Effects of an hour computer use on ulnar and median nerve conduction velocity and muscle activity in office workers

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Running title

Effects of computer on nerve conduction and muscle activity

Author contributions

The authors have contributed in the following ways: KT, SC, HN were involved in conceptualization, research design, methodology, data collection, and manuscript writing in the original draft. KT provided supervision and data analysis. SC provided software and validation of measurement. HN provided project administration and funding acquisition. All authors read and approved the final manuscript.

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Abstract

Objectives: To compare the effects of the one-hour computer use on ulnar and median nerve conduction velocity and muscle activity in symptomatic neck pain and asymptomatic office workers.

Methods: A total of 40 participants, both male and female office workers, with symptomatic neck pain (n = 20) and asymptomatic (n = 20), were recruited. Pain intensity, ulnar nerve conduction velocity, median nerve conduction velocity, and muscle activity were conducted before and after one hour of computer use.

Results: A significant increase in pain intensity in the neck area in both groups (p < 0.001). The symptomatic neck pain group revealed a significant decrease in the sensory nerve conduction velocity of the ulnar nerve (p = 0.008), while there was no difference in the median nerve conduction velocity (p > 0.05). Comparing before and after computer use, the symptomatic neck pain group had less muscle activity of the semispinalis muscles and higher anterior scalene muscle activity than the asymptomatic group (p < 0.05). The trapezius and wrist extensor muscles showed no significant difference in both groups (p > 0.05).

Conclusions: This study found signs of neuromuscular deficit of the ulnar nerve, semispinalis muscle and anterior scalene muscle after one hour of computer use among office workers with symptomatic neck pain, which may indicate the risk of neuromuscular impairment of the upper extremities. The recommendation of resting, encouraging function and flexibility of the neuromuscular system after one hour of computer use should be considered.

Keywords: median nerve, muscle activity, neck pain, nerve conduction, office worker, ulnar nerve

Key points

- The symptomatic neck pain group revealed a significant decrease in the sensory nerve conduction velocity of the ulnar nerve after an hour of computer use.
After using the computer for an hour, the symptomatic neck pain group exhibited decreased muscle activity in the semispinalis muscles and increased activity in the anterior scalene muscles compared to the asymptomatic group.

This study suggests that incorporating periods of rest, promoting functional movements, and enhancing neuromuscular system flexibility after an hour of computer use should be considered for the impact on nerve conduction velocity and muscle activity.

Introduction

Computer work is a significant cause of neck and upper extremity-related musculoskeletal disorders (WMSD).\(^1\) Office workers have major complaints of musculoskeletal symptoms related to computer use.\(^2\) A high prevalence of musculoskeletal disorders from neck and upper extremity complaints, over 50%, was observed among office workers.\(^1\) In addition, WMSD causes health sickness, absence from work, and high medical compensation.\(^5\)

Prolonged static sitting with awkward postures (e.g., forward head and rounded shoulder posture, thoracic kyphosis, and non-neutral repetitive movement of the upper extremities during computer use) had been associated with the development of neck pain.\(^6\) This factor contributed to muscle imbalance, including muscle tightness and weakness, fatigue, and joint overload of the neck and upper extremities. Moreover, tissue overload produces inflammation and swelling of the nerves, leading to nerve entrapment, followed by numbness symptoms.\(^6, 7\) Abnormal posture and function can lead to an increase in compressive loading on the cervical spine, involving muscles such as the trapezius and the levator scapulae. Additionally, this abnormal posture may elevate intradiscal pressure and load on the zygapophyseal joint surfaces in the cervical spine, ultimately leading to induced pain.\(^6\) Based on the double-crush syndrome, which indicates a significant relationship between neck pain and the occurrence of CTS (Carpal Tunnel Syndrome), this syndrome refers to the simultaneous existence of two compressive lesions along a nerve's pathway. The concept suggests that the constriction of a peripheral nerve in the upper extremity might produce an initial lesion in the nerve's proximal segment, predisposing it to subsequent damage further along its distal portion, particularly as it traverses a narrow anatomical canal such as the carpal tunnel.\(^8\)
Neuromuscular evaluations such as nerve conduction studies and muscle activity have been used widely to evaluate the function of nerves and muscles among office workers.\(^{(9-11)}\) Previous literature review studies have a consensus that prolonged hours of computer use (a minimum of > 6 hours of computer use) delayed nerve conduction velocity of the median and ulna, which indicated a higher risk of wrist pathology of carpal tunnel as a median nerve entrapment and Guyon's canal syndrome as an ulnar nerve entrapment than for non-computer users (computer use < 2 hours).\(^{(10, 11)}\) An investigation of muscle activity among office workers found a variation in results in scapular muscle activities.\(^{(9)}\) However, the duration of computer use that indicates a risk for neuromuscular impairment is still questionable. A previous study showed that an hour of computer use could increase fluid pressure and produce median nerve swelling, which may lead to the risk of carpal tunnel syndrome.\(^{(12)}\) In addition, the survey study reported musculoskeletal discomfort complaints after one hour of computer use.\(^{(12, 13)}\) Moreover, a previous study recommended that office workers should take a 10-minute break every hour of computer use.\(^{(14)}\) However, the evidence of neuromuscular evaluation that proves the effect of one-hour computer use on neuromuscular systems among computer office workers is limited. Therefore, the aim of this study is to compare the effect of one-hour computer use on nerve conduction velocity and muscle activity between computer users with and without neck pain.

**Materials and Methods**

**Study design and participant recruitment**

The study design was a cross-sectional study conducted in a Laboratory room at Walailak University. The study was approved by the Ethics Committee of the Protection of Humans, Walailak University (Ethic No. WUEC-21-312-01). A total of 40 participants were recruited through convenient sampling from Walailak University, Thailand. There were 20 participants in each group, which included the symptomatic neck pain group and the asymptomatic group. The inclusion criteria consisted of male and female office workers, aged between 30-50 years, with a body mass index (BMI) between 18.0-22.9 kg/m\(^2\) and no limited range of shoulder joint motion. The symptomatic neck pain group included participants who had neck pain without radiculopathy which was associated with computer work for more than 3 months and present pain in the...
past 7 days with a visual analog scale (VAS) > 3. Participants who had no neck pain were recruited into the asymptomatic group. Participants used the right hand to operate the mouse for daily computer work. The exclusion criteria consisted of pregnancy and medical conditions such as diabetes, hypertension, fracture, history of neck and upper extremity operation, and neuromuscular disorder. All participants have been screened for radiculopathy of the neck and upper extremities by a physical therapist with 10 years of experience, using active and passive range of motion tests, neck compression tests, and the Phalen test. The sample size was calculated based on a previous study (10) using statistical values from the median nerve conduction velocity as the primary outcome. The effect size was calculated to be 0.93. Software G*Power 3.1.9.4 was used for the analysis of the independent t-test, and it had an alpha level of 0.05 and a power of 0.80. The sample size was equal to 20 participants for each group.

**Protocol of the study**

After the screening test, participants were given an hour of rest before the main test commenced. Before engaging in computer tasks, participants underwent a self-questionnaire and investigated nerve conduction velocity test. The computer workstation was arranged ergonomically, with adjustments to accommodate each participant; while the table height was standardized to 75 centimeters, typical of a standard work desk. Chair height was adjusted to approximately match the popliteal height, and participants’ feet were placed flat on the ground. The chairs were equipped with armrests and backrests. Participants were in a relaxed, neutral position for the neck, with the top of the screen positioned at eye level. During computer use, participants were tasked with typing documents on the keyboard for an hour, using a mouse positioned on the right-hand side for computer tasks. Muscle activity was tested throughout the computer tasks. After the computer task, participants underwent a reassessment of nerve conduction velocity and neck pain intensity.

After the screening test, the participants had an hour of rest before the test started. Before computer use, the participants were tested on a self-questionnaire and the nerve conduction velocity. The computer workstation was under an ergonomic setting. The screen distance at the workstations was individually adjusted for each participant, with the table height standardized to
that of a typical work desk at 75 cm. The chair height was adjusted to approximately popliteal height and the foot rested on the ground. The chair featured armrests and a backrest. The neck participant was relaxed in the neutral position and the top of the screen adjusted to eye level. During computer use, the participants were asked to type documents on the keyboard for an hour with a mouse during computer tasks on the right-hand side. Muscle activity was tested during computer use. After computer use, nerve conduction velocity and neck pain intensity were tested.

**A self-report questionnaire**

A self-report questionnaire consisted of personal data, work characteristics, medical history, the neck pain intensity, cause of pain, onset of pain, pain duration (less or more than 3 months), and stress evaluation by the stress test questionnaire (ST-5) in the Thai version. The ST-5 was divided into five categories (insomnia, concentration, anxiety, boredom, and ignored socialization), which were evaluated within 2-4 weeks. The components assessed for each item were based on four score levels from 0 to 3 (never, sometimes, often, and usually).

**Nerve conduction study**

The nerve conduction study used the Medelec Synergy EMG/EP system (Viasys Healthcare, Surrey, United Kingdom). The evaluation consisted of motor nerve conduction studies (MNCS) and sensory nerve conduction studies (SNCS) of the median and ulnar nerve of the right hand. The placement of the nerve conduction attachment electrodes was determined based on Figure 1. In addition, a nerve conduction study was performed in a laboratory room setting at the Department of Physical Therapy, Walailak University.

The evaluation of MNCS used an orthodromic method with a surface disc electrode. Filter settings were 10-10,000 Hz, with a sweep speed of 2 milliseconds per division. An active recording electrode was placed over the motor point of the abductor pollicis brevis muscle for the median nerve. A reference electrode was positioned on the distal phalanx of the thumb over the bone or tendon. For the ulnar nerve, an active recording electrode was placed over the motor point of the abductor digiti minimi muscle. A reference electrode was positioned over the distal phalanx of the fifth finger.\(^\text{15}\)
The evaluation of SNCS used an antidromic method with ring electrodes, and filter settings were 20-2,000 Hz, with a sweep speed of 2 milliseconds per division. For the median nerve, an active ring recording electrode was attached to the proximal phalanx of the index finger, and a reference ring electrode was positioned on the distal phalanx of the index finger. For the ulnar nerve, an active ring recording electrode was positioned at the midpoint of the proximal phalanx of the little finger, and a reference ring electrode was positioned on the distal phalanx of the little finger.\(^{(15)}\)

For the site of stimulation of the median nerve, the cathode was performed at the motor point of the median nerve of the wrist between the flexor digitorum superficialis and flexor carpi radialis tendon (S1) and above the elbow crease medial to the brachial artery pulse and biceps brachii tendon (S2). For the site of stimulation of the ulnar nerve, the cathode was performed at the motor point of the ulnar nerve of the wrist, medial or lateral to the flexor carpi ulnaris tendon (S1), and at the cubital tunnel of the elbow (S2). The skin temperature at the dorsum of the right hand was 32°C.\(^{(15)}\)

**Muscle activity**

Muscle activity was evaluated by a Delsys Myomonitor® IV EMG System, USA. The electromyography (EMG) system works in 8-channel models with Wireless Mode. All EMG signals were processed using bandpass filters set at 50 Hz and 400 Hz to reduce the noise levels. The muscles, including the right semispinalis, upper trapezius, lower trapezius, anterior scalene, and wrist extensor muscle, were tested during computer use. The placement of the electromyography attachment electrodes was determined according to Figure 2. The value was reported as Root Mean Square (RMS) amplitude for 1 minute in 15-minute intervals for 1 hour.\(^{(16, 17)}\) Electrodes were attached to the following positions of the muscle to receive the EMG signal on the right side of all participants: anterior scalene muscle: one-third between the sternal notch and the mastoid process in a supine position.\(^{(17)}\) Upper trapezius muscle: middle of the distance between the 7th cervical vertebrae and the acromion process of the scapula.\(^{(16)}\) Lower trapezius muscle: middle of the distance between the vertebral border of the spine of the scapula and the 7th thoracic vertebrae.\(^{(18)}\) Serratus anterior muscle: middle of the distance between the 4th and 6th rib in the axillary line.\(^{(9)}\) Semispinalis muscle: 2.5 centimeters apart from the 2nd cervical
vertebrae.\textsuperscript{(19)} Wrist extensor muscles: one-third between the lateral humeral epicondyle and the radial styloid process.\textsuperscript{(20)}

**Statistical analysis**

Statistical analysis was calculated by the IBM SPSS Statistics 22.0 software program (IBM Corporation, USA)—a statistical significance level was set at a $p < 0.05$. The Shapiro-Wilk normality test was used to analyze the normal distribution. The analysis of pain intensity and nerve conduction studies used a paired sample $t$-test for parametric data and the Wilcoxon signed-rank test for nonparametric data to compare the pre-test and post-test within the group. The baseline of characteristic variables and the mean difference of the pre-test and post-test between groups were analyzed by an independent sample $t$-test for parametric data, and the Mann-Whitney U test was used for nonparametric data. The RMS amplitudes of EMG used repeat measure analysis to compare the differences between the symptomatic neck pain and the asymptomatic group. The post-hoc test was used to calculate RMS amplitudes of EMG within the group for 4 repetitions in 15-minute intervals for 1 hour.

**Results**

The characteristics of participants in the symptomatic neck pain and asymptomatic groups were matched by pairing 20 subjects based on age and gender. In addition, the psychological status, including stress, was evaluated using the ST-5 questionnaire. There was no difference between groups in age, weight, height, body mass index (BMI), gender, hand dominance, duration of computer use, and ST-5, as shown in Table 1.

**Pain intensity and nerve conduction study**

Pain intensity was assessed by using the VAS, and the nerve conduction study included the motor and sensory nerve conduction velocity of the median and ulna. The symptomatic neck pain group presented a significant difference between the pre-test and post-test in the VAS ($p < 0.001$) and the sensory of ulnar nerve conduction velocity ($p = 0.008$). In addition, the VAS showed a significant difference between the pre-test and post-test in the asymptomatic group ($p < 0.001$). However, neither motor nor sensory nerve velocity of the median nerve had a significant difference between the pre-test and post-test.
(Table 2). The comparison of the mean difference of the VAS (post-pre) and nerve conduction velocity of the median and ulnar nerve (pre-post) between groups is demonstrated in Table 3. Neither symptomatic nor asymptomatic groups had a significant difference in the VAS and nerve conduction velocity.

**EMG muscle activity**

The baseline EMG results revealed no significant differences between the groups across all muscles ($p = 0.170, 0.356, 0.869, 0.931, 0.546, 0.783$, respectively). The results of the RMS amplitudes found a statistical significance between the symptomatic neck pain and the asymptomatic group for the semispinalis muscle activity at 15, 30, and 60 minutes ($p = 0.038, 0.043, 0.049$, respectively). Likewise, the scalene muscle activity at 15 and 30 minutes showed a significant difference between the symptomatic neck pain and the asymptomatic group ($p = 0.033$ and 0.007, respectively). There were no statistically significant differences between the groups in the other RMS amplitudes. The RMS amplitudes of the semispinalis, upper trapezius, lower trapezius, serratus anterior, scalene, and wrist extensor muscle found no statistically significant difference within the groups (Figure 3).

**Discussion**

**Pain intensity**

The current study found a significant increase in pain intensity in the neck area in both the symptomatic neck pain and asymptomatic group after one hour of computer use. Based on the VAS scores, values $\leq 3.5$ indicated mild pain, 3.5 to 7.4 indicated moderate pain, and $> 7.5$ indicated severe pain. However, the cutoff points for pain-related interference with functioning were 2.5 to 4.5 for mild to moderate pain and 5.5 to 7.4 for moderate to severe pain.$^{(21)}$ Therefore, the symptomatic neck pain group exhibited moderate neck pain levels with moderate to severe pain-related interference with functioning after computer use. In contrast, the asymptomatic group showed mild neck pain levels with non-pain-related interference with functioning. Although the asymptomatic group demonstrated statistical significance in VAS due to a zero-pain score at baseline, this does not imply statistical relevance to pain intensity. The finding was consistent with previous studies indicating that one-hour computer uses
increased musculoskeletal complaints among computer users. Several factors of using a computer led to increased pain in the upper extremities, including poor posture during computer use (e.g., forward head and shoulder posture), causing muscle imbalance of the neck and producing neck pain. Moreover, repetitive movement of the upper extremities during computer use increases muscle activity and tension of muscle that restricts blood circulation to the nerve.

*Nerve conduction study*

After one hour of computer use, the study demonstrated a significant decrease only in sensory nerve conduction of the ulnar nerve among the symptomatic neck pain participants. This result indicated a short time of computer use in one hour could delay sensory nerve conduction velocity in office workers with neck pain. It might imply the early sign of ulnar nerve entrapment and sensory neural deficit of the ulnar nerve at the wrist joint. Guyon’s canal is a common area of entrapment caused by repetitive computer use, which is found to be inferior to the carpal tunnel of the wrist joint. A clinical study of work-related symptoms among 485 computer users found approximately 10% of computer users have ulnar nerve entrapment by a positive Tinel’s sign on the Guyon’s canal. Although our results demonstrated delayed ulnar sensory nerve conduction after 1 hour of computer use only in the neck pain group, specific explanations for this finding could not be determined. However, this study hypothesized that several factors may contribute to ulnar nerve entrapment and delay sensory nerve conduction among office workers experiencing neck pain. First, direct compressive force on the pisiform and Guyon’s canal during typing may compress the ulnar nerve. Second, repetitive hand movements while using a keyboard and mouse may create muscle imbalances and stress on peripheral nerves, leading to nerve entrapment. Third, sustained non-neutral wrist positions (e.g., wrist extension, ulnar deviation during keyboard typing, and mouse use) may increase pressure on the hypothenar eminence, resulting in ulnar nerve pressure. Fourth, leaning on the elbow while using a computer could compress the ulnar nerve at the olecranon, increasing the risk of ulnar neuropathy (OR 2.16, 95% CI 1.06-4.44). Finally, based on the double-crush syndrome, which indicates a significant relationship between cervical spine lesions and the occurrence of peripheral nerve entrapment, proximal compression of axon continuity directly leads to distal lesion sites along the same neural processes. The occurrence of
axon compression in the cervical nerve root results in the compression of the same axons at the peripheral wrist joint.\(^6, 8, 27\) This theory can explain the relationship between neck pain and the nerve conduction study. The delay in sensory nerve response of the ulnar nerve in the neck pain group suggests that there might be compression or tension loading of the brachial plexus in the lower cervical spine, leading to decreased axoplasmic flow at the cubital tunnel and Guyon’s canal, thereby disturbing the sensory signal conduction of the ulnar nerve.\(^6, 8, 27\) Furthermore, the posture of office workers while using computers may be related to the occurrence of neck pain and a decrease in nerve conduction. A forward head posture is frequently seen in office workers experiencing neck pain. Moreover, computer use could lead to an increase in forward head posture and thoracic kyphosis. This typical forward head posture involves lower cervical flexion, scapular abduction, and thoracic kyphosis, leading to an abnormal muscle imbalance that includes 1) tightness of the scalene, sternocleidomastoid, upper trapezius, levator scapulae, and pectoral muscles; and 2) weakness of the interscapular muscles, such as the middle and lower trapezius, rhomboids, and serratus anterior muscles. These imbalances may cause entrapment of lower cervical nerve roots and thoracic outlet syndrome (TOS). The shortening of the scalene and pectoralis minor muscles could compress the brachial plexus and vascular structures. The external compression on the neurovascular structures contribute to the occurrence of neck pain and delayed nerve conduction in office workers.\(^6, 26\)

The findings of the current study reveal no statistically significant differences in median nerve conduction velocity between two distinct groups of office workers. This observation leads to the hypothesis that the median nerve, experiencing lesser compression than the ulnar nerve during computer use, particularly in the neck and elbow regions, possibly due to the adoption of a forward head posture during computer use predominantly exerts stress on the lower cervical spine, which primarily affects the ulnar nerve. Additionally, leaning on the elbow while using a computer is more inclined to impose stress on the cubital tunnel, where the ulnar nerve is located, rather than the cubital fossa, associated with the median nerve. It is also posited that compression occurring at the thoracic outlet is more likely to impact the ulnar nerve in comparison to the median nerve.\(^6\) From the literature review, it is found that there is still a lack of specific studies correlating forward head posture with nerve entrapment. It is important to note that the current study did not specifically investigate the neck and upper extremities to identify causative
factors associated with delayed nerve conduction velocity among office workers with neck pain. Therefore, future studies should consider the investigation of posture to better understand these factors.

The current study differed from previous literature studies in that we investigated nerve conduction after one hour of computer use among office workers with and without neck pain. Based on the literature review, a previous study reported a significant reduction in the sensory nerve conduction velocity (SNCV) of the median and ulnar nerves in both the dominant and non-dominant hands of asymptomatic office workers compared to non-computer users. These delayed SNCV values indicated neurological wrist lesions in individuals who spent prolonged periods using a keyboard and mouse. In a prior study, nerve conduction velocity was compared between computer users who worked intensively with computers for more than 6 hours and those who worked for less than 2 hours per day. The results revealed a significant decrease in both MNCV and SNCV of the median and ulnar nerves in computer users who worked more than 6 hours per day. The findings discussed the potential cause of delayed nerve conduction, attributing it to muscle imbalance between the shortened agonist and weak agonist muscles of the upper extremity when using a computer mouse.\(^{(11)}\) Moreover, a previous study reported significant delayed SNCV and MNCV of the median and ulnar nerve in patients with moderate-severe forward head posture compared to normal and mild forward head posture.\(^{(26)}\) Forward head posture may cause brachial plexus compression that leads to decreased nerve conduction velocity.\(^{(6, 26)}\) In contrast, another study found no significant difference in sensory and motor nerve conduction velocity of the median and ulnar nerve between female computer users and non-computer users, indicating no signs of neural deficits.\(^{(28)}\) Although the current study demonstrated delayed sensory nerve conduction velocity in the symptomatic neck pain group, this was based on the lowest cut-off for normal sensory nerve conduction velocity at 45 m/s for adults. Therefore, sensory nerve conduction after one hour of computer use in the symptomatic neck pain group was normal.\(^{(29)}\)

**Muscle activity**

This study showed that the participants with symptomatic neck pain had less muscle activity in the semispinalis muscle (neck extensor) than the
asymptomatic group while having higher muscle activity in the anterior scalene muscle (neck flexor). However, there was no difference in the muscle activity of the other muscles of the neck and forearm including the upper and lower trapezius, serratus anterior, and wrist extensor muscles.

Moreover, the mean value of neck pain assessed by the VAS was 4.30 ± 1.19, which was consistent with a previous study on office workers with neck pain showing that the moderate to severe neck pain groups reported less neck extensor muscle activity than a control group without neck pain during computer typing; this was caused by head-neck flexion angles in the symptomatic office workers, which reported higher values compared to the asymptomatic group in office workers.\(^{30}\) The movement angle of the neck (e.g., craniovertebral angle) affects the semispinalis muscle.\(^{19}\) The action of the semispinalis muscle includes neck extension, ipsilateral lateral flexion, and contralateral rotation. The location of this muscle is that each fascicle is projected at four to six levels of the cervical spinous processes, thus elongating the arm moment, thereby increasing the mechanical load on the cervical spine. Thus, the frequency and amplitude of the semispinalis muscle contractions were reduced in people with neck pain, and generating force from motor unit recruitment in the semispinalis muscle was more difficult.\(^{19, 30}\) In contrast, a previous study observed an increase in the recruitment of semispinalis capitis during neck extension among computer workers with neck pain.\(^{31}\) The difference might be attributable to the amount of time spent working with a computer per day.

At the same time, the movement angle of the neck (e.g., craniovertebral angle) affects the function of the anterior scalene muscle.\(^{32}\) This muscle is one of the respiratory muscles due to its action in the elevation of the 1st and 2nd rib, neck flexion, ipsilateral neck lateral flexion, and rotation.\(^{32, 33}\) Muscle activity of the anterior scalene in patients with chronic neck pain could be increased due to changes in the motor behavior of the muscle from chronic pain.\(^{33}\) It was consistent with the findings in this study, demonstrating that the muscle activity of the anterior scalene was not constant over 60 minutes of computer use. However, previous studies indicated that the contraction of the anterior scalene muscle was 25% of the maximum voluntary contraction in the neck pain group, and their neuromuscular efficiency was lower than that of the asymptomatic group.\(^{33, 34}\)
This study showed no statistically significant difference between the upper trapezius muscle activity in the symptomatic neck pain and the asymptomatic group. These findings were consistent with previous studies that found that upper trapezius muscle activity in subjects with mild or no symptomatic neck pain contributed to the low distribution of upper trapezius muscle activity and that monotonous work tasks resulted in low-threshold motor unit activity in the trapezius muscle; therefore, the RMS in continuous EMG measurements of muscle activity was found to be constant.\textsuperscript{(16, 35)} Another reason might be that motor unit recruitment of the upper trapezius muscle was greater than usual, often seen in high neck pain groups.\textsuperscript{(30)} In addition, this study also found that upper trapezius muscle activity was not significantly different within the groups for both the symptomatic neck pain and the asymptomatic group after one hour of computer use. The reason for the difference might be that participants could adjust the distance and height of their chairs to suit working comfort. The body might adjust for the spatial distribution of upper trapezius muscle activity and maintain a center of gravity so that it would not affect muscle contraction in both groups after working with the computer for one hour.\textsuperscript{(36)}

There was no statistically significant difference between lower trapezius muscle activity in the symptomatic neck pain and asymptomatic group. It contrasted with previous studies that found the action of the lower trapezius was associated with shoulder girdles and stabilized the upper limb segment during typing.\textsuperscript{(18, 37)} However, in the study, participants with neck and shoulder pain also spent only 10 minutes typing on a computer. A previous study found that people with and without neck pain had different lower trapezius muscle activity when typing using a document holder.\textsuperscript{(18)} Although previous studies have found that neck pain causes malfunction of the scapula retraction among office workers caused by postural malalignment, postural malalignment was also reduced in those with good ergonomic positions during working.\textsuperscript{(18, 38)} However, a previous study was consistent with the current study, finding that the correction of the scapular posture caused no difference in lower trapezius muscle function during computer use in people with and without neck pain.\textsuperscript{(39)}

The current study demonstrated no significant difference in the serratus anterior muscle between the symptomatic neck pain and the asymptomatic group during one hour of computer use. This study contradicted a previous study that found serratus anterior muscle activity was higher in those with neck
pain than in an asymptomatic group because scapular winging and changes in scapular kinematics of neck pain resulted in alterations in the length-tension relations of cervical muscles that were attached to the spine. However, this previous study measured muscle strength in static muscle contraction of the upper limb during elevation, which was different from our research that measured monotonous work tasks. In addition, this previous study found that neck pain causes malfunction of the scapula retraction among office workers, which was caused by postural malalignment of the scapula upward rotation. The serratus anterior muscle is the main muscle that stabilizes the scapula and works as an upward rotation of the scapula. If this muscle is in normal strength, it would result in no difference in contraction performance for those with and without neck pain.

The study showed no significant difference between the wrist extensor muscles in the symptomatic neck pain and the asymptomatic group during one hour of computer use. This study contradicted a previous study that found that computer workers who experienced acute trapezius pain in the past year resulted in a decrease in the activity of the wrist extensor. The difference might be that participants in this previous study had trapezius and acute neck pain. However, other previous studies supported this study where it was found that the muscle activity of the wrist extensor muscle, the distal muscle, was related to a computer mouse and keyboard time. No study has ever involved forearm muscle function and neck pain, although keyboard position affects neck angle. This finding is a novel result.

There are a few limitations in this study. Firstly, this study was unable to identify the cause of delayed nerve conduction velocity or quantify computer workload that might be related to the posture of the neck and upper extremities. Secondly, a comfortable sitting position of the participants might have contributed to variations in nerve conduction velocity and muscle activity. Thirdly, data collection for each research participant did not occur during the same period of the day. However, researchers gathered the data in a laboratory room with controlled temperature and sound conditions. Additionally, participants were queried about their fatigue levels before commencing each test and were given a one-hour rest period before starting the test. Finally, the participants with neck pain reported an average of moderate pain levels. Therefore, the results of this study might not accurately reflect a population with high pain symptoms. Further studies are needed, including an investigation into
neck and upper extremity posture during computer work, the impact of different pain levels, and the results of rehabilitation on nerve and muscle function. However, this study had several advantages in reflecting the results in the computer workers group for the selection of appropriate workstations and concern nerve conduction and muscle activity for the prevention of neck pain.

Conclusions

The current findings demonstrated that an hour spent on computer use could increase neck pain, delay sensory nerve conduction velocity, and decrease muscle activity of the semispinalis muscle while increasing neck pain intensity and muscle activation of scalene muscle reduction, which may result in upper extremity impairment. Therefore, the recommendation of resting, encouraging function, and flexibility of the neuromuscular system after one hour of computer use should be considered.

Acknowledgments

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Disclosure statement

Approval of the research protocol: The study protocol was approved by the Ethics Committee of the Protection of Humans, Walailak University (Ethic No. WUEC-21-312-01). Informed Consent: Informed consent was obtained from all participants before data were collected. Registry and registration No. of the study/trial: N/A. Animal studies: N/A. Conflict of interest: This study has no conflicts of interest or financial disclosures, and all the contributors participated in the study.

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Data availability statement

The data supporting the findings of this study can be obtained from the corresponding author upon reasonable request.

References


Table 1. Characteristics of the participants in the symptomatic neck pain and asymptomatic group

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Neck pain group (n = 20)</th>
<th>Asymptomatic group (n = 20)</th>
<th>p-value</th>
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<tr>
<td>Age (years); mean ± SD</td>
<td>38.50 ± 7.54</td>
<td>37.90 ± 7.79</td>
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<td>30-40 years; n (%)</td>
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<td>Male = 3 (15)</td>
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<td></td>
<td>Female = 9 (45)</td>
<td>Female = 9 (45)</td>
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<tr>
<td>40-50 years; n (%)</td>
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<td>Male = 0 (0)</td>
<td>1.000\textsuperscript{b}</td>
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<tr>
<td></td>
<td>Female = 8 (40)</td>
<td>Female = 8 (40)</td>
<td></td>
</tr>
<tr>
<td>Gender:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Male; n (%)</td>
<td>3 (15)</td>
<td>3 (15)</td>
<td>1.000\textsuperscript{b}</td>
</tr>
<tr>
<td>- Female; n (%)</td>
<td>17 (85)</td>
<td>17 (85)</td>
<td></td>
</tr>
<tr>
<td>Weight (kg); mean ± SD</td>
<td>57.35 ± 7.34</td>
<td>59.27 ± 9.38</td>
<td>0.477\textsuperscript{a}</td>
</tr>
<tr>
<td>Height (cm); mean ± SD</td>
<td>158.65 ± 6.00</td>
<td>160.13 ± 6.46</td>
<td>0.459\textsuperscript{a}</td>
</tr>
<tr>
<td>BMI (kg/m\textsuperscript{2}); mean ± SD</td>
<td>22.80 ± 2.83</td>
<td>22.98 ± 3.10</td>
<td>0.853\textsuperscript{a}</td>
</tr>
<tr>
<td>Hand dominance:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Right (n)</td>
<td>17 (85)</td>
<td>19 (95)</td>
<td>0.602\textsuperscript{b}</td>
</tr>
<tr>
<td>- Left (n)</td>
<td>3 (15)</td>
<td>1 (5)</td>
<td></td>
</tr>
<tr>
<td>Duration of computer use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(hours); mean ± SD</td>
<td>5.85 ± 1.95</td>
<td>5.65 ± 2.46</td>
<td>0.777\textsuperscript{a}</td>
</tr>
<tr>
<td>ST-5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Low; n (%)</td>
<td>14 (70)</td>
<td>11 (55)</td>
<td></td>
</tr>
<tr>
<td>- Moderate; n (%)</td>
<td>3 (15)</td>
<td>6 (30)</td>
<td></td>
</tr>
<tr>
<td>- High; n (%)</td>
<td>2 (10)</td>
<td>2 (10)</td>
<td>0.068\textsuperscript{b}</td>
</tr>
<tr>
<td>- Severe; n (%)</td>
<td>1 (5)</td>
<td>1 (5)</td>
<td></td>
</tr>
</tbody>
</table>

\* p-value < 0.05, \textsuperscript{a} Independent sample t-test, \textsuperscript{b} Mann-Whitney U test, BMI = body mass index, ST-5 = Stress test questionnaire
Table 2. Comparison of nerve conduction velocity between the pre-test and post-test within the neck pain and asymptomatic group

<table>
<thead>
<tr>
<th>Variables</th>
<th>Neck pain group (n = 20) mean ± SD</th>
<th>Asymptomatic group (n = 20) mean ± SD</th>
<th>Baseline comparison between group (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
<td>Pre-test</td>
</tr>
<tr>
<td>Neck pain intensity by VAS</td>
<td>4.30 ± 1.19</td>
<td>5.86 ± 1.24</td>
<td>&lt;0.001 **</td>
</tr>
<tr>
<td>Nerve conduction velocity (m/s)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median nerve velocity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Motor nerve</td>
<td>58.60 ± 2.57</td>
<td>59.53 ± 3.67</td>
<td>0.191 c</td>
</tr>
<tr>
<td>- Sensory nerve</td>
<td>56.59 ± 5.96</td>
<td>55.94 ± 5.20</td>
<td>0.573 c</td>
</tr>
<tr>
<td>Ulnar nerve velocity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Motor nerve</td>
<td>64.18 ± 5.39</td>
<td>62.18 ± 5.081</td>
<td>0.064 c</td>
</tr>
<tr>
<td>- Sensory nerve</td>
<td>58.29 ± 5.34</td>
<td>54.60 ± 4.56</td>
<td>0.008 c</td>
</tr>
</tbody>
</table>

* p-value < 0.05, ** p-value < 0.001, c Independent sample t-test, b Mann-Whitney U test, a Paired sample t-test, e Wilcoxon signed-rank test, VAS = Visual analog scale
Table 3. Comparison of the mean difference of nerve conduction velocity between the symptomatic neck pain and asymptomatic group

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Neck pain group (n = 20)</td>
<td>Asymptomatic group (n = 20)</td>
</tr>
<tr>
<td>VAS (post-pre)</td>
<td>1.56 ± 1.39</td>
<td>1.98 ± 1.66</td>
</tr>
<tr>
<td>Nerve conduction velocity (pre-post) (m/s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median nerve velocity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Motor nerve</td>
<td>-0.74 ± 2.42</td>
<td>-2.11 ± 9.40</td>
</tr>
<tr>
<td>- Sensory nerve</td>
<td>0.65 ± 5.07</td>
<td>-1.79 ± 6.77</td>
</tr>
<tr>
<td>Ulnar nerve velocity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Motor nerve</td>
<td>2.00 ± 4.49</td>
<td>0.62 ± 2.94</td>
</tr>
<tr>
<td>- Sensory nerve</td>
<td>3.69 ± 5.55</td>
<td>0.94 ± 8.33</td>
</tr>
</tbody>
</table>

<sup>a</sup> Independent sample t-test, <sup>b</sup> Mann-Whitney U test, VAS = Visual analog scale
A list of Figure Legends

Figure 1. Nerve conduction attachment; (1A) Motor nerve conduction velocity of median nerve, (1B) Motor nerve conduction velocity of ulnar nerve, (1C) Sensory nerve conduction velocity of median nerve, and (1D) Sensory nerve conduction velocity of ulnar nerve.
Figure 3. Muscle activity between the symptomatic neck pain and asymptomatic group. (2A) Upper trapezius muscle activity, (2B) Lower trapezius muscle activity, (2C) Serratus anterior muscle activity, (2D) Scalenus muscle activity, and (2E) Wrist extensor muscle activity. The error bars represent standard deviation.