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RESEARCH ARTICLE

COMPARING THE EFFECTS OF ERGONOMIC AND STANDARD OFFICE CHAIRS ON TRUNK MUSCLE ACTIVATION

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ABSTRACT

Purpose: Musculoskeletal disorders are one of the most common health problems faced by individuals who sit for prolonged periods. The sitting design of office chairs has recently become an important aspect in preventing the musculoskeletal disorders. The aim of this study is to determine the effect of different chair types on trunk muscle activation.
Material and Methods: Fifteen healthy participants (age 22.92 ± 3.40 years) were included in the study. Participants' muscle activations were assessed with the surface electromyography device while sitting and typing on the computer for 1 hour. These muscles were Thoracic Erector Spinae, Transversus Abdominus/Internal Oblique, and Upper Trapezius.
Results: When two different types of chairs were compared, in the first 10 minutes, % Maximum Voluntary Isometric Contraction difference was observed only in the Thoracic Erector Spinae ($p<0.05$). Also, % Maximum Voluntary Isometric Contraction difference was found only in the Transversus Abdominus/Internal Oblique ($p<0.05$) during the last 10 minutes. No significant difference was identified in two chair types in terms of activation of Upper Trapezius ($p>0.05$).
Conclusion: It should be considered that chair type may change the activation of trunk muscles in individuals working in a long-term sitting posture. Therefore, the use of ergonomic chairs suitable for the physiological needs of individuals should be recommended in order to encourage increased trunk muscle activation during prolonged sitting.

Keywords: Electromyography, ergonomics, muscle activation, office chairs.

INTRODUCTION

Musculoskeletal disorders (MSD), one of the most common health problems faced by office workers during work activity, are neuromuscular diseases that affect nerves, tendons, muscles, ligaments, and skeletal structure of the body (1,2,3). The most common MSD among office workers is neck and low back pain. The causes of these diseases include a sedentary lifestyle, prolonged sitting at a desk, and adaptation to sitting postures characterized by increased flexion and rotation in the neck and low back area among office workers (4). Many studies examining the impacts of parameters like furniture design at the office, working chair and desk design as well as prolonged sitting in front of computer and posture disorders of office workers indicated that ergonomic deficiency is a major risk factor for the work-related MSD (5,6,7). Any disproportion in chair dimensions may disrupt the ability of postural muscles to support the body, as well as causing pain and a feeling of discomfort by straining neuromuscular system unnaturally. A chair that satisfies ergonomic needs can reduce the incidence of musculoskeletal system symptoms and contribute to the prevention of spinal problems (7). Thus, sitting comfort and design of office chairs has recently become an important aspect in preventing the MSD (8,9).

Many studies exist examining the changes in trunk muscular activation in sitting postures by using different chairs or surfaces (10-16). As a result of some studies, changes of chair or surface altered (increased or decreased) trunk muscle activations (11,14,15,16), while in some studies these changes did not have any effect on trunk muscle activations (10,12,13). Office workers usually need to sit for long hours to perform their duties. However, studies using EMG in their evaluations performed their measurements in short sitting periods (13,14,15). Studies evaluating long sitting periods (from 1 hour to 3 hours) focused only on the activations of Upper Trapezius (UT), and Erector Spinae (ES) muscles (10, 12). The Transversus Abdominus (TrA) and Internal Oblique (IO) muscles work as a local system that balances the compressive forces acting on the upper lumbar segments of the spine and increases lumbar stability through intra-abdominal pressure control (16). Therefore, the inclusion of IO/TrA muscles in studies examining the effects of chairs on trunk muscle activation is of great importance in terms of interpreting the results. Thus, the aim of this study designed with surface electromyography (sEMG) was to identify changes in UT, Thoracic Erector Spinae (TES) and IO/TrA muscles activation while using two different types of chairs in healthy participants in 1 hour.

MATERIAL AND METHODS

Fifteen healthy participants (9 males and 6 females) who worked sitting for at least 2 hours a day were included in this study. Demographic characteristics are given in Table 1. Exclusion criteria included having a deformity that may prevent sitting, having low back-neck problem in the last 12 months and still suffering from pain in this area, having a neurological or systemic disease, being pregnant, and having a body mass index below 18.5 or above 30. First, the participants' history and demographic information were collected. A segmental body composition analyser (Tanita Corp., BC418, Tokyo, Japan) was used to assess body mass index. Ethical approval was obtained from a local university ethics commission (Date: 06.02.2018, Number: 14574941-199-178316, Research Code Number: 2018-25). All the participants were informed about the study, and they signed an "Informed Consent Form" stating that they volunteered to take part in the study.

Figure 1. Standard office chair

Figure 2. Ergonomic office chair

The research was designed as a single group, repeated measures study. A sEMG device (Noraxon, USA, Inc, Scottsdale, AZ) was used to assess the activation of muscles. The assessments were conducted with the sEMG for 2 days and on two types of chairs while the participants were performing predetermined activities. Before starting the measurement, the subjects were shown the chair settings. One of the chairs was a non-ergonomic, non-adjustable standard office chair with backrest (see Fig. 1). As for the other chair, its seat depth, back hardness, lumbar support, armrest height, the width and angle of arm support, and angle and height of neck support were adjustable while it could support particularly spinal curves ergonomically. With the backrest applying resistance to the user, this chair could also be inclined 8 degrees forward and reclined 25 degrees and locked in four different positions (see Fig 2).

A randomization program was used to determine on which chair each participant would start the trial. The participants were asked to perform a single office task (typing on the computer desk) for 1 hour in their usual working posture. Over this 1 hour period, EMG signals were recorded. The second assessment was conducted after 7 days.

In collecting data, Noraxon's Mini DTS 8-channel EMG system (Noraxon, USA, Inc, Scottsdale, AZ) was used to measure signals obtained from the muscles. To record the EMG signals, the study used disposable, self-adhesive Ag/AgCl electrodes (Noraxon Dual EMG Electrode, USA), which are only intended for surface EMG applications.

Table 1. Demographic characteristics of participants.

	Participants (n=15) (mean±SD)
Age (years)	22.92 ± 3.40
Weight (kg)	63.02 ± 12.65
Height (cm)	174.78 ± 11.59
BMI (kg/m^2)	20.52 ± 2.96

SD: Standard Deviation, BMI: Body Mass Index

Since the previous sEMG study demonstrated there was no significant difference in muscle activation on the right and left sides of the body in healthy participants during relatively static tasks, only the muscles on the right side of the body were analysed (15). These muscles were TES, IO/TrA, and UT. Electrodes were placed at a distance of 20 mm, the diameter of the two circular adhesive areas was 1 cm, and dimensions of the figure 8-shaped adhesive were 4 cm x 2.2 cm (1.56 x 0.87 inch) (17). Before placing the electrodes, the area was shaved and lightly abraded with cotton soaked in alcohol to decrease the skin impedance below 5 kΩ (18). The electrodes were placed in parallel orientation to the determined muscle fibers as recommended by Surface Electromyography for the Non-Invasive Assessments of Muscles (SENIAM) (18). As TrA is positioned below the IO muscle fibers, the electrode determined for the IO also captures electrical signals for the TrA (17). Therefore, the data on these two muscles were assessed and interpreted together. The first 10 minutes and the last 10 minutes were included in the electromyographic analysis. Raw EMG signals were first checked visually for possible electrocardiographic artefact. Then, 10 Hz, IIR, Butterworth High-Pass and 500 Hz, IIR, Butterworth Low-Pass movement artefact and EKG filter were applied, and the Root Mean Square (RMS) values were computed by using the raw EMG data within sequential time windows (time windows: 0.1 s) to assess the EMG signals. After chair trials, Maximum Voluntary Isometric Contraction (MVIC) was induced for each muscle to normalize the EMG data, and EMG amplitudes were recorded.

Statistical Analysis

For statistical analyses, Statistical Package for Social Sciences (SPSS), Version 22.0 (SPSS inc., Chicago, IL, USA) was used. Visual (histogram and probability graphs) and analytical methods (Kolmogorov-Smirnov/ Shapiro-Wilk Tests) were used to check whether the data were normally distributed, visual. Non-normal variables were indicated by using median (IRQ) while categorical variables were identified by using frequency and percentage (%). Wilcoxon Test was performed to determine the difference between the two chair types. For statistical significance, type 1 error level was set at 5%.

Table 2. Comparison of EMG values for both chair types in the first 10 minutes of the measurement

	Standard Office Chair	Ergonomic Office Chair	p
	Median (IQR)	Median (IQR)	
Upper Trapezius (MVIC%)	3.05 (1.48/9.26)	3.26 (1.02/6.55)	0.394
Thoracic Erector Spinae (MVIC%)	4.49 (3.96/7.74)	5.88 (4.09/12.98)	**0.047***
Transversus Abdominis/ Internal Oblique (MVIC%)	2.03 (1.37/4.54)	2.43 (1.08/4.00)	0.394

*p < 0.05. EMG: Electromyography, MVIC: Maximum Voluntary Isometric Contraction, IQR: Interquartile Range

Ethical Approval

Ethical approval was obtained from Gazi University Ethics Committee (Date: 06.02.2018, Number: E.25915, Research Code Number: 2018-25).

RESULTS

The comparison of the EMG activity on both chair types in the first 10 minutes of the 1 hour record indicated that there was a difference in MVIC% in the TES (p<0.05) while there was no significant difference between the chairs in other muscles (p>0.05, Table 2). According to the analysis result, it was found that muscular activation of the TES on the ergonomic chair was higher than the standard chair; however, the activation levels of other muscles were similar on both chairs.

Comparison of the EMG activity on the chairs in the last 10 minutes displayed a difference in MVIC% in the IO/TrA (p<0.05), whereas no significant difference was observed between the chairs in other muscles (p>0.05, Table 3). This result showed that the activation level of the IO/TrA in the ergonomic chair was higher than the standard chair while the activation levels of other muscles on both chairs were similar.

DISCUSSION

In this study, UT, TES, and IO/TrA muscle activation changes of individuals who perform typing tasks on the computer for 1 hour in 2 different chairs were examined. We found that the activation of the TES muscle in the first 10 minutes and the activation of the IO/TrA muscles in the last 10 minutes were higher in the ergonomic chair compared to the standard chair. No significant difference was identified between the two chair types regarding the activation of UT muscle. Office workers spend about 82% of their working time in a sitting position. Office work typically involves a prolonged static work posture, repetitive movements, and inappropriate hand and spine positions during work (19,20). For this reason, musculoskeletal disorders are very common among office workers (8, 9, 19). It has been reported that a chair that meets ergonomic requirements can be beneficial in reducing musculoskeletal symptoms and preventing spinal problems (7). Therefore, an increased number of studies are investigating the need for chairs that can support physiological curvatures ergonomically and reduce the inactivation of the trunk muscles in individuals who work in prolonged sitting postures and different types of chairs (10, 14, 15, 16). In their study on surgeons, Dalager et al. (2018) compared the effects of two custom-built ergonomic chairs with different and adjustable backrests, and a regular office chair on the muscle activation of the trapezius and ES (12). The study concluded that the ergonomic chair had no impact on the activation of the trapezius and the ES muscles. The authors claimed that

Table 3. Comparison of EMG values for both chair types in the last 10 minutes of the measurement

	Standard Office Chair	Ergonomic Office Chair	p
	Median (IQR)	Median (IQR)	
Upper Trapezius (MVIC%)	3.26 (1.90/8.15)	5.32 (1.81/8.76)	0.691
Thoracic Erector Spinae (MVIC%)	4.61 (2.51/8.60)	6.81 (4.33/10.12)	0.191
Transversus Abdominis/ Internal Oblique (MVIC%)	1.66 (1.30/2.54)	2.21 (1.71/4.23)	**0.031***

*$p < 0.05$. EMG: Electromyography, MVIC: Maximum voluntary isometric contraction, IQR: Interquartile Range

conducting the study using an occupational group that focused on patient safety and required intense concentration might have affected adaptation to the chair (12). Ellegast et al. (2012) investigated the effects of a standard office chair and four specific dynamic office chairs on the muscle activation of the TES and UT. The study reported no significant difference in muscle activation between the chairs. It was concluded that although the participants were shown how to use the chairs as a result of the fieldwork, their behaviour was difficult to control. Also, the participants were not accustomed to the chair, which may have affected the results (21). Neck disorders are very prevalent among office workers because of prolonged computer use. Ergonomic studies conducted on pain-free subjects asserted that a high level of muscle activation in the neck and shoulder area is a major risk factor for the development of a MSD (22). In our study, it was assumed that the muscle activation of the UT on the ergonomic office chair would decline significantly compared to the standard chair owing to its neck support with adjustable height and angle, armrest, and arm support. However, similar to the literature, there was no difference between the chairs. This may be due to the large standard deviation in UT and the fact that the participants could not adapt to the chair adequately because they were using the chairs for the first time during the measurement. Several studies have shown that a well-adjustable ergonomic chair increases productivity and reduces musculoskeletal complaints (19,21). For this reason, before the measurements, the participants were shown the adjustments of the chair. They were asked to adjust their chairs according to their comfort and sit in the position they felt comfortable. Thus, they may not have been able to use the neck and arm support of the chair effectively. For this reason, there may not be a difference between the chairs in terms of UT muscle activations.

According to the literature, the muscle activation by the TES was not affected by the chair type, but strongly affected by the diversity of office tasks performed (10). On the contrary, we found that the activation of the TES muscle in the first 10 minutes were higher with the ergonomic chair compared with the standard chair. The ergonomic office chair used in the present study can be adjusted in every aspect. It was considered that the chair could change the activation levels of the muscles by creating a push effect on the user because of its sensitive backrest. In addition, in a study investigating how TES muscle activation is affected by postural changes, it was observed that switching from sitting upright to slump sitting reduced the activation of the TES muscle by 3% maximal voluntary isometric contraction (15). Although we did not make postural assessment in our study, the reason for the increase in TES activation can be considered as the chair facilitating the upright sitting posture. As expected, TES muscle activation was higher in the ergonomic chair in the first 10 minutes.

The TrA and IO muscles function as a local system to counterbalance compressive forces on the upper lumbar segment of the spine and increase lumbar stability by controlling intra-abdominal pressure (16).

Analysis of the relevant literature did not reveal a similar study comparing the muscle activation of IO/TrA while performing computer typing tasks during prolonged sitting in ergonomic and standard chairs. The duration of the studies investigating the effects of different chairs on the activation of the IO/TrA muscles is 10 minutes or less. Besides, the studies compared standard office chairs without backrests with dynamic chairs (13,14). These studies found that IO/TrA muscle activation was not affected by the chair type. These results may be because of short evaluation times and the comparison of chairs with and without backrests. We found that the activation of the IO/TrA in the last 10 minutes was higher on the ergonomic chair compared with the standard chair. Rasouli et al. confirmed the association between slump posture and low activity of the TrA. (23). This result may be due to the fact that the ergonomic chair supports physiological curvatures and induces sitting upright with lumbar support. Although the sitting posture was not evaluated in our study, according to our clinical observation during the one-hour EMG measurement, the participants were urged to sit upright on the ergonomic chair using its adjustable lumbar support and applying resistance to the backrest. This posture resulted in, as expected, an increase in the muscle activation of the TES and IO/TrA.

In the literature, studies comparing the effects of different seat types on the activations of the muscles generally made short-term evaluations (30 min and below). However, longer-term evaluations should be preferred to interpret the results of the evaluations made in individuals who worked sitting for long hours, more effectively. In this study, EMG recordings were obtained for 1 hour while the participants performed the task of writing on the computer. By analysing the first and last 10 minutes of the one-hour recording, in addition to the acute responses, we wanted to get information about whether these muscles are different regarding their activation by the two-seat types after 1 hour.

Strengths and Limitations

The first limitations of this study were that the participants were not accustomed to the chairs used and thus, they might have failed to adapt to them. The second, the study was laboratory research. Although subjects were asked to maintain their natural sitting postures during the evaluation, they may not have been able to perform the usual natural sitting postures due to the placement of the EMG electrodes. The third limitation is postural evaluation was not performed on the participants during the EMG evaluation. The final limitation was the inclusion of healthy participants who worked in a sitting position for at least 2 hours a day instead of office workers.

CONCLUSION

Comparing the difference in UT, TES, IO/TrA muscles activation on ergonomic and standard office chairs in individuals working sitting for a prolonged time, this study concluded that the muscle activation of the TES was higher in the first 10 minutes on the ergonomic chair compared to the standard chair. On the ergonomic chair, the muscle activation of the IO/TrA was higher than the standard chair in the first 10 minutes. The increase in activation of the TES and IO/TrA muscles while sitting in an ergonomic chair can reduce the stress on passive structures such as joints and ligaments, and this may prevent the development of musculoskeletal problems. For this reason, it should be considered that chair type can change the activation of trunk muscles in individuals working in a long-term sitting position, and the chairs should be adjusted in accordance with the physiological needs of the individuals. Further research is needed for the long-term assessments of office workers evaluated with their own chairs in their own working environment.

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