson AL, Hansson GA, Kalliomaki A, Moritz U and Sjolund BH: Pressure pain thresholds and electromyographically defined muscular fatigue induced by a muscular endurance test in normal women. Clin J Pain 16(2):155-63, 2000

Persson AL, Brogargh C and Sjolund BH: Tender or not Tender: Test –Retest repeatability of pressure pain thresholds in the Trapezius and the Deltoid muscles of healthy women. J Rehabil Med 36:17-27, 2004

Petzke F, Harris RE, Williams DA, Clauw DJ and Gracely RH: Differences in unpleasantness induced by experimental pressure pain between patients with fibromyalgia and healthy controls. Eur J Pain 9: 325-35, 2005

Prisby R, Glickman-Weiss EL, Nelson AG and Caine N: Thermal and metabolic responses of high and low fat women to cold water immersion. Aviat Space Environ Med 70:887-91, 1999

Punnett L and Wegman: Work-related musculoskeletal disorders: the epidemiological evidence and debate, J Electromyogr Kinesiol 14(1):13-23, 2004

Ratzon N, Schejter-Margalit T and Froom P: Time to return to work and surgeons' recommendations after carpal tunnel release. Occup Med 56:46-50, 2006

Rice VJ, Nindl B and Pentikis JS: Dental Workers, Musculoskeletal Cumulative Trauma, and Carpal Tunnel Syndrome, Who is at Risk? A Pilot Study Int J Occup Saf Ergon 2(3):218-233, 1996

Rising DW, Bennett BC, Hursh K and Plesh O: Reports of body pain in a dental student population. J Am Dent Assoc 136(1):81-6, 2005

Rolke R, Magerl W, Campbell KA, Schalber C, Caspari S, Birklein F and Treede RD : Quantitative sensory testing: a comprehensive protocol for clinical trials. Eur J Pain 10: 77-8, 2006

Ryall C, Coggon D, Peveler R, Reading I and Palmer KT A case-control study of risk factors for arm pain presenting to primary care services. Occup Med 56:137-43, 2006

Sand T, Zwart JA, Helde G and Bovim G: The reproducibility of cephalic pain pressure thresholds in control subjects and headache patients. Cephalalgia 17: 748-55, 1997

Sarlani E, Grace EG, Reynolds MA, and Greenspan JD: Sex differences in temporal summation of pain and after sensations following repetitive noxious mechanical stimulation. Pain 109:115-23, 2004

Sarlani E, Farooq N and Greenspan JD: Gender and laterality differences in thermosensation throughout the perceptible range. Pain 106:9-18, 2003

Sarlani E and Greenspan JD: Gender differences in temporal summation of mechanically evoked pain. Pain97:163-9, 2002

Scoitti VM, Mittack VL, Dimarco LM,Ford LM, Plezbert J, Santipadri E, Wigglesworth J and Ball K: Clinical precision of myofascial trigger point location in the trapezius muscle. Pain 93:259-266, 2001

Shultz SJ, Nguyen AD, Windley TC, Kulas AS, Botic TL and Beynnon BD: Intratester and intertester reliability of clinical measures of lower extremity anatomic characteristics: implications for multicenter studies. Clin J Sport Med 16:155-61, 2006

Sherman JJ, LeResche L, Mancl LA, Huggins K, Sage JC and Dworkin SF: Cyclic effects on experimental pain response in women with temporomandibular disorders. J Orofac

Pain 19:133-43,2005

Simons DG: Review of enigmatic MTrPs as a common cause of enigmatic musculoskeletal pain and dysfunction. J Electromyogr Kinesiol 14:95-107, 2004

Smith GS, Wellman HM, Sorock GS, Warner M, Courtney TK, Pransky GS and Fingerhut LA.: Injuries at work in the US adult population: contributions to the total injury burden. Am J Public Health 95:1213-9, 2005

Sorock GS and Courtney TK: Epidemiologic concerns for ergonomists: illustrations from the musculoskeletal disorder literature. Ergonomics 39:562-78, 1996

Stecco L: Fascia Manipulation for Musculoskeletal pain, Piccin, Padova, Italy, 2004, pp 13-31

Stohler CS and Ashton-Miller JA: Servo-controlled stepped and ramped mechanical tissue algometry. J Biomech 40:1635-40, 2007

Stohr T, Krause E and Selve N : Lacosamide displays potent antinociceptive effects in animal models for inflammatory pain. Eur J Pain 10: 241-9, 2006

Svendsen KB, Jensen TS, Hansen HJ and Bach FW: Sensory function and quality of life in patients with multiple sclerosis and pain. Pain114: 473-81, 2005

Swenson KK, Nissen MJ, Ceronsky C, Swenson L, Lee MW, Tuttle TM: Comparison of side effects between sentinel lymph node and axillary lymph node dissection for breast cancer. Ann Surg Oncol: 9(8):745-53, 2002

Takahashi K, Taguchi T, Itoh K, Okada K, Kawakita K and Mizumura K: Influence of surface anesthesia on the pressure pain threshold measured with different-sized probes. Somatosens Mot Res 2(4):299-305, 2005

Taylor KO: Morbidity associated with axillary surgery for breast cancer ANZ Journal of Surgery 74, 5: 314, 2004

Travell J and Simons D G, Myofascial pain and Dysfunction: The Trigger point manual, Volume 1 Williams and Wilkins, Baltimore, 1999, pp 30-85

Treede RD, Rolke R, Andrews K and Magerl W: Pain elicited by blunt pressure: neurobiological basis and clinical relevance. Pain 98: 235-40, 2002

Tunks E, McCain GA, Hart LE, Teasell RW, Goldsmith CH, Rollman GB, McDermid AJ and DeShane PJ: The reliability of examination for tenderness in patients with myofascial pain, chronic fibromyalgia and controls. J Rheumatol 22:944-52, 1995

Ugnat AM, Xie L, Morriss J, Semenciw R, Mao Y: Survival of women with breast cancer in Ottawa, Canada: variation with age, stage, histology, grade and treatment. Br J Cancer 22; 90:1138-43, 2004

van Amelsvoort LG, Spigt MG, Swaen GM and Kant I: Leisure time physical activity and sickness absenteeism; a prospective study. Occup Med 56:210-2, 2006

Vahabi M. Breast cancer screening methods: a review of the evidence. Health Care Women Int: 24(9):773-93, 2003

Vanderweeen L, Oostendorp RA, Vaes P and Duquet W: Pressure algometry in manual therapy, Man Ther 1:258-265,1996

Vezina N, Tierney D, Messing K: When is light work heavy? Components of the physical workload of sewing machine operators working at piecework rates. Appl Ergon Aug; 23(4):268-76, 1992

Wahlstrom J, Svensson J, Hagberg M and Johnson PW: Differences between work methods and gender in computer mouse use. Scand J Work Environ Health 26:390-7, 2000

Westgaard RH and Winkel J: Guidelines for occupational musculoskeletal load as a basis for intervention: a critical review. Appl Ergon Apr 27:79-88, 1996

Zakaria D, Robertson J, MacDermid J, Hartford K and Koval J: Work-related cumulative trauma disorders of the upper extremity: navigating the epidemiologic literature. Am J Ind Med 42:258-69, 2002

Zaza C and Farewell VT: Musicians' playing-related musculoskeletal disorders: an examination of risk factors. Am J Ind Med 32(3):292-300, 1997

Internet

www.breastcancer.org

http://images.google.ca/imgres?imgurl=http://www.bccancer.bc.ca/NR/rdonlyres/50A52E07-CA0E-4C98-8BD9-FB0968610EDC/18085/axillary_lymph_nodes3.jpg&imgrefurl=http://www.bccancer.bc.ca/HPI/CE/Nursing/breastcancer/treatmentoptions/surgery.htm&h=265&w=250&sz=45&hl=en&start=21&um=1&tbnid=nzL_recidL3yAM:&tbnh=112&tbnw=106&prev=/images%3Fq%3Daxillary%2Blymph%2Bnodes%26start%3D18%26ndsp%3D18%26svnum%3D10%26um%3D1%26hl%3Den%26client%3Dfirefox-a%26channel%3Ds%26rls%3Dorg.mozilla:en-US:official%26hs%3DzWw%26sa%3DN

Annex 1

Consentement de participation à un projet de recherche

Je, _____ , accepte de participer à un programme de recherche conjoint mené par l'Université du Québec à Montréal et l'université Concordia. Le projet de recherche est sous la supervision de Alain Comtois Ph.D., professeur régulier au département de Kinanthropologie à l'Université du Québec à Montréal et de Robert D. Kilgour, Ph.D., FACSM, professeur aggrégé au département de Exercise Science à l'université Concordia. L'équipe de recherche est composée de monsieur David Jones, étudiant à la maîtirse à l'Université du Québec à Montréal et Tracy Griffiths et Christina Grace qui sont deux thérapeutes du sport au département de Exercise Science à l'université Concordia.

A. Objectif

J'ai été informé que le but du projet de recherche est de déterminer la validité d'un appareil de mesure connu sous le nom d'algomètre mesurant les seuils de douleur à la pression de points gachettes situés à des endroits variés aux niveaux du cou, des épaules et des bras.

B. Procédures

Tous les tests utilisant l'algomètre seront menés au pavillon des sciences Richard J. Renaud situé au campus Loyala de l'université Concordia. Les procédures expérimentales se dérouleront comme suit :

Je devrai être disponible pour les évaluations durant une période de quatre jours consécutifs. La première journée prendra une heure de votre temps et ensuite 45 min par jour pour les autres journées. Donc, un total de près de 3½ heures sera requis de votre part.

1. Le premier jour des évaluations devra coïncider avec le dernier jour de mon cycle menstruel normal.

2. Lors de la première rencontre pour le projet, mon épaule droite sera examinée à l'aide de palpation par deux thérapeutes sportifs (Tracy Griffiths et Christina Grace) participant au projet. Chacune des thérapeutes effectuera une évaluation indépendante de mon épaule visant à identifier la présence d'un nodule possible aux sites potentiels des points gachettes. Par la suite, les thérapeutes se consulteront et marqueront 8 petits points (à l'aide d'un crayon feutre indélébile) sur et autour de mon épaule droite. Je ne devrai

pas enlever ces points d'encre durant les 4 jours d'évaluations. Des mesures concernant ma grandeur et mon poids seront aussi prises à cette première rencontre.

3. Au cours de cette même journée je vais rencontrer la personne en charge de la prise de données (Dave Jones). Je ne devrai pas discuter des données enregistrées avec cette personne ainsi qu'avec toutes les personnes impliquées dans cette étude.

4. La personne en charge de la prise de données appliquera un algomètre manuel sur les huit points marqués aux niveaux de mon cou, mon épaule et de mon bras du côté droit. L'algomètre mesurera les seuils de douleur à la pression sur les huit points marqués à l'encre. Je devrai aviser (à l'aide d'un interrupteur situé dans ma main) la personne en charge de la prise de données lorsque la pression appliquée changera de la sensation de pression à celle de douleur. Trois (3) séries de données seront enregistrées.

5. Je devrai prendre rendez-vous avec la personne en charge de la prise de données pour les trois journées subséquentes d'évaluation.

6. La première évaluation devrait durer environ 2 heures. Les évaluations suivantes dureront en moyenne 45 minutes. Chaque évaluation sera planifiée à l'avance et je devrai aviser les chercheurs à l'avance si je ne suis pas en mesure de participer à une de ces séances.

C. Risques reliés à la participation

Je pourrais ressentir de la douleur à un ou plusieurs des points marqués à la suite de l'application de l'algomètre. Au cours des tests physiques, je devrai effectuer la tâche jusqu'au moment où je jugerai que le niveau d'inconfort n'est plus tolérable.

D. Les bénéfices reliés à la participation

Les bénéfices de participer à ce projet de recherche se situent dans deux catégories : une personnelle et une collective.

a. À un niveau personnel, il existe peut-être un ou deux endroits autour de mon cou, épaule ou bras qui peuvent être identifiés comme étant hypersensible. Sachant que ces endroits sont sensibles et pourraient éventuellement devenir problématique m'aidera à mettre en place une stratégie préventive afin de réduire le potentiel de risque éventuelle au niveau de mon cou, épaule et bras.

b. À un niveau collectif, la douleur au cou, épaule et bras touche énormément de personnes issues de milieux différents. Les informations recueillies nous aiderons à valider l'efficacité de l'algomètre à évaluer la douleur dans la région du cou, des épaules et des bras. L'algomètre pourra ainsi être utilisé pour évaluer l'efficacité de différents types de traitement pour diminuer la douleur, tel que, par exemple, la réorganisation de poste de travail ou l'utilisation de la glace au niveau de l'épaule.

Il est clairement attendu que je participe à cette étude de façon purement volontaire et que je suis complètement libre de me retirer à n'importe quel moment de l'étude en cours sans me causer de préjudice défavorable.

Tous les renseignements recueillis durant cette étude sont strictement confidentiels et ne seront pas transmis d'aucunes façons à qui que ce soit sans mon autorisation écrite remise aux chercheurs responsable de l'étude. Par contre, ces informations pourront être utilisées afin d'avancer le niveau des connaissances scientifiques et pourront être publiées dans des revues scientifiques en s'assurant que mon anonymat soit maintenu.

E. Sujets

En tant que sujet, je suis une femme âgée entre 20 et 45 ans. Je n'ai connu aucunes complications au niveau de l'épaule durant les six derniers mois et à ma connaissance actuelle je n'ai pas d'autres problèmes médicaux qui m'empêcheraient de participer à cette étude. Je reconnais que le cycle menstruel affecte le seuil de détection de la pression à la douleur que nous allons mesurer et actuellement j'ai un cycle menstruel régulier qui dure entre 26 à 31 jours. Il est attendu que je ne prends pas de contraceptifs oraux. Il est aussi attendu que je ne consommerai pas de breuvage caféiné au moins une heure avant le début de l'expérimentation et il est aussi attendu que je vais m'abstenir de consommer un analgésique (ex., aspirin) au moins 8 heures avant le début de l'expérimentation.

F. Questions

Vous êtes totalement libre de poser des questions que vous jugez pertinentes. Toutes questions sur le projet de recherche, plaintes ou commentaires peuvent être adressés à tous les membres du personnel impliqué dans ce projet de recherche. De plus, vous êtes invité à demander des explications additionnelles si vous avez le moindre doute. Les responsables de la recherche sont Alain Comtois, directeur du projet de maîtrise, Robert D. Kilgour, co-directeur du projet de maîtrise et Dave Jones, étudiant à la maîtrise. Les

coordonnées respectives de ces trois personnes sont fournies à la fin de ce formulaire de consentement.

De plus, ce projet de recherche a reçu l'approbation du Comité d'éthique du Département de kinanthropologie et les coordonnées apparaissent au bas du présent formulaire de consentement.

Pour toutes questions touchant la responsabilité des chercheurs ou dans l'éventualité où la plainte ne peut leur être adressée directement, vous pouvez faire valoir votre situation auprès du sous-comité du Comité institutionnel d'éthique de la recherche chez l'humain (CIÉR) de l'UQÀM aux coordonnées apparaissant au bas du présent formulaire de consentement.

Je suis satisfait des explications reçues et j'ai lu attentivement la démarche de l'étude. J'ai pris connaissance des risques possibles de participer à cette recherche tel que décrite dans le présent formulaire de consentement et j'accepte de participer en tant que sujet dans ce projet de recherche intitulé : L'utilisation de l'algomètre sur les points gachettes de la région du cou, de l'épaule et du bras.

Date: _____ , _____ , 2005

(mois) (jour)

Nom: _____Signature: _____

(Lettres moulées)

Témoin: _____Signature: _____

(Lettres moulées)

Coordonnées :

Alain-S. Comtois, Ph.D. :numéro de téléphone : (514) 987-3000 poste 1506
adresse électronique : comtois.alain-steve@uqam.ca

Robert D. Kilgour, Ph.D.:numéro de téléphone : (514) 848 2424 extension 3322
adresse électronique : kilgour@alcor.concordia.ca

Dave Jones, B.Sc., CAT :numéro de téléphone : (514) 848 2424 poste 3318
adresse électronique : dhjones@vax2.concordia.ca

CIÉR de l'UQÀM :secrétariat du Comité : service de la recherche et de la création
Université du Québec à Montréal
C.P. 8888, succursale Centre-ville
Montréal, QC
H3C 3P8
Numéro de téléphone : (514) 987-3000 poste 7753
Adresse électronique : src@uqam.ca

Département de kinanthropologie :Université du Québec à Montréal
Case postale 8888, succursale Centre-ville
Montréal (Québec) Canada
H3C 3P8

Annex 2

Consent Form to Participate in Research

I, _____ , agree to participate in a joint program of research being conducted by the Université du Québec à Montréal and Concordia University. This research project will be supervised by Alain Comtois Ph.D., professeur régulier, in the Department of Kinanthropologie at Université du Québec à Montréal and by Robert D. Kilgour, Ph.D., FACSM, who is an Associate Professor in the Department of Exercise Science at Concordia University. The research team includes David Jones, a Graduate student at the Université du Québec à Montréal, Tracy Griffiths and Christina Grace both of whom are athletic therapists in the Department of Exercise Science at Concordia University. Completing the research is Ron Rehel M.Sc., from the Department of Exercise Science at Concordia University, who will act as the second data collector.

A. Purpose

I have been informed that the purpose of the research is to determine the validity of using a measuring devise know as an Algometer to assess pressure pain thresholds of different trigger point locations in the neck, the shoulder an arm regions.

B. Procedures

All tests using the Algometer will be conducted at the Richard J. Renaud, Science Pavilion on the Loyola Campus of Concordia University. The following summarizes the protocol of experimental procedures:

7. I will be asked to make myself available on four consecutive days of testing.

8. The very first day of testing will coincide within the last four days of my normal menstrual cycle.

9. At my first meeting for the project, my right shoulder will be palpated by two experienced athletic therapist (Tracy Griffiths and Christina Grace) who are members of the project. Each athletic therapist will be evaluating my shoulder on their own, looking for any nodule structures at potential trigger point locations. The two athletic therapists will then confer with each other and place a small ink mark on eight different locations in and around my right shoulder. I will be asked not to remove the ink mark over the 4 days of testing. Measurements of my height

and weight will also be recorded on this day.(The palpation of the trigger point locations, by the two athletic therapists, will be repeated within one day, after the completion of the last set of algometer measures.

10. On the same day I will then meet with the Data collector (Dave Jones). I will be asked not to discuss any of the recorded information with the Data collector. I will also be asked to not discuss my recorded information with any one else connected to the study.

11. The Data Collector will apply a hand held Algometer to eight different landmarks in and around neck shoulder and arm on the right side of my body. The Algometer will measure pressure pain thresholds at eight different landmarks. I will immediately indicate to the data collector (via a hand held switch) when the pressure from the Algometer changes from the sensation of only pressure to pressure/pain or pain. Three complete sets of data will be collected.

12. I will make arrangements to meet with the Data collector for the subsequent three days.

13. The first testing session is expected to last approximately 2 hours in total. Subsequent testing will require approximately 45 minutes of my time to complete. Each session will be scheduled in advance and I will advise the researchers in advance if I am unable to participate on the scheduled day.

14. Within 5 days of completion of testing, I will have a series of skin fold measures taken at the same trigger point locations. This will involve a skin fold calliper being applied to my skin surface. Two data collectors will be involved in this process. One data collector will fold the skin surface, while the second data collector will apply the skin fold calliper to obtain the measures.

C. Risks of participation

I may experience pain at one or more of the landmarks following the application of the algometer. As well, during the physical tests I will be asked to conduct the task until the level of discomfort is no longer tolerable.

D. Benefits of participation

The benefits of my participation in this project fall into two categories. The first on a personnel level and the second on a collective level:

a. On a personnel level, there may be one or more landmarks in and around my neck, shoulders and arms which may be identified as being hypersensitive. Knowing that the landmarks are sensitive may become problematic in the future can help me to implement some preventative strategies to decrease my risk of developing neck, shoulders problem.

b. On a collective level, pain in around the neck, shoulder and arm afflict large groups of women from various backgrounds. This being the first phase of a three phase project, the information collected will help to validate the effectiveness of an Algometer in assessing pain in the neck shoulder and arm region. The Algometer may then be used to evaluate the effectiveness of various treatment regimes at diminishing pain, such as cooling of injured areas.

I am participating in this experiment on a strictly volunteer basis and I am free to withdraw at any time prior to or during the experimental session.

All the information obtained during the course of this study is strictly confidential and will not be released to anyone without my written consent to the researchers. However, this information may be used to advance the body of scientific knowledge and may therefore be published in scientific journals where my anonymity will be entirely preserved.

E. Subjects

As a subject, I am female, between the ages of 20 and 45 years of age. I have had no shoulder problems over the last six months and I have no other known medical problem which may exclude me from participating in this project. I understand that a woman's menstrual cycles affect the pressure pain threshold values that will be obtained. I have regular menstrual cycles that last between 26 and 31days. I will be asked whether or not I am using oral contraceptive medication, to determine if the medication has an impact on the pressure pain threshold values than are being obtained.

As a subject in the project, I will be asked to refrain from consuming any caffeine products for at least four hours before participating in the testing protocol. I will also be asked to refrain from ingesting an analgesic medication (ex., aspirin) for at least 24 hours prior to my participation in the testing protocol. I will refrain from applying any oils, creams or lotions to the areas marked as trigger point locations. I will be asked not to undertake any new physical activity, especially if that activity involves the upper body, which may have an impact on pressure pain threshold values

F. Questions

You are entirely free to ask any question that you believe is relevant. Any question about the project, complaints, or comments may be addressed to any of the investigators involved in this research project. In addition, you are invited to ask any type of additional explanations if you have any doubts about your willingness to participate in this research project. The investigators responsible for this research project are Alain Comtois, thesis director, Robert D. Kilgour, thesis co-director and Dave Jones, master's student. The coordinates where these individuals may be reached are listed at the end of this consent form.

In addition, this research project as received approval by the institutional local ethics committee of the department of kinanthropologie at UQAM. The ethics committee coordinates may also be found at the end of this consent form.

For any other questions that you may have regarding the responsibility of the investigators or in the eventuality that any complaint may not be addressed directly to them, you may contact directly the UQAM institutional ethics committee {in French: *sous-comité du Comité Institutionnel d'Éthique de la Recherce chez l'Humain (CIÉR) de l'UQAM*} at the coordinates provided, as well, at the end of this consent form.

I am satisfied of the explanations that I have received and I have fully read the procedures. I am aware of the risks involved in participating in these experiments outlined in this consent form. I consent to be a subject in the research project entitled "The use of an algometer on trigger points in the neck, shoulder and arm region"

Date: _____ , _____ , 2006

Name: _____Signature: _____

(Print)

Witness: _____Signature: _____

(Print)

Coordinates:

Alain-S. Comtois, Ph.D.: Telephone number: (514) 987-3000 extension 1506
E-mail: comtois.alain-steve@uqam.ca

Robert D. Kilgour, Ph.D.: Telephone number: (514) 848 2424 extension 3322
E-mail: kilgour@alcor.concordia.ca

Dave Jones, B.Sc., CAT: Telephone number: (514) 848 2424 extension 3318
E-mail: dhjones@vax2.concordia.ca

CIÉR at UQÀM: secrétariat du Comité : service de la recherche et de la création
Université du Québec à Montréal
C.P. 8888, succursale Centre-ville
Montréal, QC
H3C 3P8
Telephone number: (514) 987-3000 extension 7753
E-mail: src@uqam.ca

Département de kinanthropologie :Université du Québec à Montréal
Case postale 8888, succursale Centre-ville
Montréal (Québec) Canada
H3C 3P8