



Effects of postural and visual stressors on myofascial trigger point development and motor unit rotation during computer work

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ABSTRACT

Musculoskeletal complaint rates are high among those performing low-level static exertions (LLSEs), such as computer users. However, our understanding of the causal mechanisms is lacking. It was hypothesized that myofascial trigger point (MTrP) development might be one causal mechanism to help explain these complaints and that static postural and visual demands may be contributing factors. Therefore, the purpose of this experiment was to examine MTrP development and the behavior of multiple parts of the trapezius muscle under postural and mental stress (represented by visual stress) conditions during computer work. Twelve subjects (six male and six female) were monitored for MTrP development via expert opinion, subject self-report, and cyclic changes in EMG median frequency across fourteen spatial locations. Results showed that MTrPs developed after one hour of continuous typing, despite the stress condition. Interestingly, both the high postural and high visual stress conditions resulted in significantly fewer median frequency cycles (3.76 and 5.35 cycles, respectively), compared to the baseline low stress condition (6.26 cycles). Lastly, the MTrP location as well as locations more medial to the spine showed significantly fewer cycles than other locations. Findings suggest that MTrPs may be one causal pathway for pain during LLSEs and both postural and visual demands may play a role in muscle activation patterns, perhaps attributing to MTrP development and resultant discomfort.

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1. Introduction

The nature of modern work is changing. Physically demanding jobs are now being replaced with many more service oriented jobs that require work at low levels of physical loading. More specifically, computer work at visual display terminals (VDTs) is becoming much more prominent in the workplace and at home. According to the Bureau of Labor Statistics (BLS), 77 million Americans use a computer at work. This represents over half of the total employed American public. In addition, with continual technological advances, future work trends indicate that this type of work is expected to represent an even greater percentage of jobs in the future (NRC, 2001).

Despite this shift, musculoskeletal complaint rates continue to be high among computer users. Studies have reported MSD prevalence rates of 20% to over 75% among these types of workers (Hsu

and Wang, 2003; Ming et al., 2004). However, our understanding of the causal mechanisms leading to such high prevalence rates among computer users is lacking.

It is known that the physical demands for computer work are much different than those required during typical manufacturing and industrial tasks. Computer tasks typically require much lower levels of physical force and much more mental processing than industrial work. In terms of physical demand, computer work imposes low-level static exertions (LLSEs) on the musculoskeletal system. An important aspect of these types of exertions is that the muscle is rarely (if ever) able to relax completely (Jonsson, 1988); therefore, the duration of sustained contraction is thought to be a critical component for MSD risk. Originally, it was thought that these LLSEs could be maintained for an unlimited amount of time. However, experience and research may contradict this belief.

In the 1970s, static contractions of 15% MVC (maximum voluntary contraction) was thought to be the level at which these exertions could be held endlessly (Rohmert, 1973). Since then, other studies have claimed that lower static levels ranging from 0.5%

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to 5% MVC may still pose problems to workers (Jensen et al., 1993a; Jonsson, 1988; Veiersted et al., 1990). Still others suggest that fatigue and discomfort can develop at any contraction level (Mathiassen et al., 1993; Sato et al., 1984; Sjogaard et al., 1986). The point is that there is growing concern that LSEs (at any level) pose risk to workers, but there is no consensus as to “how much” force can be maintained for “how long”. This lack of consensus is believed to be due to the poor understanding of the underlying mechanisms through which the health effects occur.

In addition to physical demand, computer work also imposes high mental demands on users. Visual information must be processed, interpreted, and reacted to in a very short period of time, resulting in high cognitive demands on workers. Visual parameters such as glare, lighting, screen resolution, or text legibility may directly impact cognitive demands during computer work. However, it is not clear how these visual and mental demands might impact the musculoskeletal system, and translate into physical symptoms. Studies have shown that increased mental demand may result in greater muscle co-contraction (Finsen et al., 2001; Laursen et al., 2002; Leyman et al., 2004) and sustained muscle activation (Waersted and Westgaard, 1996). However, such results do not fully explain the casual pathway for pain and discomfort during computer work.

One potential pathway that may help explain musculoskeletal discomfort during computer work is through the development of myofascial trigger points (MTrPs). MTrPs are contraction “knots” or “nodes” that can form within a taut band of muscle or at myotendinous junctions that are believed to be a source of pain. Although the exact causal mechanisms through which this pain occurs are not well understood, many believe that MTrPs cause unusually high oxygen demands to maintain contraction, creating an area of hypoxia. With time, fibers under continual contraction in an oxygen starved environment eventually exceed their tissue tolerance, resulting in microtrauma. Such microtrauma is followed by a local inflammatory response that is believed to play a crucial role in elevated pain response (Simons, 1997, 2004; Simons et al., 1999). In an effort to distinguish MTrPs from other musculoskeletal disorders, the following diagnostic criteria have been agreed upon by several researchers (Alvarez and Rockwell, 2002; Mense et al., 2001; Simons et al., 1999):

- The pain is typically muscle-oriented.
- MTrPs are hypersensitive and applied pressure produces or aggravates the pain and tenderness.
- The pain is reproducible and MTrPs are consistently found in the same part of the muscle for a particular person. The same amount of pressure on the contra-lateral muscle, if not involved in the syndrome, does not produce pain or tenderness.
- Stimulation of the MTrP produces pain that is felt locally, is referred in a pattern distant from the TrP, or both. The referred pain and tenderness are projected in a predictable pattern.
- Hardening of a taut band of muscle fibers passing through the MTrP in a shortened muscle can be palpated.
- When the MTrP is stimulated by snapping palpation or needle penetration, a local twitch response of the taut band of muscle is produced.
- Injection of a local anesthetic into the MTrP promptly eliminates the pain, tenderness, and other signs and symptoms.

While the above diagnostic criteria are commonly cited, there is no true gold standard for MTrP diagnosis. Therefore, more studies are needed to better understand their etiology, which may lead to improved diagnosis and treatment.

The neck and shoulders, particularly the trapezius muscle, are common sites for MTrPs (Simons et al., 1999; Sola et al., 1955). Although the exact causal mechanisms are largely unknown,

MTrPs are common among workers exposed to LSEs (Mense, 2002; Rachlin, 1994; Simons, 1997) such as computer work. Prevalence rates among such workers have ranged from 21% to 93% (Mense et al., 2001). Despite such prevalence rates, MTrPs have received little attention by researchers and ergonomists as potential sources of pain for computer users.

While MTrPs have been explained as purely “electrophysiological phenomenon” (Gerwin, 1994), there are very few studies in ergonomics or biomechanical literature that have investigated electromyography (EMG) and trigger point development. Those that have studied MTrPs with EMG have primarily used invasive techniques (wire or needle electrodes) to assess muscle activity (Hubbard and Berkoff, 1993; McNulty et al., 1994; Simons et al., 2002). However, the methodological approach of such studies is controversial as it unclear whether abnormal electrical activity was the result of the MTrP or the result of the needle electrode inserted into the muscle. Therefore, less invasive surface EMG studies are needed.

Only recently has a study been conducted to investigate MTrPs with surface EMG under low-level static conditions (Treaster et al., 2006). This study measured MTrP development and EMG at a single location in the upper trapezius while subjects performed computer tasks. Interestingly, the study found that MTrPs developed after continuous typing for just 30 min and the level of visual demand affected this development as well as muscle activation patterns in the upper trapezius muscle (Treaster et al., 2006). However, additional studies are needed to support this claim and understand the nature of this pathway.

The purpose of this experiment was to examine the development of MTrPs and discomfort under LSE task conditions. We hypothesized that postural stressors and mental demand (represented by visual stress) might independently impact MTrP development during computer work. MTrP development was monitored via cyclic changes in median frequency recorded from an EMG array on the trapezius and established independently by a myofascial specialist and subjectively rated for pain intensity by subjects.

2. Methods

2.1. Subjects

Twelve subjects (6 male, 6 female; mean = 23.4 years, range = 20–30 years) were recruited from the university student population to participate in the study. Accepted subjects had no history of upper extremity disorders, no major ocular pathology, and had a minimum touch typing ability of 30 words per minute. Subjects who reported poor sleep quality or intense physical activity in the preceding 24 h were excluded from the study. Subjects that could not be palpated for a MTrP in the upper division trapezius by the clinician’s pre-experiment screening were excluded. Subjects with MTrPs in the trapezius that could not be released by the clinician during the pre-experiment screening were also excluded. Testing protocol was approved by the University’s Institutional Review Board.

2.2. Protocol

The study was a repeated measures design with three levels of workstation condition:

- Baseline – low visual stress/low postural stress (VL/PL)
- High visual stress/low postural stress (VH/PL)
- Low visual stress/high postural stress (VL/PH)



Fig. 1. Depiction of three experimental conditions (from left to right, VL/PL, VH/PL, VL/PH).

The three workstation conditions are illustrated in Fig. 1 and are described in Tables 1 and 2. A Latin Square order was used to test the three conditions. Test conditions were conducted on different days with a minimum separation of seven days to minimize carry-over effects between conditions. When possible, the experimental sessions were conducted at approximately the same time of day to minimize diurnal effects.

Upon arrival, subjects were shown the experimental workstation, given a brief explanation of the research objectives, and signed an informed consent form approved by the university's Human Subjects Committee. Subjects were then screened for touch typing ability and filled out a questionnaire on age, use of corrective lenses, handedness, and unusual physical activities that had occurred in the preceding 24 h.

After the initial screening, the computer workstation setup was adjusted according to subject anthropometry and the workstation condition to be tested. Subjects then moved to a separate room for pre-experiment examination by a myofascial specialist (clinician).

The clinician palpated the subjects' dominant side upper division trapezius to locate a MTrP. For all accepted subjects, MTrPs were located in the trapezius approximately midway between the 7th cervical vertebrae (C7) and the acromion. Once located, the skin directly overlying the MTrP was marked with an "X" to aid in electrode placement and spatial orientation of the EMG array. The specialist then rated the severity of the MTrP using the following rating criteria as previously reported in Treaster et al., 2006:

- 0 = no palpable nodule within muscle, no pain or discomfort with compression.
- 1 = palpable nodule within muscle, no pain or discomfort with compression.
- 2 = palpable nodule within muscle, discomfort but not pain with compression.
- 3 = palpable nodule within muscle, mild pain with compression.
- 4 = palpable nodule within muscle, distinct pain with compression but no referred pain.
- 5 = palpable nodule within muscle, distinct pain with compression, distinct referred pain.

Table 1
Description for low and high visual stress conditions.

Viewing parameter	Low visual stress (VL)	High visual stress (VH)
Monitor brightness setting	100/100	50/100
Monitor contrast setting	20/100	100/100
Viewing distance	66 cm	33 cm
Font size	14 point	7 point
Task light (glare source)	Off	On

Next, each subject was asked to verbally rate the pain intensity upon the clinician's palpation of the MTrP on a 0–5 scale, with 0 = no pain at all, and 5 = worst imaginable pain. It is important to note that all subjects were blinded to the clinician's ratings. Specialist and subject MTrP ratings were recorded pre- and post-experimental task exposure for all subjects.

Once marked and rated, all detected trigger points in the trapezius and surrounding muscles were released by a combination of percussion, stretch and relaxation techniques. Once released, the clinician repeated palpation to ensure a trigger point sensitivity rating criterion of "0" as described previously. Therefore, all subjects were considered free of trigger points in the trapezius and surrounding muscles prior to the start of the experimental task. It is also important to note that the myofascial specialist was blinded to the experimental condition to be tested.

EMG electrodes were affixed to the skin overlying the trapezius and located MTrP as described herein (Fig. 2) and connected to pre-amplifiers. Just prior to the experimental task, a standard visual analog scale (VAS) was administered to collect self-reported musculoskeletal discomfort in the neck and upper back.

The experimental task was designed to simulate a simple computer typing task. A commercial typing program (Typing Tutor 10, Pearson Software, CA) was used to display target text on a computer monitor and the subject's task was to type the text as accurately as possible. The subject's typing appeared directly below the target text on the monitor. Therefore, since no external hardcopy of text was necessary, the task promoted continual viewing of the

Table 2
Description of workstation elements.

Workstation parameter	Posture: low stress (PL)	Posture: high stress (PH)
Horizontal location of monitor	Directly in front of subject, at a distance of 66 cm	At 45° to right side of subject, at a distance of 66 cm
Vertical location of monitor	Top of screen at eye level	Bottom of screen at eye level
Table height	At elbow height Elbow angle >90° Forearms fully supported, shoulders relaxed	Above elbow height Elbow angle <90° Forearms unsupported, shoulders loaded
Chair height	Knees and hips at same level; knee/thigh angles ~90°	Knees higher than hips; knee/thigh angles <90°
Keyboard location	Away from front edge of table, to allow full forearm support	At front edge of table, no forearm or wrist support

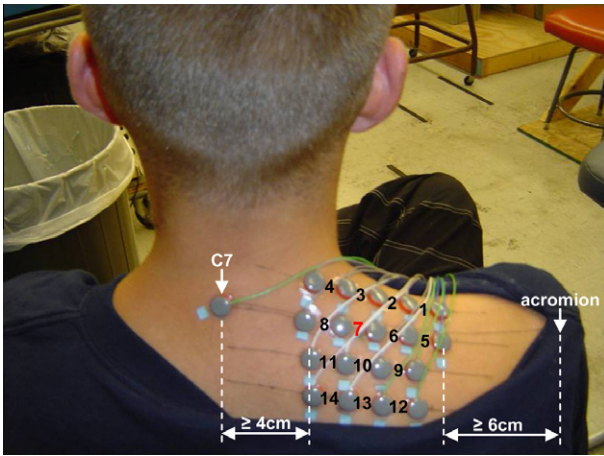


Fig. 2. Placement of surface electrode array (14 channels) over trapezius muscle. Channel 7 records EMG data directly over the trigger point location, as determined by myofascial specialist.

computer monitor and created a static neck and head posture. For each of the three workstation conditions, subjects performed the typing task continuously for approximately one-hour.

During the experimental typing task, surface EMG activity was recorded over the trigger point site as well as surrounding spatial locations on the upper division trapezius. Cyclic changes in the frequency content representative of motor unit rotation were extracted from this data as biomechanical measures of musculoskeletal stress. Methods were based on work pioneered by McLean and colleagues (McLean et al., 2001, 2000). At the end of the typing session, the post-experiment VAS discomfort survey was administered, the electrodes were removed, the skin was cleaned, and the subject returned to the other room for post-experiment MTrP examination and release by the myofascial specialist.

2.3. Apparatus

2.3.1. EMG data collection

EMG signals were recorded from a fourteen channel, bipolar EMG grid configuration. The grid recorded EMG data from fourteen spatial locations (channels) with respect to the marked MTrP on the dominant side of the trapezius muscle. The skin surface was prepared according to accepted EMG practice (Marras, 1992). Adhesive collars were attached to electrodes (12 mm wide with 4 mm cavity) and were filled with electrolytic gel to ensure good electrical contact with the skin surface. Several criteria were considered when placing the EMG array. First, the EMG grid was aligned with the location of the palpated trigger point such that channel 7 in the array configuration always recorded data over the MTrP. Secondly, all electrodes were aligned with the direction of the muscle fibers and single differential EMG signals were recorded along such lines (Fig. 2). Studies have shown that muscle fibers of the upper division trapezius run from the seventh cervical vertebrae (C7) to the lateral edge of the acromion (Hagg, 1993; Jensen et al., 1993b). The inter-center electrode distance was set at 2 cm. Additionally, in an effort to minimize noise and cross-talk, spacing of the EMG grid had to allow a minimum lateral distance of 4 cm from C7 and a minimum medial distance of 6 cm from the lateral edge of acromion (Jensen et al., 1993b). If the above criteria could not be met, the experiment ceased and the data were excluded from the study.

A standard laboratory grade EMG system (Grass-Telefactor Model 12 Series Neurodata Amplifier) was used for this study. EMG signals were differentially amplified by 10,000 (CMRR > 80 dB

at 60 Hz), with a sampling rate of 1024 Hz, 10 Hz high-pass filter, 1000 Hz low-pass filter, and a 60-Hz notch filter to minimize power line interference in the EMG signal. The analog-to-digital (A/D) conversion was done using a 16 bit converter (Model PCI-6031E Multifunction DAQ, National Instruments, TX, USA). The data were recorded quasi-continuously during the experiment and stored on a computer for later analysis. Due to software limitations to save and process the data, it was necessary to collect and save EMG data in 1 min increments before proceeding with additional data collection. This process usually required less than 5 s, after which the ensuing data collection period immediately began.

2.3.2. Potentiometers and video monitoring

Dual tri-axial potentiometers were used to monitor 3-dimensional head posture throughout the experimental sessions. A video camera was used in conjunction with potentiometer data to help control for postural shifts throughout the experimental sessions. All EMG data with significant postural shifts were excluded.

2.4. EMG analysis

Before processing the trapezius EMG data, these data were analyzed and filtered for large postural shifts. Data with large postural shifts would bias the frequency cycling data, therefore were excluded from the dataset. Data had to meet all of the following criteria in order to be excluded:

- Sudden change (within 2 s) of >1 V in potentiometer data tracking head movement.
- Obvious spike in filtered EMG >2 times the average amplitude of the trial.
- Obvious movement of shoulder, neck, or head as assessed by video.

Once filtered, the EMG data were ready to be processed to determine frequency cycling. First, the 1 min data increments recorded quasi-continuously over each 1-h test session were combined to yield 60 min of EMG data. In order to obtain the median frequency cycling data, Fast Fourier Transforms (FFT) were performed on EMG data recorded over each 1-h test session in one-

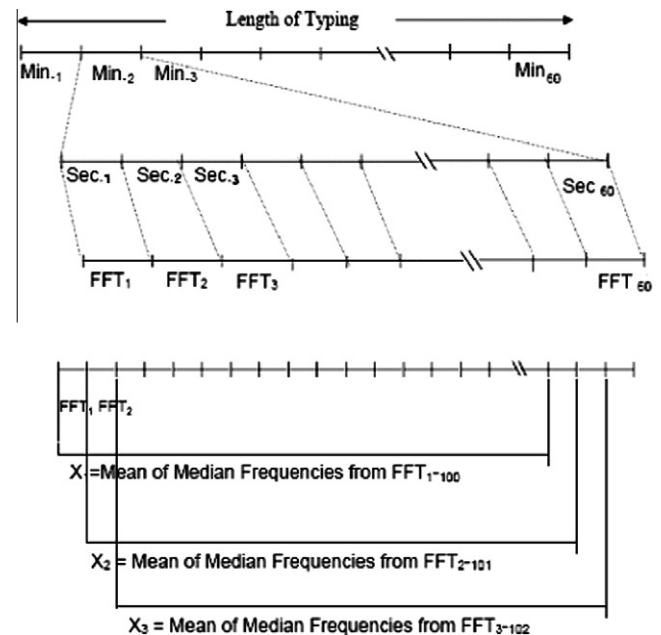


Fig. 3. EMG analysis and FFT processing illustration to calculate the running means of the median frequencies. FFT = Fast Fourier Transform.

second epochs, yielding a median frequency for each epoch. Next, running means of the median frequencies for 100 consecutive epochs were determined, with a 99-epoch overlap (1 epoch sliding window) between successive running means calculations (Fig. 3).

The running means were then graphed for each subject and each condition (36 graphs total). Each graph was analyzed manually to determine the total number of frequency cycles that occurred over the 1-h typing task. Changes in median frequency of at least 5 Hz but less than 30 Hz either upward or downward, followed by a reversal (i.e. change in median frequency in the opposite direction) of at least 5 Hz were defined as a “cycle”. The above criterion was based upon McLean and colleagues (McLean et al., 2001, 2000) who suggested such changes in median frequency to be indicators of motor unit (MU) rotation.

2.5. Statistical analysis

Once diagnostics were completed to ensure that parametric test assumptions were not violated, a repeated measures analysis of variance (ANOVA) model was used to test the main effect of workstation condition for each dependent variable. A separate ANOVA model was run to test the main effect of muscle spatial location on median frequency cycling data. Tukey–Kramer multiple comparisons testing was used for all significant effects in order to further evaluate and understand the nature of these conditional differences. Significance levels (α) of 0.05 and 0.10 were reported.

3. Results

3.1. Trigger points

The post-experiment examination by the myofascial specialist revealed that trigger points had redeveloped (to some extent) after

Table 3
Mean (standard deviation) of trigger point sensitivity ratings as a function of condition, by myofascial specialist and subjects.

Experimental condition		Specialist rating	Subject rating
VL/PL	Pre	1.42 (0.67)	1.79 (1.03)
	Post	1.92 (0.90)	2.08 (0.93)
VH/PL	Pre	1.67 (0.89)	1.29 (1.10)
	Post	2.17 (1.03)	1.88 (1.21)
VL/PH	Pre	1.58 (1.16)*	1.79 (1.20)
	Post	2.50 (0.67)*	2.33 (1.07)

Pre = pre-experiment; post = post-experiment.
* Significance at 0.05 for pre- versus post-comparison.

1-h of continuous typing in all conditions, despite the fact that they were released just prior to the experiment.

The pre- versus post-experiment results showed that specialist trigger point ratings varied only as a result of the high postural stress (VL/PH) condition (Table 3). The specialist rating showed significantly greater trigger point development after the high postural stress condition compared to prior the experiment. In contrast, the other conditions (VL/PL and VH/PL) did not show significant differences between pre- and post-experiment trigger point ratings by the specialist. No significant differences were found between pre- and post-experiment subject trigger point ratings for any of the three conditions.

3.2. EMG median frequency cycling

Results showed that workstation condition had a significant effect on the number of cycles reported across all locations combined. As shown in Fig. 4, significant differences were reported between all three conditions, with postural stress (VL/PH) resulting in the fewest cycles (mean = 3.76) and the baseline low stress condition (VL/PL) resulting in the greatest number of cycles (mean = 6.26).

Muscle spatial location relative to the trigger point also had a significant effect on cycling. As indicated in Fig. 5 below, six locations showed significantly greater cycling (means ≥ 6.0 cycles) than the trigger point location which averaged 3.6 cycles over the trial.

3.3. Musculoskeletal discomfort ratings (visual analog scale)

The pre- versus post-experiment results for reported neckache/backache showed significantly greater post-experiment ratings in all three experimental conditions. Condition also had a significant main effect as postural stress (VL/PH) resulted in greater neck/backache scores (VAS change = 46.75 mm) than the low stress (VL/PL) condition (VAS change = 18.17 mm). Visual stress (VH/PL) was not significantly different from either of the other two conditions (VAS change = 33.25 mm; Fig. 6).

4. Discussion

Results from this study suggest that MTRPs may be one viable pathway for pain and discomfort during LLSEs, such as those required during computer work. It was expected that high postural stress conditions would lead to the development of trigger points,

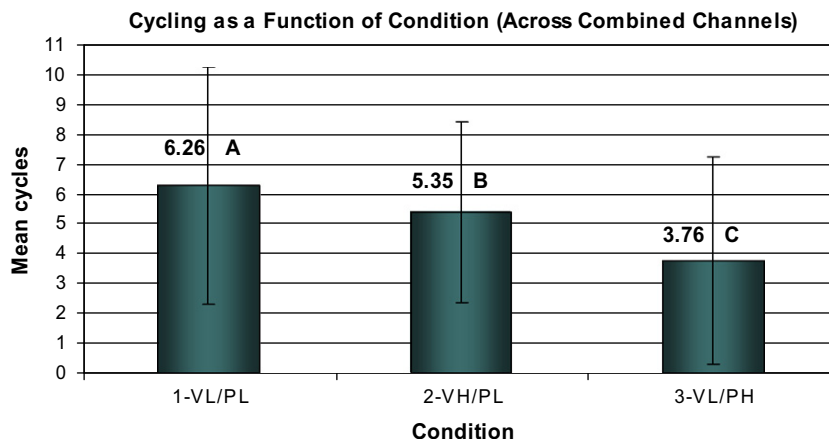


Fig. 4. Average median frequency cycles (across all spatial locations combined) as a function of condition. Whiskers = 1 standard deviation. Results showed that all three conditions were significantly different from one another.

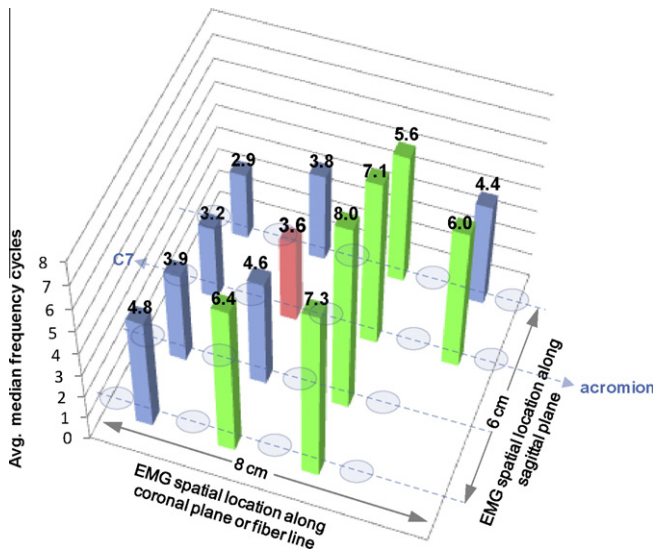


Fig. 5. Average median frequency cycles (across all subjects) as a function of muscle spatial location (relative to MTrP). Location highlighted in red represents the MTrP location. Green (lighter) locations represent locations that are significantly different from MTrP location ($p < 0.05$). Grey discs indicate electrode placement while the dotted lines represent muscle striation lines.

while the baseline low stress condition would not. However, trigger points developed (to some extent) in the trapezius after one-hour of continuous typing, no matter the stress condition. In addition, musculoskeletal discomfort (neckache/backache) was significantly greater post-experiment compared to pre-experiment after all three conditions. These findings suggest that continuous computer work involving LLSEs for a period of only one-hour may have detrimental effects on the body, even in conditions compliant with current ergonomic guidelines for office work (VL/PL).

Results also suggest that both postural and visual demands during LLSEs may play a role in muscle activation/recruitment patterns, perhaps impacting myofascial trigger point development and resultant musculoskeletal discomfort. While there were no significant differences in pre- versus post-experiment trigger point ratings for the low stress and high visual stress conditions, there were significant differences in median frequency cycling between all three conditions. Both high physical and high visual stress conditions showed significantly fewer cycles than the low stress condition. This finding is consistent with a previous study that also

found less cycling in high visual stress conditions (Treaster et al., 2006).

However, one might question how visual stress might impact muscle activation. It is believed that visual stressors such as glare, poor screen resolution, and small font size as defined in this study may have imposed greater mental demand by making it difficult to read the text on the screen. As some studies suggest, it is believed that greater mental demand may result in sustained muscle activation, a logical precursor to MTrP development (Waersted and Westgaard, 1996). Perhaps there is a central stress mechanism through which physical and visual/mental task parameters impact the body, reduce motor unit rotation patterns, potentially attributing to MTrP development and resultant discomfort.

Results from this study also lend support to previous studies suggesting that there is unequal loading about a single muscle during LLSEs (Sjogaard and Sogaard, 1998). In general, the location directly over the trigger point as well as locations more medial to the spine showed significantly fewer frequency cycles than other locations. Therefore, certain parts of the trapezius muscle and certain fibers may be at greater risk for fatigue, failure, and trigger point development than others. But questions remain as to why different parts of the muscle behave differently and how this relates to MTrP development. Some have proposed that unequal loading is a function of anatomical location and the mechanics of the muscle. As the trapezius approaches the spine, the fibers become more like fascial connective tissue that behave differently from normal muscle fibers, perhaps attributing to less cycling closer to the spine. Others have suggested that unequal load sharing may be due to low-threshold motor units, termed “Cinderella” fibers, being continuously recruited and overloaded during LLSEs (Hagg, 1990; Sjogaard and Sogaard, 1998; Sogaard, 1995) while others claim it is related to the location of the motor endplate region (innervation zone) of a muscle (Jensen et al., 1993b; Veiersted, 1991). Despite these efforts, no consensus exists that fully explains unequal load sharing of muscles and how this might relate to MTrP development. Future studies are needed to understand this phenomenon.

Findings from this study also have implications on workplace design. While it has been well established that postural factors are important in workplace design, less is known about the impacts of visual and cognitive factors on the musculoskeletal system. Results from this study showed that both postural and visual factors in computing environments have impacts on muscle activation patterns, as assessed by median frequency cycling. Such results reinforce the importance of considering not just physical parameters, but visual parameters as well when optimizing VDT workstations for users.

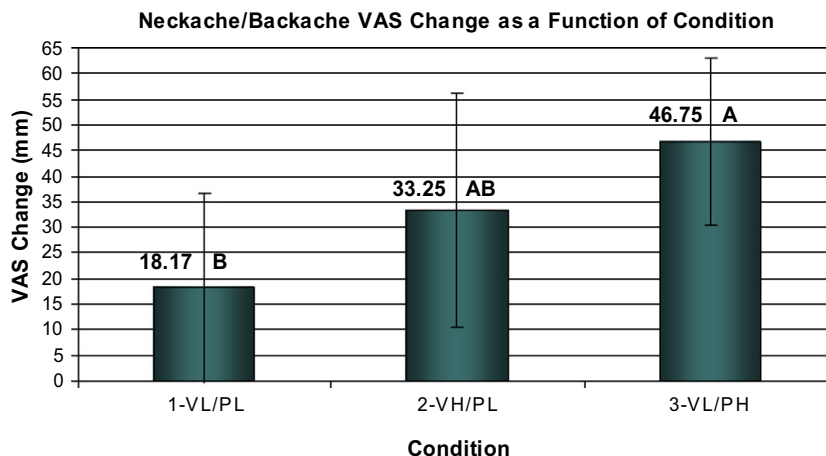


Fig. 6. Mean VAS scores for neck/backache (post-pre) as a function of condition. Whiskers = 1 standard deviation. Results showed that VL/PL and VL/PH conditions were significantly different; however, VH/PL condition was not significantly different from the other two conditions.

Lastly, results suggest that users that comply with current ergonomic guidelines for office work may not be immune to musculoskeletal complaints during this type of work. Since trigger points redeveloped in all conditions, it may be important to realize that modification of the physical layout, alone, may not deter musculoskeletal symptoms from occurring. Perhaps other interventions such as micro-breaks, task variety, and psychological well-being programs play a role in mitigating MTrP development. Future studies are needed to prove or disprove such benefits.

Several limitations should be considered when interpreting this research. First, this study investigated a limited number of young men and women (ages 20–30) and did not control for individual differences or personality types. Additional studies are needed to understand if aging and/or personality type play a role in trigger point development. Second, the stress conditions imposed on the subjects were based on expert opinions on what would stress the musculoskeletal and visual systems while performing a single typing task. Thus, many other possible levels or conditions could have been investigated. Moreover, while the experimental task only lasted one hour, it is probable that many workers continuously perform computer tasks for much longer durations. Additional research is needed to investigate more complex computer-based tasks over longer work durations. This study relied on the expertise of a clinician to palpate the upper division trapezius, locate and diagnose a taught band as a MTrP, and rate the sensitivity. As reliability of manual palpation of MTrPs has been questioned by previous works (Myburgh et al., 2008; Lucas et al., 2009), it is realized that future studies are needed to more objectively identify and diagnose trigger points. Furthermore, although efforts were taken to minimize postural shifts while recording EMG, it is still unclear whether variations in frequency cycling can be directly attributed to MTrP development or small shifts in innervation zone position. Inspection of the raw multi-channel EMG data could help us answer such a question. Lastly, as the clinician's MTrP examination was only performed pre- and post-experimental task condition, it could not be determined exactly when MTrPs developed during the typing session. Additional studies and analyses are needed to understand these temporal relationships.

5. Conclusions

This study could be summarized by the following:

- Myofascial trigger points developed (to some extent) after only one hour of continuous typing in all subjects, despite the stress condition. Therefore, trigger points may likely be one causal pathway for pain during LLSEs.
- Secondly, the finding that muscular function (i.e. motor unit rotation as assessed by median frequency cycling) was affected not only by the postural demands of the task, but the visual demands as well provides motivation for future research in workplace ergonomics.
- Lastly, loads (i.e. median frequency cycling) were not distributed equally across the trapezius muscle, possibly attributing to MTrP development; however, the reasons for this unequal loading are not well understood. Efforts to further understand the mechanisms and injury pathways are needed.

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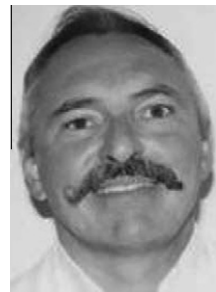
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