Immediate Effect of Stress-induced Computer Typing on EMG Activity of Accessory Breathing Muscles and Respiratory Rate

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ABSTRACT

Stress-induced computer work has been reported to be a factor affecting work-related musculoskeletal disorders (WMSDs). Limited studies have been conducted concerning stress-induced work, compared with physical related factors. The aim of this study was to determine the effects of stress-induced computer work on changes in accessory breathing muscle activity and respiratory rate. Ten healthy volunteer computer users with 20-40 years of age performed 30 minutes of computer typing with a 10-minute induced stress in the middle period. During the first and last 10 minutes they were allowed to type at a comfortable pace and speed. Electromyography (EMG) activity of the upper trapezius and anterior scalene muscles and the respiratory rate were recorded throughout 30 minutes. EMG activity of accessory breathing muscles and respiratory rate were significantly increased during computer typing with a 10-minute induced stress. No significant difference of both accessory breathing muscles activity and respiratory rate were found during the first and the last 10-minute periods. This study's findings suggested that psychosocial stress during computer work results in increased accessory breathing muscles activity, change breathing patterns, and may lead to increased tendency of WMSDs.

Keywords: computer work, psychosocial stress, EMG activity, accessory breathing muscles

J Public Health 2019; 49(2): 144-154

Article info: Received October 1, 2018; Revised January 25, 2019; Accepted March 7, 2019.

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Introduction

Work-related musculoskeletal disorders (WMSDs) are major health problems for computer workers[1]. Many related studies have shown that computer work for long periods increased the risk of neck symptoms and disorders related to the duration of computer work[2-3]. Increased neck muscle activities from the muscles occurred during computer work including the sternocleidomastoid, anterior scalene and upper trapezius[4]. These muscles are known as accessory breathing muscles which normally work when a requirement exists for more oxygen consumption[5]. Few studies have found the relationship between accessory breathing muscles activities and respiratory rate[6-7]. Recruitment of accessory breathing muscles is common with increased physical demand, resulting in increased respiratory rate and decreased intercostal muscles and diaphragm activities[5, 8].

Among sedentary workers, implying less physical demand, less activity from accessory muscles should have occurred. However, some studies have found high activity of the muscles among these workers[9-10], particularly of the trapezius muscle. Interestingly, stress was found to cause increased upper trapezius muscle activity[11], resulting in decreased pain tolerance and increased pain sensitivity, which made this muscle prone to high activity and becoming injured[12]. However, apart from the upper trapezius muscle, few studies concerning other accessory breathing muscles have been conducted in relation to stress. Recruitment of accessory breathing muscles is common when physical demand increases, to help the intercostal muscles and diaphragm activity[5, 13]. This study aimed to determine changes in accessory breathing muscle activity and respiratory rate during stress-induced computer typing.

Material and methods

Participants

The study employed a comparative design approved by the Mahidol University Institutional Review Board (MU-IRB COA. No. 2017/218.2711). Ten healthy volunteer computer workers aged 20 to 40 years were recruited. The criteria included 1) having regular experience in computer typing 4 to 8 hours daily at least one year, 2) having normal eye sight and 3) having stress level not more than level 2 resulting from the Suanprung Stress Test-20[14]. Participants with a diagnosis of musculoskeletal problem or disorders from an orthopedic physician, any neurological symptoms, history of systemic diseases, respiratory disease or cardiovascular disease, were excluded.

Sample size calculation

Following Upiriyasakul's study in 2012[15], sample size was calculated to warrant a clinical study pertaining to risks of enrolling either an inadequate number of participants or more participants than the minimum necessary to reject the null hypothesis. The researcher calculated the sample size using δ = 6.74, α = 0.05 and 1-β = 0.95. The number of participants after estimating a 20% of dropout was 10.

Procedure

Before starting the stress-induced computer task, participants adjusted their individual workstations, based on comfort. Typing speed[16] was determined to measure the physical demand during 30 minutes of computer typing. The stress questionnaire[17] was used to measure the mental demand before and after the computer typing task. The respiratory sensor was strapped around the chest wall at xiphoid process level (NeXus-10 Mark II, Mind Media, The Netherland). The Ag-AgCl surface electrodes were placed on the upper trapezius and anterior scalene muscles. One related study of the upper trapezius muscle indicated high activity during computer work in a stressful environment[11]. Furthermore, the anterior scalene muscle caused thoracic outlet syndrome, one disorder of WMSD. Electromyography (EMG) from these muscles and respiratory rate were recorded during 30 minutes of computer typing with 10-minute induced stress in the middle period.

Stress-induced computer task

The duration of computer work in this study was divided in 3 periods of 10 minutes; the first period (T_1), the middle period (T_2) and the last period (T_3). During T_1 and T_3 the participants needed to type by copying the text shown in the typing program at their own comfortable pace and speed. They were allowed to skip any typing error. During T_2 the participants were instructed to type as fast as they could with the highest accuracy possible. The participants were concerned about word collection and typing speed while typing. Every minute the participants were encouraged to work faster and faster for 10 minutes. The researcher also informed participants that they would receive payment for participating but the payment might be deducted when typing accuracy was less than 90% during the T_2 period. The typing program used in this study was taken from https://www.speedtypingonline.com/typing-test[16].

Surface EMG recordings

EMG activity of the accessory breathing muscles were measured using a surface EMG (Telemyo Direct Transmission System, Naroxon INC, USA© 2012) during computer work. The Ag-AgCl surface electrodes were placed at the posterior triangle of the neck at the level of the cricoid cartilage, so as to lie over the lower portion of the anterior scalene muscle[18]. On the upper trapezius muscle, the markers were placed 2 cm slightly lateral to and at one half of the distance between the spinous process of C7 and the acromion of the scapula[19]. The inter-electrode impedance was kept below 2 kΩ. EMG was set at 1000 Hz sampling rate with the 350 Hz of low pass frequency and the 30 Hz of high pass frequency to reduce the noise level. Raw EMG data was calculated to determine root mean squared (RMS).

Data deduction and statistical analysis

EMG amplitude of both muscles and respiratory rate were averaged from every 10 minutes of data. One-way repeated ANOVA was used to test significant differences of EMG amplitude of the accessory breathing muscles, respiratory rate and physical demand between periods of computer typing task. The paired t-test was used to test significant differences in mental demand before and after computer typing task

Results

Ten participants were recruited from healthy volunteers who had used computers regularly. In all, 5 males and 5 females were aged 26.89 ± 4.29 years had dominant right hand, ±and 23.14 ± 1.99 kg/m^2 of body mass index (BMI) (Table 1)

Table 1 Participant characteristics

	Mean ± SD (n = 10)	**Minimum (n = 10)**	**Maximum (n = 10)**
Age (year)	26.89 ± 4.29	21	32
Weight (kg)	68.56 ± 10.18	51	80
Height (cm)	171.56 ± 7.88	159	180
BMI (kg/m^2)	23.14 ± 1.99	19.43	24.69

Data presented as Mean ± SD

kg = kilogram, cm = centimeter, kg/m^2 = kilogram per square meter

The EMG activity of the accessory breathing muscles and respiratory rate changed significantly in the identical direction. Significant differences were observed at $p<0.05$ during 30 minutes of computer typing with a 10-minute induced stress during the middle period (Table 2). The EMG amplitude of the accessory breathing muscle and respiratory rate increased with stress induced during the middle period and decreased after the stress was withdrawn.

Table 2 Average value of EMG amplitude of the accessory breathing muscle and respiratory rate during 30 minutes of computer typing with 10 minutes induced stress in the middle period.

	T_1 (Mean ± SD)	T_2 (Mean ± SD)	T_3 (Mean ± SD)	F	*p*-value
Accessory breathing muscle (mV)					
Rt. Upper trapezius	16.91 ± 18.76	32.97 ± 33.86	11.67 ± 19.8	4.91	0.047*
Lt. Upper trapezius	6.57 ± 5.18	25.53 ± 16.42	8.11 ± 6.96	5.42	0.038*
Rt. Anterior scalene	2.64 ± 1.24	3.72 ± 2.05	2.85 ± 1.31	9.35	0.011*
Lt. Anterior scalene	2.96 ± 2.53	4.54 ± 2.39	2.96 ± 1.27	6.85	0.023*
Respiratory rate (bpm)	21.1 ± 3.38	28.25 ± 4.23	21.03 ± 3.94	36.28	<0.01**

* Significant difference at *p*-value <.05 by one way repeated ANOVA

** Significant difference at *p*-value <.01 by one way repeated ANOVA

T_1 = first period, T_2 = middle period, T_3 = last period, mV = micro volts, bpm = breath per minute

Post-hoc analysis of these periods showed no significant difference of the EMG amplitude of both the upper trapezius and anterior scalene muscles, and respiratory rate between T_1 and T_3 (Table 3). The muscles activity and respiratory rate between T_1 and T_2 and between T_2 and T_3 significantly differed at $p<0.05$. These results showed the effect of the psychosocial stress on accessory breathing muscles activity and respiratory rate.

The physical demand presented by speed typing during the 30 minutes of computer typing with a 10-minute induced stress in the middle period showed no significant difference (Table 4). The stress questionnaire represented the mental demand using the level of stress between pre- and posttest after 30 minutes of computer typing. The results showed significantly different stress level (Table 5).

Table 3 Post-hoc EMG activity of accessory breathing muscles and respiratory rate while typing on a computer keyboard at T_1, T_2, and T_3

	T_1 (Mean ± SD)	T_2 (Mean ± SD)	*p*-value	T_1 (Mean ± SD)	T_3 (Mean ± SD)	*p*-value	T_2 (Mean ± SD)	T_3 (Mean ± SD)	*p*-value
Accessory breathing muscle (mV)									
Rt. Upper trapezius	16.91 ± 6.25	32.97 ± 11.29	0.028*	16.91 ± 6.25	11.67 ± 6.6	1.00	32.97 ± 11.29	11.67 ± 6.6	0.03*
Lt. Upper trapezius	6.57 ± 1.73	25.53 ± 5.48	0.025*	6.57 ± 1.73	8.11 ± 2.32	1.00	25.53 ± 5.48	8.11 ± 2.32	0.036*
Rt. Anterior scalene	2.64 ± 0.41	3.72 ± 0.68	0.035*	2.64 ± 0.41	2.86 ± 0.44	1.00	3.72 ± 0.68	2.86 ± 0.44	0.032*
Lt. Anterior scalene	2.96 ± 0.84	4.54 ± 0.8	0.016*	2.96 ± 0.84	2.96 ± 0.42	1.00	4.54 ± 0.8	2.96 ± 0.42	0.035*
Respiratory rate (bpm)	21.1 ± 1.13	28.25 ± 1.41	<0.01**	21.1 ± 1.13	21.03 ± 1.31	1.00	28.25 ± 1.41	21.03 ± 1.31	<0.01**

* Significant difference at *p*-value < .05 by one way repeated ANOVA

** Significant difference at *p*-value < .01 by one way repeated ANOVA

T_1 = first period, T_2 = middle period, T_3 = last period, mV = micro volts, bpm = breath per minute

Table 4 Physical demand

	T_1 (Mean ± SD)	T_2 (Mean ± SD)	T_3 (Mean ± SD)	F	*p*-value
Typing speed (wpm)	22.33 ± 2.55	22.89 ± 3.06	22.33 ± 2.45	2.612	0.142

T_1 = first period, T_2 = middle period, T_3 = last period, wpm = words per minute

Table 5 Mental demand

	Before typing (Mean ± SD)	After typing (Mean ± SD)	*p*-value
Stress level	1 ± 0.00	2.11 ± 0.33	<0.001**

**Significant difference at *p*-value < .01 by paired t-test

Discussion

The activities of all the accessory breathing muscles and respiratory rate during 30 minutes of computer typing with a 10-minute induced stress in the middle period were increased significantly (Fig 1). Increased parameters may lead to the development of WMSDs. However, Yeampattanaporn et al. in 2014 found an association between neck muscle activity and breathing function among people with neck pain. Those with neck pain had decreased breathing function and high neck muscles activity[7]. However, related studies collected data during resting. The upper trapezius as well as the anterior scalene muscle are accessory breathing muscles that might increase activity when physical demand increases, implying more oxygen requirement[5,13]. In addition, many studies showed computer work in a stressful environment affected upper trapezius muscle activity[11, 20]. Moreover, the increased sympathetic activity affected change in breathing pattern to dysfunctional breathing that decreased diaphragm muscle activity and increased accessory breathing muscle activity. The decreasing activity of the diaphragm muscle affected decreased chest expansion and increased accessory breathing muscle activity. Likewise, this study found that psychosocial stress can result in increased upper trapezius muscle activity. The definition of psychosocial stress is given as a stress associated with nonphysical factors[11]. Therefore, psychosocial stress and physical demand can be the causes of high muscle activity. This increase can be also due to increased sympathetic activity to promote general survival to mental or physical threat, determined by increased muscle activity[21].

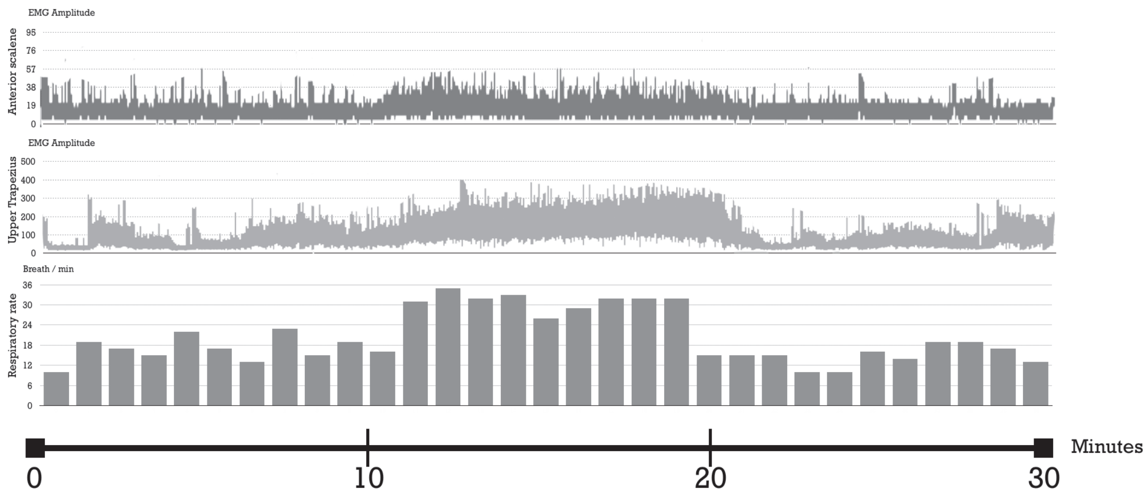

Figure 1 Average value of EMG amplitude of the accessory breathing muscle (upper trapezius and anterior scalene) and respiratory rate during 30 minutes of computer typing

Furthermore, Blatter and Bongers in 2002 found more than two hours of computer work was enough to stimulate physical factors such as muscle contraction[22]. However, this study proved the physical demand the throughout 30 minutes of work was similar. The significant increase of both muscle activities and respiratory rate in this study could be the result of psychosocial stress. With this increase, breathing function and pattern to gain more oxygen would be altered as a requirement of the body[7].

Conclusion

This study found increased accessory breathing muscle activity and respiratory rate during the 10-minute induced stress period. These increases may lead to the development of WMSDs. To prevent WMSDs, this study suggested to investigate not only physical factors such as breathing function, posture that promotes relaxed neck and shoulder muscles and muscle pain, but also psychosocial stress factor.

Acknowledgments

The authors would like to give special thanks and deepest appreciation to all participants for their excellent cooperation. We would like to thank Huachiew Chalerm-prakiet University for funding to support this research.

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ผลแบบทันทีของงานพิมพ์คอมพิวเตอร์แบบเครียดต่อการทำงานของคลื่นไฟฟ้ากล้ามเนื้อของกล้ามเนื้อช่วยหายใจและอัตราการหายใจ

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บทคัดย่อ

การทำงานคอมพิวเตอร์แบบเครียดเป็นระยะเวลานานส่งผลต่อการเกิดโรคทางระบบกระดูกและกล้ามเนื้ออันเนื่องมาจากการทำงาน แต่ยังมีข้อจำกัดในการศึกษาเปรียบเทียบการทำงานแบบเครียดกับปัจจัยทางกาย ดังนั้นการศึกษาในครั้งนี้มีวัตถุประสงค์เพื่อศึกษาผลของงานคอมพิวเตอร์แบบเครียดต่อการเปลี่ยนแปลงการทำงานของคลื่นไฟฟ้ากล้ามเนื้อของกล้ามเนื้อช่วยหายใจและอัตราการหายใจ อาสาสมัครผู้ใช้งานคอมพิวเตอร์สุขภาพดี จำนวน 10 คน (20-40 ปี) ทำการพิมพ์งานเป็นระยะเวลาทั้งหมด 30 นาที โดยกระตุ้นความเครียดในนาทีที่ 11-20 แต่นาทีที่ 1-10 และนาทีที่ 21-30 อาสาสมัครถูกขอให้พิมพ์งานด้วยความเร็วที่สะดวกสบาย คลื่นไฟฟ้ากล้ามเนื้อของกล้ามเนื้อ upper trapezius, anterior scalene และอัตราการหายใจ ถูกบันทึกตลอด 30 นาที พบว่า ผลของการทำงานของคลื่นไฟฟ้ากล้ามเนื้อของกล้ามเนื้อช่วยหายใจและอัตราการหายใจมีค่าเพิ่มขึ้นอย่างมีนัยสำคัญระหว่างการพิมพ์ร่วมกับการกระตุ้นความเครียดในนาทีที่ 11-20 แต่ไม่มีความแตกต่างอย่างมีนัยสำคัญของการทำงานของคลื่นไฟฟ้ากล้ามเนื้อของกล้ามเนื้อช่วยหายใจและอัตราการหายใจในนาทีที่ 1-10 และ นาทีที่ 21-30 การศึกษานี้ได้แสดงให้เห็นว่าความเครียดในระหว่างการทำงานคอมพิวเตอร์ส่งผลให้เกิดการทำงานของกล้ามเนื้อช่วยหายใจเพิ่มขึ้นและมีการเปลี่ยนแปลงรูปแบบการหายใจซึ่งอาจมีแนวโน้มทำให้เกิดโรคทางระบบกระดูกและกล้ามเนื้ออันเนื่องมาจากการทำงานเพิ่มขึ้น

คำสำคัญ: การทำงานคอมพิวเตอร์, ความเครียด, การทำงานของคลื่นไฟฟ้ากล้ามเนื้อ, กล้ามเนื้อช่วยหายใจ

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