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Original Article

The influence of seat height, trunk inclination and hip posture on the activity of the superior trapezius and longissimus

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Abstract. [Purpose] This study was aimed at investigating the influence of seat height and body posture on the activity of the superior trapezius and longissimus muscles. [Subjects and Methods] Twenty two healthy subjects were instructed to perform a total of eight different body postures, varying according three main factors: seat height (low and high seat); trunk inclination (upright and leaning forward at 45°); and the hips in abduction and adduction. Electromyography of the superior trapezius and longissimus was collected bilaterally, and the average values were obtained and compared across all the postures. [Results] The activity of the superior trapezius and longissimus significantly changes according to the seat height and trunk inclination. For both seat heights, sitting with trunk leaning forward resulted in a significant increase in the activity of both muscles. When sitting in a high seat and the trunk leaning forward, the superior trapezius activity was significantly reduced when compared to the same posture in a low seat. [Conclusion] This study contributes to the knowledge on the influence of the body posture and seat configuration on the activity of postural muscles. Reducing the biomechanical loads on the postural muscles must be targeted in order to improve users' comfort and safety.
Key words: Posture, Seat, Electromyography

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INTRODUCTION

Many current leisure and work-related activities are performed in a seated posture. In 2006, socioeconomic costs related to back pain and injuries in the US amounted to more than 100 billion dollars; in the Netherlands they amounted to 3.5 billion euros[1)]. In this context, pain is considered as a long-term effect of an imbalance between work-related physical factors, body posture and a subject's physical capacity[2)]. Investigating how body posture and seat configuration affects the biomechanical loads on back muscles is therefore important in order to better comprehend the mechanical interaction between user and seat interface.

Evidence suggests that signs of perceived body discomfort, such as tension, fatigue, soreness, or tremors, are predictors of back pain[2)]. In a recent study, Waongenngarm et al.[1)] found that one hour of sitting in an upright, slumped or leaning forward position is related to increased discomfort in both the upper and low back, as well as in the hips, with the highest levels found in the leaning forward posture.

Sitting upright, that is, head and trunk vertically aligned, with both the hips and knees flexed in 90°, is usually considered

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an appropriate posture for prolonged sitting[1]. However, maintaining the trunk upright in the long term requires a continuous activity of the postural muscles, which may lead to fatigue, pain and injuries. Computer usage, a typical activity in a seated posture, has been related to neck and shoulder problems[3]. Although it may be difficult to indicate one single factor that leads to pain and discomfort in computer users, it is suggested that the sustained forward head posture plays an important role as it increases the activity of the upper trapezius[4]. Additionally, in a variety of work activities, subjects lean the whole trunk forward, in order to better see the field of action, such as in dentistry. These professionals work with the head forward and the trunk leaning forward, which has been correlated with a high prevalence of postural pain and discomfort[5–9]. A recent study, by Kietrys et al.[10], found a significant correlation between increased cervical flexion and the higher level of activity of the trapezius muscle in the usage of mobile devices.

Previous studies have addressed the influence of body posture and seat characteristics on muscle activity[1, 11, 12]. The study by Kamil and Dawal[13] demonstrated that there is a correlation between postural angle (trunk and pelvic angles) and the activity of the erector spinae, multifidus and cervical erector spinae muscles. The authors found that postures close to neutral (upright) required lower muscle activation than those with the trunk leaning forward. Similarly, the influence of the pelvic inclination and seat configuration was investigated by Watanabe et al.[14], who found that with the pelvis inclined the muscle activity is higher in stable-seat sitting posture compared to unstable-seat (sitting on a balanced disk). However, to our knowledge, no study has reported how seat height, trunk and hips posture affect the activity of postural muscles.

This study aimed to investigate the influence of seat height and body posture on the activity of the superior trapezius and longissimus. Specifically, the influence on muscle activity was investigated, taking into account three main factors: low and high seat position; trunk inclination; abduction/adduction of the hip. It is hypothesized that these factors potentially affect the activity of the superior trapezius and longissimus muscles, and that both a higher seat position and hip abduction may reduce the electromyographic (EMG) activity of these muscles in a posture with the trunk leaning forward.

SUBJECTS AND METHODS

Twenty two subjects were recruited at the São Paulo State University (UNESP, Bauru, Brazil) and voluntarily participated in the study. The sample consisted of 11 men and 11 women, with a mean age of 22.3 ± 2.7 years, mean height of 1.7 ± 0.1 meters and mean weight of 61.6 ± 13.1 kilograms. Participants met the following inclusion criteria: (1) 18 years or older; and (2) having had no upper or lower back pain, injuries or deformities that could influence the maintenance of the body postures investigated in this study. Prior to data collection, volunteers were informed about the purpose and methods of the study, read and signed an informed consent form that had been approved by the Ethics Committee of the Faculty of Architecture, Arts and Communication, UNESP (Process N. 1.000.176).

A total of eight different body postures were investigated, varying according to three main factors: seat height (low seat defined as a seated posture with hips and knees at angles of 90° in a side view when sitting upright, and high seat defined as a posture with hips and knees at angles of 120° in a side view); trunk inclination (trunk upright and trunk leaning forward at 45° in a side view); and the hips in abduction (a posture with maximum hips abduction while still maintaining knees and feet vertically aligned) and adduction (with both thighs parallel to each other and aligned with the trunk). In all the investigated postures, the elbows were flexed at 90°, with the arms in a vertical position. Figure 1 shows the eight different postures that were investigated in this study.

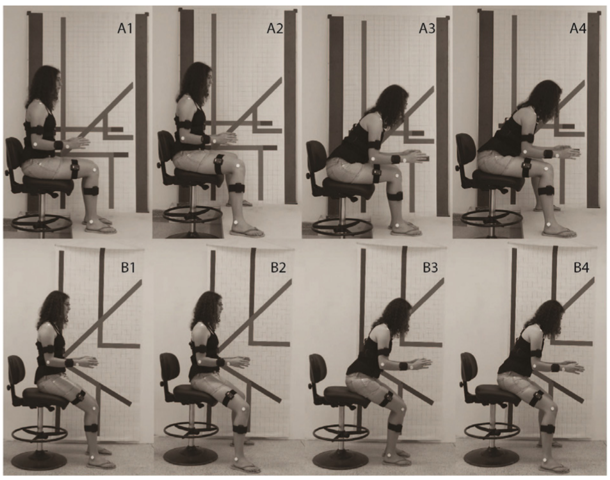

Fig. 1. The eight postures varying according three main factors: Seat Height (A: Low Seat; B: High Seat); Trunk Inclination: (1–2: upright; 3–4; leaning forward at 45°); and Hips Position (1 and 3: Adduction; 2 and 4: abduction).

Subjects maintained each posture for 20 seconds, with one minute of resting interval between two postures. In order to provide a reference for the trunk positioning (upright and leaning forward at 45°) a reference panel with the angles of the trunk and the arms was placed alongside the subject. For each seat height (low and high), a sequence of four postures were adopted by the subjects that were then repeated with the other seat height. The seat height sequence was randomized for each subject.

Electromyographic (EMG) measures of the superior trapezius and longissimus muscles were collected using the T-sens surface EMG of the CAPTIV wireless system (TEA Ergo, Nance, France). Round Ag/AgCl triode surface electrodes T3402 M (Thought Technology, Montreal, Canada) were placed bilaterally. The electrodes for the upper trapezius were placed at 50% on the line from the acromion to the spine on vertebra C7, and the electrodes of the longissimus was placed at two finger widths lateral from the process spinal of L1. Data was sampled at 2,048 Hz, with 128 Hz RMS calculation, and analyzed with the CAPTIV L-7000 software (TEA Ergo, Nance, France).

The average values of all the subjects for the EMG measurements of bilateral superior trapezius and erector spinae longissimus were obtained. The Shapiro-Wilk test was performed to check the distribution of the data. The Friedman test was performed to verify statistical differences between the EMG in the eight postures for each muscle (superior trapezius and longissimus). In order to verify statistical difference in paired data, the Wilcoxon test was applied, since the data did not have a normal distribution. Significance was determined by $p \leq 0.05$. All statistical analyses were performed using the SPSS statistics software, version 22.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

The analysis of the average EMG values showed that the activity of both muscles—superior trapezius and longissimus—significantly changes according to the seat height and trunk inclination (Friedman's test, p=0,00). Tables 1 and 2 summarizes the average values of EMG found in all the configurations for both muscles.

When comparing different positioning regarding seat height (low and high), trunk inclination (upright and leaning forward) and hips (abduction and adduction), it can be noted that sitting with the trunk leaning forward results in a significant increase in the EMG activity of both superior trapezius (Table 1) and longissimus (Table 2).

Seat height appears to be a factor that affects the EMG of the superior trapezius more than it affects the longissimus in a leaning forward posture. While no significant difference related to seat height was found in the EMG activity of the longissimus, sitting with the trunk leaning forward in a high seat significantly reduces the activity of the superior trapezius in comparison to a low seat with the same body posture. This decrease was found in both hip positions: abduction (p=0.000) and adduction (p=0.005), and no significant difference related to seat height was found in an upright posture, either for the superior trapezius or the longissimus.

For most of the cases, sitting with the hips abducted resulted in lower EMG values than with the hips in adduction, although statistically significant difference was found only in three of the eight possible combinations. The only situation in which the EMG values were found to be lower with hips adducted than abducted was with the superior trapezius, in the low seat and trunk leaning forward posture, but this was still not significant (p=0.302).

Table 1. Average EMG activity of the Superior Trapezius in all seat/posture configurations

Trunk / Hips posture	High seat	Low seat	
Leaning forward / abduction	20.6 (± 18.2)	29.0 (± 22.6)	*
Leaning forward / adduction	22.8 (± 19.9)	26.5 (± 20.9)	*
Upright / abduction	21.0 (± 19.7)	18.6 (± 17.2)	
Upright / adduction	22.3 (± 19.6)	21.8 (± 20.1)	

EMG values are expressed in mV. *p<0.05

Table 2. Average EMG activity of the Longissimus in all seat/posture configurations

Trunk / Hips posture	High seat	Low seat
Leaning forward / abduction	26.6 (± 37.2)	23.5 (± 12.6)
Leaning forward / adduction	24.2 (± 13.2)	23.9 (± 12.5)
Upright / abduction	12.3 (± 8.0)	14.7 (± 10.0)
Upright adduction	13.9 (± 9.9)	14.4 (± 11.5)

EMG values are expressed in mV. *p<0.05

DISCUSSION

This study found that seat height and body posture significantly influence the activity of the superior trapezius and longissimus muscles. Additionally, sitting with the trunk leaning forward resulted in a significant increase in the EMG activity of both muscles, corroborating the study of Kamil and Dawal[13]. This is a relevant finding considering that many current daily and work-related activities are performed in a seated posture, with some forward inclination of the trunk and neck[3, 6, 10].

Possibly the main finding of the current study is how seat height differently influences the biomechanical loads on the superior trapezius and the longissimus. While the last was not influenced by seat height with the trunk leaning forward, there was a decrease in the EMG activity of the superior trapezius in a leaning forward posture when sitting in a high seat, in comparison to a low seat. Although we did not measure neck posture, a possible explanation for this finding is based on the assumption that a higher seat would lead to a better lumbopelvic posture that, consequently, would result in a more adequate posture for the cervical region. The influence of the lumbopelvic posture on the cervical region was previously discussed in the study of Annetts et al[15]. Another interesting finding is that seat height does not influence the activity of either the superior trapezius or the longissimus in an upright posture, therefore a higher seat would only be beneficial (biomechanically) for activities performed in a posture with the trunk leaning forward.

The current results suggest that sitting with the hips in abduction may have a beneficial effect on the biomechanical loads on the trapezius and longissimus muscles, although in only three of the eight situations was a statistically significant difference found. We believe that the hips in abduction influence the trunk posture by bringing the pelvis in an anterior tilt and that this may have an effect on the postural muscles, but pelvic angle was not measured in the present study.

Although this study produced important findings, it has limitations that must be noted. First, cervical position in relation to the trunk, and hips adduction/abduction, were not controlled. Additionally, subjects' perceptions of discomfort were not assessed. This could contribute to building up a correlation between objective measurements and subjective perceptions. Therefore, future studies should address the influence of seat configuration and body posture on objective and subjective measurements, such as EMG and a discomfort scale.

This study showed that seat height, trunk inclination and hips posture influence the activity of the superior trapezius and longissimus muscles. When sitting with the trunk leaning forward, a higher seat significantly reduces the EMG activity of the superior trapezius. Additionally, the results suggest that sitting with the hips in abduction reduces the activity of both muscles, although with no statistical differences in most of the cases. This study provides additional knowledge regarding the ergonomics and biomechanics of seated postures. Furthermore, these findings also have implications for the ergonomic design of chairs and other body-support interfaces related to activities in which the users are required to maintain a posture with the trunk leaning forward. Reducing the biomechanical loads in seated posture activities must be targeted, in order to benefit both product usability and safety as well as users' comfort and satisfaction.

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