The Electromyography (EMG) Study of Erector Spine and Multifidus Muscles Activity during Sitting on Different Classroom Furniture

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Abstract

Sitting posture can affect the spine muscle activity. The aim of study was the measurement of lumbar muscle (erector spine and multifidus muscle) activity in students with different height while sitting on the same classroom furniture. The subjects classified in two groups according ISO 5970 for dimensions of classroom furniture. The muscle activity of the lumbar erector spine and the multifidus muscles were measured by surface electromyography (EMG) at the start and after 30 minutes sitting. The result of the study indicated that there was significant difference in the RMS for the lumbar erector spine muscles Group I and there was no significant difference in the RMS for multifidus muscles at the start and after 30-min sitting in the Group I, there was no significant difference in the MF measured values for the lumbar erector spine and the multifidus muscles at the start and after 30-min sitting in the Group I, but there was a significant difference in RMS and MF values measured for the lumbar erector spine and the multifidus muscles in Group II after 30-min sitting (P<0.05). This study revealed that the high desks and benches cause the increase in muscle activity in the lumbar erector spine and the multifidus muscles in students during sitting in the classroom.

Key words: Electromyography; Sitting Posture; Muscle Activity; Lumbar Erector Spine; Multifidus Muscle

Introduction

Children remain seated at school for a considerable amount of times. Static posture and prolonged sitting in a forward bending position, as student often acquire, put an extreme physiological strain on the muscles, the ligaments and in particular on the discs (Kieran et al., 2012). Sanders and McCormic (1992) point out that adjustable furniture was fundamental to developing and maintaining good posture. Certain features of such furniture can be made adjustable to meet the needs of the users (Holder, 2013). Such research demonstrates that constrained postures increase discomfort and health risk (Aaras et al., 1997). Static and constrained postures interrupt blood flow in direct proportion to the loads acting on the muscles (Cioni et al., 2010). Muscle oxygenation is reduced with fairly low loads (Pisasale et al., 2000). School work requires children to sit for extended periods of time and they may adopt a bad sitting posture. Many researchers have observed that a lot of discomfort is associated with Static and constrained postures (Marshall et al., 1995). At this stage of physical development (at the age of 10), changes to the spinal Column can come about as a result of incorrect posture frequently caused by inappropriate school furniture (Troussier et al., 1994).

Panayiotopoulos, et al. (2004) demonstrated that mismatch between the student’s bodily dimensions and the classroom furniture available to them (Panagiotopolou et al., 2004). Prolonged sitting in a conventional chair,
one that produces a 90° hip flexion, has been associated with low back pain (Pisasale et al., 2000). Brunswic (1984) showed that flexion position during sitting is associated with overstretching of the posterior ligaments and paraspinal muscles (Chang et al., 2008). Activity of spine-stabilizing muscles is for enhancing the lumbopelvic stability (Osslilvan et al., 2002).

In the evaluation of chairs, different methods have been used to measure comfort: anthropometry, subjective assessment and objective measurements such as postural, biomechanical and physiological measurements. The use of anthropometry may be useful to define functional dimension of chairs but it does not help with other features affecting comfort such as shape or inclination of seat pan and backrest (Bishu et al., 1991). Objective measurements of postures and other biomechanical and physiological factors have been also widely used to analyze their relationship with different chair features (Otun and Anderson, 1988).

Some studies have highlighted the high prevalence of back pain that exist among school- children (Watson et al., 2002; Wedderkopp et al., 2001). Storr-paulsen and Aagard- Hensen (1994) found that when children remained seated between 19 and 90 minute during a 90 minute double lesson and older children sitting for longer periods of time. They also indicated that students time spent when sitting, 57% was spent leaning forward with 43% spent leaning backwards (Storr-Paulsen and Aaggard-Hensen, 1994). Parcells et al., (1999) found that less than 20% of a total of 74 children could find acceptable chair/desk combination when the anthropometric dimensions of the children were considered (Parcells et al., 1999). Marschall et al., (1995) demonstrated subjects had significantly designed furniture (adjustable with sloping desk, back and knee Support). Subjects also demonstrated less neck flexion (34.4°) and significantly larger hip angle than when seated at traditional work – station (neck flexion=38.7°, hip angle=95.5°).

The National Institutes for Occupational Safety and Health (NIOSH) analyzed the weight of the epidemiologic evidence for the association between selected of the upper extremities and the low back and exposure to physical factor at work. Children sitting in static postures during lessons showed increased level of upper back pain in the last month and neck pain in the last week (Bernard, 1997). EMG activity of the superficial lumbar multifidus, internal oblique and thoracic erector spine muscles was significantly lower during slump sitting than during erect sitting (Bergmark, 1989).

The function of the lumbar spine muscles has been examined previously using electromyography (EMG), but there has been an overwhelming focus on the lumbar erector spine muscles and the multifidus muscles in the students with different anthropometrical characters while sitting on the nonadjustable desk and bench.

The aim of this study was investigated the effect of bench height on the lumbar erector spine muscles and the multifidus muscles activity in the healthy and pain students.

Materials and methods

Participants
Twenty four healthy male subjects were selected from student population. The subjects had no history of back disorders. A written consent form was obtained from subjects after they were given a clear explanation of the objectives and procedures of the study.

Subjects were classified in two groups according to match between school furniture dimensions and children’s anthropometry (Gouvaliand Boudolos, 2006) and ISO 5970 for dimensions of classroom furniture (Callaghan and McGill, 2001). Group I (11 subjects) (Control group) were student’s with height range from 164 to 180 cm, (14.1 (SD±0.3) years; 172.8 (SD±4.8) cm; 66.7 (SD±9.4) kg; BMI: 23.3 (SD±3.3), and Group II (13 subjects) were students with height range from 146 to 160 cm (13.8 (SD±0.9) years; 155.6 (SD±5.4) cm; 47.9 (SD±9.8) cm; BMI: 19.8 (SD±3.8)).

Furniture measurements
The dimension of the desk and bench that were measured are the following:
Bench height: the distance from the heights point on the front of the bench to the floor.
Bench depth: from the back of sitting surface of the bench to its front
Desk height: from the floor to the top of the front edge of desk

Apparatus and procedures
A traditional desk and bench which commonly used in schools in Iran was used in this study. The height desk and bench were appropriate for Group I according to the match between school furniture dimensions and children’s anthropometry and ISO 5970 for dimensions of classroom furniture. The same set of furniture was used for Group II. Therefore, based on the ISO 5970, the height of the furniture was greater than the appropriate value. A traditional desk and bench which commonly used in schools in Iran was used in this study. The height of the desk and bench was 77 cm and 25 cm, respectively.
Muscle activity

Electromyography activities were recorded from two different back muscles, the lumbar erector spine, 3 cm lateral to L3 spinous process (McGill, 1992), and lumbar multifidus, 3 cm lateral to L5 spinous process (MacIntosh et al., 1986). An 8-channel portable EMG recorder (ME 8000, mega Electronics Ltd, kupio, Finland) was used at a bandwidth of 1-1000 Hz bandwidth and a sampling rate of 1 kHz (Callaghan and McGill, 2001). The skin surface was prepared using rubbing alcohol to minimize skin resistance before the disposable Ag/AgCl surface electrodes were placed bilaterally on the skin over the selected muscles.

The root mean square (RMS) and median frequency (MF) values of EMG signals from the tested muscles were calculated for the 2 testing conditions to determine the influence of the desk-bench height on muscle activity. RMS value of each EMG signal for the 2 minute before and after of the 30 minute sitting task was computed for this purpose.

Sitting task

Each of the subjects was instructed to sit on the Bench for 30 minute, while they are watching a video film. The subjects were allowed to move and adjust themselves.

Results

A paired t-test was used to test for statistical difference before and after sitting task in RMS and MF values for the two groups. The significance level was set at 0.05.

Anthropometric dimensions

<table>
<thead>
<tr>
<th>Table 1: the dimensions of desk and bench</th>
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<tr>
<td>Desk height (cm)</td>
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<tr>
<td>77</td>
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</table>

Muscular activity

Table 2 shows the comparison of mean RMS and MF values for the lumbar erector spine and multifidus muscles before and after sitting task in Group I. Table 3 shows the compare mean of RMS and MF values for the lumbar erector spine muscles and multifidus muscle before and after sitting task in Group II. As shown in the Table 2 the lumbar erector spine which is involved in back extension in the sagittal plane and lumbo-pelvic stability had significant increase in muscle activity during sitting task in Control group (Group I) and the multifidus muscles which is involved in back extension in the sagittal plane and lumbo-pelvic stability had no significant increase in muscle activity during sitting task in Control group (Group I) but the EMG values showed significant increase in the two muscles in 2 minute before and after of the 30 minute sitting task in Group II (P<0.05).

Table 2: the compare of mean RMS and MF values for the lumbar erector spine muscles and multifidus Muscles before and after sitting task in Control group (Group I). (X ±SD)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group I</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMS means of erector spine muscles (μ.v.s)</td>
<td>3719.54±1195.57</td>
</tr>
<tr>
<td>RMS means of multifidus muscles (μ.v.s)</td>
<td>3602.63±1151.85</td>
</tr>
<tr>
<td>MF means of erector spine muscles (μ.v.s)</td>
<td>18.81±6.41</td>
</tr>
<tr>
<td>MF means of multifidus muscles (μ.v.s)</td>
<td>17.72±1.55</td>
</tr>
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</table>

*; (P<0.05)
Table 3: show the compare mean of RMS and MF values for the lumber erector spine muscles and the multifidus muscle before and after sitting task in Group II.(X ±SD)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group II</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>pre</td>
</tr>
<tr>
<td>RMS means of erector spine muscles (μ.v.s)</td>
<td>2400.92±1632.5</td>
</tr>
<tr>
<td>RMS means of multifidus muscles (μ.v.s)</td>
<td>2243.92±1711.74</td>
</tr>
<tr>
<td>MF means of erector spine muscles (μ.v.s)</td>
<td>23.38±15.96</td>
</tr>
<tr>
<td>MF means of multifidus muscles (μ.v.s)</td>
<td>34.53±26.69</td>
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<tr>
<td></td>
<td>post</td>
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<tr>
<td>RMS means of erector spine muscles (μ.v.s)</td>
<td>2635.69±1634.14 *</td>
</tr>
<tr>
<td>RMS means of multifidus muscles (μ.v.s)</td>
<td>3672.25±1430.75*</td>
</tr>
<tr>
<td>MF means of erector spine muscles (μ.v.s)</td>
<td>4.38±5.26*</td>
</tr>
<tr>
<td>MF means of multifidus muscles (μ.v.s)</td>
<td>9.69±10.86*</td>
</tr>
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*; (P<0.05)

Discussion and Conclusion

This study investigated the effect of non-adjustable bench and desks on lumbar muscles activity in students. The results indicated that when the furniture were appropriate for subjects of Group I according to anthropometric and ergonomically standards, in control group electromyography activity of the lumbar erector spine muscles increased significantly (Table 2). In the Group II the EMG activity of the lumbar erector spine muscles was increased significantly (Table 3). As shown in the Table 2 the lumbar erector spine which is involved in back extension in the sagittal plane and lumbo-pelvic stability had significant increase in muscle activity during sitting task in Control group (Group I) and the multifidus muscles which is involved in back extension in the sagittal plane and lumbo-pelvic stability had no significant increase in muscle activity during sitting task in Control group (Group I) but the EMG values showed significant increase in the two muscles in 2 minute before and after of the 30 minute sitting task in Group II (P<0.05).

Osullivan et al. (2002) demonstrated that EMG activity of the superficial lumbar multifidus, internal oblique, and thoracic erector spine muscles was significantly lower during sloped sitting than during erect sitting (Osullivan et al., 2002), it appears that postural muscle activity decrease as the lumbo-pelvic region becomes dependent on its passive structures to maintain the position against gravity at end – range spine flexion. However, lack of proportion between bench and desk with dimensions of anthropometric characteristics of student’s, subject’s showed significantly increased in RMS and MF during sitting task. The results are in agreement with Saito et al. (1997), that found that non-adjustable VDT devices could cause poor posture, visual and musculoskeletal problems for users. Park, et al (2000) found that in the forward – bending position the new keyboard- mouse support in front of the subjects prevented excessive trunk flexion and reduced muscle fatigue in the lumbar erector spine muscle. In our study the chair hasn’t any backrest and it’s similar to the bench. By increasing the height of the desk, students pull their shoulders and arms forward and such as, find themselves more fatigue on the muscles of shoulder and back to overcome this deformation keeps the users in related condition for the shoulders (Landerand Noyes, 1999). In Group II the results show an increased in the lumbar erector spine and the multifidus muscles activity (P<0.05), because of chair was high and they should sitting on the reclined back posture which can effect on their muscle activity, in the other hand in Group I, subjects seat on the appropriate furniture and there for no increasing in the lumbar erector spine and the multifidus muscles activity (P<0.05).

In Conclusion, the posture of the Student requires more attention. The use of ergonomically bench and desk should be propagated, because it had a significant positive effect on the muscle tension of them. This study has implication for designers regarding the design of school furniture. There are also implications for the future work force with many young adults entering the work place with neck and back pain already present. Different sitting postures may contribute to discomfort at different sit. Children adopt every different posture during lessons. However, School furniture may contribute to postural variation but children usually do adopt various postures regardless of the furniture.

Conflict of interest

The authors declare no conflict of interest
References


