The effects of asymmetric sitting postures on the trapezius and erector spinae during a computer mouse task in sedentary people

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Research Article

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Abstract

Background

Although a neutral sitting posture is recommended to avoid potentially musculoskeletal discomfort, many asymmetric sitting postures are still adopted during a computer mouse task in sedentary people. The computer mouse task is also an asymmetric upper extremity task. Both asymmetric sitting posture and asymmetric upper extremity task have detrimental effects for long-term sedentary people.

Objectives

To determine how personal characteristics (gender, age, BMI) influenced sedentary people, to investigate the effects of asymmetric sitting postures on muscular activity of trapezius and erector spinae, and to evaluate the differences in the right and left muscular activities during a computer mouse task in sedentary people.

Methods

A 3x3x2 (Backrest conditions x Lower extremity conditions x Right-left difference of examined muscles) repeated-measured experiment was design. The activities of four muscles (the trapezius and erector spinae on both sides) were collected by surface electromyography. Sixty sedentary people were recruited and randomly assigned sitting postures. All of them were right handed, and the right side was task side.

Results

For the personal characteristics, the female group in Gender variable and the underweight groups in BMI variable appeared lower EMG activity in trapezius. The 20–29 and forty-and-over groups in Age variable and healthy group in BMI variable appeared higher EMG activity in erector spinae. The trapezius activity was lower in the left cross-legged sitting posture than in the symmetric sitting posture. The erector spinae activity was higher in the right side than in the left side in both the left and the right cross-legged sitting postures.

Conclusion

The compensation mechanism of lower back regions was found in asymmetric sitting postures, although the muscle activity of neck/shoulders regions decreased in the non-task side cross-legged sitting postures. The present study suggests that asymmetric sitting postures are not appropriate options for sedentary people during the operation of a computer mouse.

Background

In modern occupational contexts, most office workers sit for prolonged periods. According to some studies, the sedentary behaviours are positively related to some personal characteristics including obesity, Body Mass Index (BMI), metabolic symptoms, and other health problems (1–4). The studies also reported that the neck, shoulder, and back discomfort increased when operating computer mouse at work and sit for prolonged periods in sedentary people (5, 6).

For alleviating the musculoskeletal discomfort, sedentary people often attempt to adopt cross-legged sitting postures. The effects of cross-legged sitting postures on the spinal and pelvic regions have been examined in the previous researches(7–10). The cross-legged sitting postures decreases abdominal muscle activity to prevent fatigue (7), increases hip flexion and hip adduction to contribute stability (8), and causes significant malalignment of the pelvis and trunk (9, 10). What the previous researches recommended to avoid potentially painful positions was not the cross-legged sitting posture but a neutral sitting posture (11, 12).

Operating a computer mouse was a common task when sedentary people performed standard computer work. Operating a computer mouse was asymmetric task and tended to cause the imbalance muscle activity for their shoulder and neck regions(5). Evidence suggests that cross-legged sitting during a computer typing task (symmetric task) has detrimental effects, and this posture cannot be recommended for long-term sedentary work (10). As of now the impact of various sitting posture on shoulder and neck regions when operating a computer mouse (asymmetric task) still remained to be investigated. In addition, previous research focused on comparing the differences between right cross-legged sitting postures and neutral sitting postures (7, 9, 10, 13), with little examination of the effects of the right cross-legged sitting posture and the left cross-legged sitting posture. Our research was conducted in an attempt to understand the effects of right and left cross-legged sitting postures on right and left muscle activity of neck and lower back in sedentary people when performing a computer mouse task.

The present study aimed to determine how personal characteristics, including gender, age, and BMI, influenced muscle activity when operating a computer mouse in sedentary people. This research also aimed to investigate the relationships between muscular activity and various sitting postures in sedentary people. For muscular activity, the trapezius and erector spinae were chosen to indicate the workloads of the neck/shoulders and low back. For sitting postures, our research attempted to categorize the various sitting postures according to backrest conditions and lower extremity conditions. The backrest categories were full-backrest, non-backrest, and humpbacked-backrest. The lower extremity categories were right cross-legged posture (cross-legged with the right knee over the left knee), left cross-legged posture, and symmetric sitting. Nine sitting postures were developed based on backrest conditions (3) and lower extremity conditions (3).

Method

Subjects

Sixty subjects (30 males and 30 females) ranging in age from 21 to 54 years (mean 32.64 (SD $\pm$ 8.41) years), all of whom worked with computers in their offices for over 8 hours each day, were recruited through an internet advertisement. All were sedentary, and none had a history of orthopaedic surgery or musculoskeletal injuries. The Institutional Review Board of Fu Jen Catholic University approved all protocols and consent forms (FJU-IRB NO: C103147). Informed consent was obtained directly from the participants. All methods were performed in accordance with the relevant guidelines and regulations by including a statement in the Ethics approval and consent to participate section to this effect. The demographics of the subjects are presented in Table 1.

Table 1
The descriptive data of the demographic data of the subjects

Items		Range	Mean	SD	Median
Age (years)	Male n = 30	21.00–54.00	33.70	8.63	32.00
	Female n = 30	21.00–48.00	29.57	8.16	26.00
Height (cm)	Male n = 30	163.00–189.00	174.93	5.38	174.50
	Female n = 30	147.00–173.00	158.27	6.45	157.50
Weight (kg)	Male n = 30	52.00–87.00	68.97	9.14	67.50
	Female n = 30	40.00–70.00	52.10	7.82	50.50
BMI	Male n = 30	17.78–28.74	22.55	2.89	21.90
	Female n = 30	16.56–27.77	20.82	3.09	20.10
Seat height (cm)	Male n = 30	31.00–44.00	39.83	2.34	39.00
	Female n = 30	27.00–41.00	35.13	4.11	36.00

Experimental protocol

Experimental design and posture assignment

A Backrest conditions (3) x Lower extremity conditions (3) x Right-Left difference of examined muscles (2) repeated measures experiment was designed. The Backrest factors was the full-backrest, non-backrest, and humpbacked-backrest conditions. The Lower extremity factors was the left cross-legged, right cross-legged, and symmetric sitting postures. The Right-Left difference of the examined muscles factor was the right and left sides. Backrest conditions and Lower extremity conditions were within-subject factors. The Right-Left difference of examined muscles was a between-subject factor.

Backrest conditions (3) x Lower extremity conditions (3) were integrated into 9 postures. For example, the full-backrest x left cross-legged sitting conditions featured a full-backrest and left cross-legged sitting

posture (Fig. 1, left). The subjects were first introduced to all of the sitting postures. After the introduction, the sitting postures were randomized and assigned, and the subjects maintained each posture for three minutes while playing a computer game with a mouse. A competitive computer game was selected because muscle activity is greater during the performance of stressful computer tasks than during typing, editing, and precision tasks (5). To increase motivation, our team provided extra gifts as rewards for the top three performers.

EMG Data Collection and Analysis

EMG data were concurrently collected while the subjects were seated in each assigned posture. Surface EMG data were recorded with a commercial recording system (Nexus-10 Mind Media BV, Roermond, The Netherlands) and surface electrodes. The surface electrodes, each having a diameter of 5 mm, were placed over the middle fibres of the left trapezius (Left Trapezius), middle fibres of the right trapezius (Right Trapezius), left lumbar part of the erector spinae (Left Erector), and right lumbar part of the erector spinae (Right Erector) with 2 cm between any two electrodes. After the skin was cleaned with alcohol, the electrodes were placed on the thickest area of the muscle belly based on the suggestion of Edlaji and Perotto (14). The earth electrode was placed on the clavicle.

EMG data of maximum voluntary contraction (MVC) were measured by a research assistant during maximum isometric contraction against static resistance. For the MVC of the trapezius, the subjects performed maximum isometric shrugs against downward static resistance on the shoulders provided by a research assistant while in an upright sitting posture. For the MVC of the erector spinae, the subjects lay prone and performed maximum isometric trunk extension until the umbilicus left the mat while the assistant provided downward static resistance on the shoulders. Each time, the participant performed maximal contraction against resistance for 6 seconds. The EMG data were collected from the second to the fifth seconds. Each participant performed three trials separated by rest periods of 3 minutes. If the participants still felt tired after resting, the resting time was prolonged. The resistance was provided by the same research assistant and supervised by the principal investigator to ensure inter-rater reliability.

The EMG data of the experimental conditions were measured during each assigned sitting posture. While the subjects maintained an assigned sitting posture and played a computer game with a mouse for three minutes, the EMG data were collected for analysis during the third minute (2'00"-2'59").

Data processing

Raw EMG data were collected at 1,024 Hz using BioTrace+ software and a data acquisition card on a notebook computer. EMG raw signals were recorded and processed with a 10–10,000 Hz band-pass filter, amplified by a gain of 500. Filtered signals were full-wave rectified and smoothed with a 50-msec time constant to produce a linear envelope. The EMG signals were quantified in terms of root mean square (RMS). RMS is used in EMG studies to describe the energy that a muscle generates in the time domain.

For the MVC trial, the EMG activities of each muscle were quantified in terms of RMS measured over a 3-second period, and the data of the first and last seconds were deleted. The curve of the rectified EMG signal was integrated; that is, the muscular activity value was the area under the 3-second period. For consistency in time series, the data were divided by 3. The rectified EMG data were averaged across the 3 trials under the same condition.

For each experimental trial, the EMG activities of each muscle were quantified in terms of RMS measured over a 60-second period, and the data of the first and last 15 seconds were deleted. The curve of the rectified EMG signal was integrated; that is, the muscular activity value was the area under the 30-second period. For consistency in time series, the data were divided by 30.

The dependent variable, normalized EMG (MVC %), was a supposed exertion level as a percentage of the MVC; that is, $\text{normalized EMG (MVC \%)} = (\text{EMG for sitting posture} / \text{EMG for MVC}) \times 100$.

Statistical analyses

A 2x3x3 repeated analysis of variance (ANOVA) was used to analyse the MVC% data of each muscle for the Gender (2) x Age (3) x BMI (3) experimental design. A 3x3x2 mixed repeated analysis of variance (ANOVA) was used to analyse the MVC% data of each muscle for the Backrest conditions (3) x Lower extremity conditions (3) x Right-Left difference of examined muscles (2) experimental design. Bonferroni post hoc tests and paired t tests were used as follow-up tests for pair-wise comparisons of means. Sphericity was determined using Mauchly's Test, prior to the calculation of within-participant tests. Where sphericity could not be assumed, Huynh-Feldt adjustment for violations of sphericity was used and the degree of freedom was adjusted based on the value of epsilon. Significance was noted for a probability of a false positive of less than 5% ($p < .05$). Data were analysed in SPSS for Windows (IBM, NY, USA).

Results

The relationship between personal characteristics and Trapezius activity

For EMG activity of the trapezius, only two factors (Gender and Age) interaction were found ($p = 0.001$). But, the post hoc test indicated no significantly effect under gender condition or under age condition. The main effect of gender was significantly found ($F(1,532) = 16.141, p < 0.001$). Post hoc test indicated that the EMG activity of the trapezius was lower in the female group than in the male group. The main effect of BMI was also significantly found ($F(2,532) = 9.545, p < 0.001$). The post hoc test indicated that the EMG activity of the trapezius was lower in the underweight group than in the healthy and overweight groups, and the EMG activity of the trapezius was lower in the healthy group than in the overweight group. The variable Age was found to have no significant difference ($F(1,532) = .976, p = 0.377$) (see Table 2).

Table 2

The results of three-way repeated ANOVA for EMG activity in the anthropometric dimensions of examined muscles

Muscle	Trapezius		Erector Spinae	
Variances	F	p	F	p
Gender (G)	16.141	< .001** (F < M)	0.041	0.839
Age (A)	0.976	0.377	10.278	< .001** (A3 < A2,A4)
BMI (B)	9.545	< .001** (U < H < O)	9.740	< .001** (U,O < H)
GxA	7.628	.001**	0.958	0.384
GxB	1.293	0.275	6.528	0.002*
AxB	1.880	0.131	1.370	0.250
GxAxB	13.176	< .001	3.152	0.043
*p < 0.05, **p < 0.01.				
Male (M), Female (F); A2: 20–29 years; A3: 30–39 years; A4: >40 years; Underweight (U): <18.4; Healthy weight (H): 18.5–24.9; Overweight: (O) > 25.				

The relationship between personal characteristics and Erector spinae activity

For EMG activity of the erector spinae, only two factors (Gender and BMI) interaction were found ($p = 0.002$). But, the post hoc test indicated no significantly effect under gender condition or under BMI condition. The main effect of variable Age was found to have a significant difference ($F(2,532) = 10.278$, $p < 0.001$). Post hoc test indicated that the EMG activity of the erector spinae was higher in the 20–29 and forty or older groups than in the 30–39 group, and no difference was found between the 20–29 and forty or older groups. The main effect of BMI was also found to have a significant difference ($F(2,532) = 9.740$, $p < 0.001$). Post hoc test indicated that the EMG activity of the erector spinae was higher in the healthy group than in the underweight and overweight groups, and no difference was found between the underweight and overweight groups. The variable Gender was found to have no significant difference ($F(1,532) = .041$, $p = 0.839$) (see Table 2).

Effects of sitting postures on Trapezius activity

No interaction effects were found ($p > 0.05$) for the EMG activity of the trapezius under Backrest conditions, Lower extremity conditions, and Right-left of examined muscles. Only one variable, Lower extremity conditions, was found to have a significant difference ($F(2,236) = 4.176$, $p = 0.019$) (see Table 3). The post hoc test indicated that the EMG activity of the trapezius was lower in the Left cross-legged sitting posture (mean = 31.639 ± 14.092) than in the Symmetric sitting posture (mean = 33.145 ± 14.393) ($p = 0.044$). No difference was found between Symmetric posture and Right cross-legged sitting posture (mean = 31.877 ± 14.013) ($p = 0.090$). No difference was found between the Right and Left cross-

legged sitting postures (mean = 31.639 ± 14.092) ($p = 0.75$). These results indicated that the EMG activity of the trapezius decreased in the Left cross-legged sitting posture, but no difference was found for this muscle in the Symmetric and Right cross-legged sitting postures (see Fig. 2).

Table 3

The results of three-way mixed repeated ANOVA for EMG activity in the Backrest, Lower extremity posture, and Right-Left difference of examined muscles conditions

Muscle / Variances	Trapezius		Erector Spinae	
	F	p	F	p
Backrest (B)	0.161	0.850	0.029	0.968
Lower extremity posture (L)	4.176	0.019* (L < S,R)	0.942	0.388
Right-Left difference of examined muscles (D)	1.547	0.216	0.825	0.005** (LM < RM)
B x L	0.472	0.737	1.763	0.150
B x D	0.416	0.660	0.118	0.887
L x D	0.630	0.512	1.866	0.048*
B x L x D	0.402	0.775	1.440	0.221
* $p < 0.05$, ** $p < 0.01$.				
left cross-legged sitting condition (L), right cross-legged sitting condition (R), symmetric sitting condition (S), right examined muscles (RM), left examined muscles (LM)				

In addition, no significant differences were found in EMG activity of the trapezius in the Backrest factors ($F(2,236) = 0.161$, $p = 0.850$) and Right-Left difference of the Trapezius ($F(1,236) = 1.547$, $p = 0.216$) (see Table 3).

Effects of sitting postures on Erector spinae activity

For EMG activity of the erector spinae, a significant interaction of Lower Extremity conditions and Right-Left difference was found ($F(2,236) = 1.866$, $p = 0.048$) (see Table 3). Subsequent analysis of the Lower extremity conditions indicated that the EMG activity of the erector spinae was lower in the left side (mean = 24.474 ± 14.577) than in the right side (mean = 27.356 ± 13.942) in the left cross-legged sitting posture ($p = 0.005$), and EMG activity of the erector spinae was lower in the left side (mean = 24.661 ± 15.375) than in the right side (mean = 27.673 ± 14.272) in the right crossed-legged sitting posture ($p = 0.004$). However, no difference was found between the EMG activity of the erector spinae of the right (mean = 26.050 ± 14.655) and left sides (mean = 24.465 ± 15.029) in the symmetric sitting posture ($p = 0.163$). These results indicated that the left side EMG activity of the erector spinae decreased in the Asymmetric sitting posture (Left cross-legged sitting posture and Right cross-legged sitting posture), but no difference

in the Right-Left EMG activity of the erector spinae was found when sitting in the Symmetric posture (see Fig. 3). In addition, no significant difference in the EMG activity of the erector spinae was found for the Backrest conditions ($F(2,236) = 0.029$, $p = 0.968$) (see Table 3).

Discussion

This study evaluated the differences in the right and left muscular activities of the trapezius and erector spinae when operating a computer mouse during various sitting postures (Backrest conditions (3) x Lower extremity conditions (3)). The effects of personal characteristics, asymmetric sitting posture, asymmetric task of upper extremity, and compensation mechanism on muscle activity will be discussed as follows. One important point in our discussions is that the lower muscle activity of trapezius should be the better condition in musculoskeletal activity of neck/shoulders regions, and higher muscle activity of erector spinae should be the better condition in musculoskeletal activity of low back region. These considerations were based on the previous studies findings; the higher muscle activity of trapezius and the lower muscle activity of erector spinae in poor sitting postures were stated (15, 16).

Effect of personal characteristics on trapezius activity

In this study, we found that the muscle activity of the trapezius was lower in females than in males, and lower in the healthy and underweight groups than in the overweight group. The previous studies also found that increased contraction of neck/shoulder muscles in poor sitting posture (16). And, a significant trend for increased obesity risk and metabolic symptoms among office workers was found (4). In our study, personal characteristics, male gender and overweight BMI, are indicative of a need for more attention to sitting postures and their effects on work-related musculoskeletal discomfort in the neck/shoulder regions in sedentary people.

Effect of personal characteristics on erector spinae activity

In this study, regarding the BMI variable, we found that the muscle activity of the erector spinae was higher in the healthy group than in the overweight and underweight groups. Regarding the age variable, the muscle activity of the erector spinae was higher in the 20–29 and forty-and-over groups than in the 30–39 group. A previous study reported that participants without low back pain could control their lumbar-pelvic regions better while sitting than could people without pain (15, 17, 18). The previous studies also found that reduced contraction of trunk muscles in poor sitting posture (15). The personal characteristics, such as 30–39 in the Age variable, and the overweight and underweight groups in the BMI variable, should indicate a need to pay more attention to sitting postures and their effects on work-related musculoskeletal discomfort in the low back in sedentary people.

Effect of sitting postures on trapezius activity

Our finding that trapezius activity was lower in the left cross-legged posture (asymmetric sitting posture) than in symmetric sitting posture, but no difference was found between the right cross-legged posture

(asymmetric sitting posture) and the symmetric sitting posture. The game task with a computer mouse (an asymmetric task) was adopted in our research. All of the subjects were coincidentally right handed, so in this study, the right side was the task side and the left side was the non-task side. A previous study reported that trapezius activity was lower on the non-task side than on the task side when sedentary people performed computer mouse task in symmetric sitting (5). The previous studies also found that the compensation mechanism in cross-legged sitting, such as weight shifting to the ipsilateral side (9), posterior pelvic tilt (7, 8), and reduced contraction of abdominal muscles (8, 15). Therefore, the compensation mechanism might be an explanation for our finding. It suggested that the compensation mechanism have been adopted in the trunk and pelvic, so that both right and left sides of trapezius muscle activity decreased in non-task side cross-legged sitting than in symmetric sitting during the operation of a computer mouse.

Another finding of this study was that the trapezius activities were no significant differences in the backrest conditions is consistent with the study of Caneiro, O'Sullivan (19). The backrest conditions, including full-backrest, non-backrest, and humpbacked-backrest, have a few minor effects on the trapezius activities.

Effect of sitting postures on erector spinae activity

Our research found greater muscle activity in the right erector spinae than in the left erector spinae in asymmetric sitting postures (both left and right cross-legged postures), but not in the symmetric sitting posture. Previous research showed that the muscle activity of the external oblique was significantly higher in asymmetrical sitting than in symmetric sitting (7). Another study found that continuous cross-legged sitting caused significant malalignment of the pelvis (9) and trunk (10). In our study, cross-legged sitting, in both right and left cross-legged sitting postures, was found to significantly increase right erector spinae activity. In our study, the right side was task side during computer mouse task. Therefore, it was suggested that the body using the right (task side) erector spinae muscles to compensate for the spine asymmetry caused by the cross-legged sitting postures.

Research limitations

The present study did not collect the information regarding the subjects' perception of musculoskeletal discomfort. In the future, the relationship between musculoskeletal discomfort and compensation mechanism should be investigated for sedentary people performing symmetric and asymmetric tasks in cross-legged sitting posture for prolonged periods.

Conclusions

This research began from the standpoint of asymmetric sitting postures, rather than a neutral sitting posture, to understand the muscle activity features during operation of a computer mouse for sedentary people. The results indicated that trapezius activity was significantly lower in the left (non-task side) cross-legged sitting posture than in the symmetric sitting postures. In addition, the muscle activity of the

erector spinae was higher than that of the right (task side) erector spinae in both the left and the right cross-legged sitting postures. Even through the muscles activity of neck/shoulders regions decreased in the non-task side cross-legged sitting posture, the compensation mechanism of lower trunk and pelvis regions was found in asymmetric sitting posture. Therefore, asymmetric sitting postures are not appropriate options for sedentary people. The findings should be of relevance in the development of recommendations for sedentary people.

Declarations

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Authors' contributions

CWS contributed to the design of the study, project management, and data analysis. HPC was responsible for the design of the study, project management, data analysis and contributed to manuscript writing. CHL contributed to the design of the study, data collection, data analysis, and manuscript writing. All authors read and approved the final version of the manuscript.

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Availability of data and materials

The datasets for the study are available from the corresponding author upon reasonable request.

Ethics approval and consent to participate The Fu Jen University Institutional Review Board approved the study (C103147). All study participants provided written informed consent.

Consent for publication

Not applicable.

Competing interests

All other authors declare that they have no competing interests.

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Figures

Figure 1

Full-backrest x left cross-legged sitting condition (left), non-backrest x left cross-legged sitting condition (middle), humpbacked-backrest x left cross-legged sitting condition (right).

Figure 2

EMG activity (Mean (SD)) of the Trapezius in the three lower extremity posture conditions and two side conditions.

Figure 3

EMG activity (Mean (SD)) of the Erector spinae in the three lower extremity posture conditions and two side conditions.