A dental stool with chest support reduces lower back muscle activation

Viet Tran[a], Reid Turner[a], Andrew MacFadden[b], Stephen M. Cornish[c*], Dale Esliger[d], Kunio Komiyama[a], and Philip D. Chilibeck[e]

[a]College of Dentistry, University of Saskatchewan, Saskatoon, Canada, S7N 5E4
[b]College of Arts and Sciences, University of Saskatchewan, Department of Psychology, Saskatoon, Canada, S7N 5A5
[c]Faculty of Kinesiology and Recreation Management, University of Manitoba, Winnipeg, Canada, R3T 2N2
[d]School of Sport, Exercise and Health Sciences, Loughborough University, Leicestershire, United Kingdom, LE11 3TU
[e]College of Kinesiology, University of Saskatchewan, Saskatoon, Canada, S7N 5B2

Running Head: Dental stool and muscle activation

*Corresponding Author:

Stephen M. Cornish, PhD
117 Frank Kennedy Centre
Faculty of Kinesiology & Recreation Management
University of Manitoba
Winnipeg, Manitoba, CANADA R0A 0A2
Email: Stephen.Cornish@umanitoba.ca

Abstract

Activation of back musculature during work tasks leads to fatigue and potential injury. This is especially prevalent in dentists who perform much of their work from a seated position. We examined the use of an ergonomic dental stool with mid-sternum chest support for reducing lower back muscle activation. Electromyography (EMG) of lower back extensors was assessed from 30 dental students for 20 seconds during three conditions in random order: 1) sitting up-right at 90° of hip flexion in a standard stool, 2) leaning forward at 80° of hip flexion on the standard stool, and 3) leaning forward at 80° of hip flexion while sitting on the ergonomic stool. Muscular activity of the back extensors was reduced when using the ergonomic stool compared to the standard stool, by 33 -50% ($p<0.01$). This suggests a potential musculoskeletal benefit with use of a dental stool with mid-sternum chest support.

Keywords: spine, posture, fatigue, injury

1. Introduction

The profession of general dentistry is at a high risk for development of musculoskeletal disorders because dentists require optimal visualization of a relatively small operative field resulting in prolonged and static maintenance of posture [1-3]. This type of strain places the dental practitioner at an increased risk of developing lower back pain. The prevalence of back pain among dentists ranges from 36 to 72% [1,2,4,5].

A variety of ergonomically designed dental stools have been proposed for alleviating musculoskeletal disorders [6,7]. Hardage et al. [6] showed that low back muscle activity could be reduced with a back support; however, this may be impractical during practice when a dentist must lean forward to work on a patient. Parsell et al. [7] showed that neither rigid arm support nor chest support with mobile arm support on a dental stool was effective for reducing lower back muscle activity. They suggested that the dentists' unfamiliarity with the mobile arm support may have increased low back activation, cancelling any benefit from chest support. The objective of the present investigation was to compare the degree of back musculature activation in dental students while leaning forward on a regular dental stool and on an ergonomically-altered dental stool with mid-sternum chest support. We hypothesized that the ergonomic stool would result in significantly less lower-back muscle activation.

2. Material and Methods

2.1. *Participants*

A total of 30 (16 male and 14 female) participants were tested in this study. The participants ranged from second to fifth year dental students from the College of Dentistry at the University of Saskatchewan. Participants were 21 to 30 years of age with an average of 24 (SD 3) years. All participants were considered healthy with no previous history of back injury or complaint and absence of any known systemic musculoskeletal disorders. All participants signed an informed consent form and the study was approved by our university's human ethics review board.

2.2. ***Muscles investigated***

Dorsal muscle activity was recorded using electromyography (EMG) from two back muscles, the longissimus thoracis and iliocostalis lumborum. The iliocostalis lumborum is a global stabilizer while the longissimus thoracis is considered a global mobilizer [8]. These two muscles, along with the spinalis thoracis, form the erector spinae muscle group, which is involved in vertebral extension, and lay within a fascial compartment between the posterior and anterior layers of the thoracolumbar fascia and traverses the length of the back. These two posterior extensor muscles were chosen due to their superficial nature allowing for relative ease of landmark placement for EMG surface electrodes.

2.3. ***Experimental method***

A two lead analog surface EMG (Bagnoli-2, Delsys Inc., Boston, Mass.) along with the EMGworks computer software program was used to measure muscle activation. Two electrodes, 10 mm apart, were attached at each the level of L2 and L3 of the right iliocostalis lumborum and longissimus thoracis muscles respectively. A reference electrode (ground) was attached to the kneecap. The EMG main amplifier unit included single differential electrodes with a bandwidth of 20 (5) Hz to 450 (50) Hz, a 12 dB/ octave cut-off slope, and a maximum output voltage frequency range ±5 V. The overall amplification or gain per channel was 10,000. The system noise was <1.2 μV (rms) for the specified bandwidth. The electrodes were two silver bars (10 mm · 1 mm diameter) spaced 10 mm apart, with a common mode rejection ratio of 92 dB. The EMG was recorded as raw EMG (V) and stored in the computer for analysis. The sampling rate was set at 1,024 Hz which is more than double the highest frequency cut-off value of the bandwidth (450 Hz) as required by the Nyquist criterion. The raw EMG data were then used to calculate root mean square (RMS) using the EMGworks software.

Participants' muscle activity was tested using two dental stool designs. The first standard dental stool was a model "G" serial #1119 (Ritter, Canada). The second stool had a similar seat but was modified to include a chest support, located at mid-sternum, aimed at minimizing lower back strain. The function of this anterior chest support is to allow the operator to transfer their weight onto the chest pad in turn reducing the strain placed on the lower back.

Muscle activity was assessed during three conditions (Figure 1), in a randomized, counter-balanced order. In the first condition participants were measured sitting at 90° of hip flexion and knee flexion on a standard stool (Condition 1; Figure 1a) with their hands out in front of them as though they were working on a patient (i.e. elbows flexed at 90°, with forearms unsupported, hands in a neutral position). A consistent 90° posture was verified using a goniometer. This 90° posture was used as a baseline to simulate what would be considered perfect posture; a posture that places minimal strain on the lower back. In the second condition participants leaned forward to 80° of hip flexion on the standard dental stool and placed their hands out in front of them, again with elbows flexed at 90° with forearms unsupported, and hands in a neutral position (Figure 1b). The final test condition had the participants seated on the modified dental stool (Condition 3) with 80° of hip flexion, the same as the second condition, but this time supported in the position by a chest pad (Figure 1c). EMG was collected during muscle contractions for all three isometric conditions and was measured for a period of 20 seconds.

2.4. *Statistics*

A repeated measures ANOVA was used to determine differences in EMG values between conditions for each muscle group. The alpha level was set at 0.025 to adjust for the number of statistical tests (i.e. 0.05/2) to reduce chance of type I error. When warranted, post-hoc analysis was performed using Tukey's HSD test to determine the differences between the three conditions. All analyses were done using (Statistica version 7, StatSoft Inc., Tulsa, Oklahoma). All data are reported as mean (SD).

3. Results

A main effect of condition was observed for both muscle groups ($p<0.01$). For each muscle group, the Tukey's post-hoc test indicated muscle activity was highest in condition 2 (i.e. standard dental stool, hips at 80° flexion) when compared with conditions 1 (i.e. standard dental stool, hips at 90° flexion) and 3 (dental stool with chest support, hips at 80° flexion) ($p<0.01$; Figure 2). Iliocostalis lumborum and longissimus thoracis muscle activity was reduced by approximately 33% and 50% respectively when comparing condition 2 to condition 3.

4. Discussion

The current study has demonstrated that the use of a chest support on a dental stool results in a significant decrease in EMG activity of both the longissimus thoracis and iliocostalis lumborum during a simulated operating position when compared with a standard dental stool. This suggests that using a chest support may reduce erector spinae fatigue in dental practitioners. This has important implications because dental professionals frequently have low back pain associated with the postures maintained during work [1,2,9]. This study is novel in that it is the first to show that use of a sternum support extending from a dental stool can reduce muscle activation in the lower back and potentially reduce lower back strain.

Only two previous studies have assessed ergonomic design of dental stools using EMG. Hardage et al. [6] compared stools with and without lower back support and determined that EMG activity of the lower back was reduced by about 49% with the lower back support. Participants were evaluated in an upright position (i.e. with hips at a 90° angle) and hands resting on the knees. One could argue that this might not be the best simulation of a dentist's position while working on a patient. A proper simulation would require a forward lean with arms extended. Parsell et al. [7] found that stools with rigid arm supports and with chest support combined with mobile arm support had no effect on activation of lower back musculature. They suggested that the lack of familiarity with the mobile arm support may have increased lower back muscle activation in their participants, cancelling out any benefit of the chest support. They only studied 13 participants and therefore, their study may have been underpowered to detect statistical differences between their chairs. Our study indicates that chest support on a dental stool is effective for reducing muscle activity of the lower back.

A limitation of our study was that muscle EMG activity was only recorded for a 20 second interval. The short time interval was utilized in order to obtain pilot data that would be able to determine the practical nature of adding a chest support to a standard dental stool. The reality of dental work suggests dental practitioners will sustain strained static positions for a much longer time than measured.

Our results imply that chest support on a dental stool may result in reduced lower back strain which could lead to reduced lower back pain if used in a clinical setting. This inference is suggested but it is acknowledged that our study did not test this hypothesis directly. Further, certain positions of the dentist during dental procedures may require more hip flexion or more exaggerated trunk flexion or rotation to gain direct vision or proper instrument orientation. Thus, the chest support may interfere with some of these movements which may limit its application in a clinical setting.

A more extensive clinical trial would be needed to verify that a measureable reduction in back muscle strain can be demonstrated in practitioners using the chest support while performing dental procedures; however, there does remain potential for a health benefit with the use of an ergonomically designed operator stool for dental professionals. When abnormal postures are not necessary, the chest support stool could permit dental practitioners to operate in a more comfortable and relaxed manner which may lead to a reduction in lower back pain in this population.

5. Conclusion

Our results suggest that the use of a chest support during hip flexion reduces the activity of two major erector spinae muscles. This may be one method of modifying the environment of dental professionals to reduce the risk of lower back injury in this highly susceptible group. Further clinical trials evaluating both environmental (modification of dental stools) and personal (improved fitness levels and core musculature strength) factors will help determine which interventions are effective for reducing the risk of lower back pain in dental practitioners.

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Figure Captions

Figure 1. The three different testing conditions: **a)** Condition 1: hips, knees, and elbows at 90° flexion **b)** Condition 2: hips at 80° flexion, and knees and elbows at 90° flexion **c)** Condition 3: Identical to position 2, except with mid-sternum chest support.

Figure 2. Average root mean square EMG activity of **a)** longissimus thoracis; and **b)** iliocostalis lumborum over 20 seconds in three conditions. *Significantly greater muscle activity in condition 2 (80° hip flexion, no support) when compared to condition 1 (90° hip flexion, no support) and condition 3 (80° hip flexion, chest support) ($p < 0.01$). Data are presented as mean ± SD.

Figure 1 a.

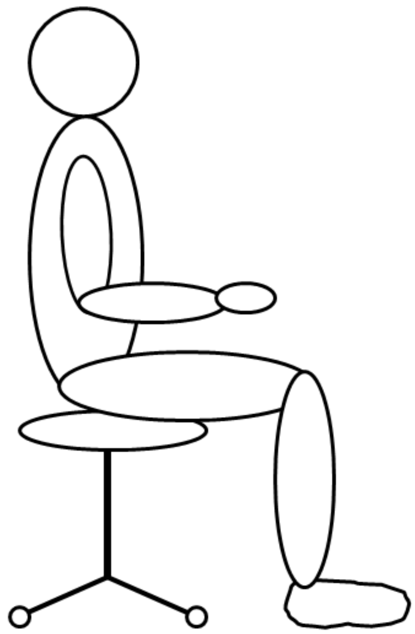

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Figure 1 b.

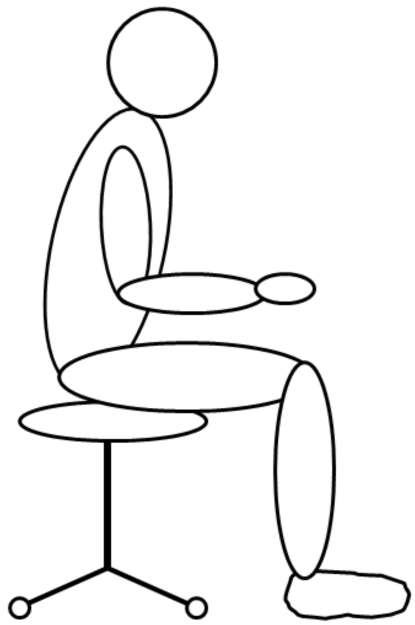


Figure 1 c.

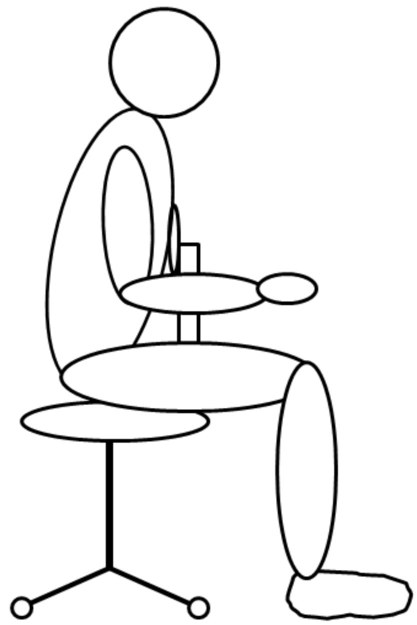
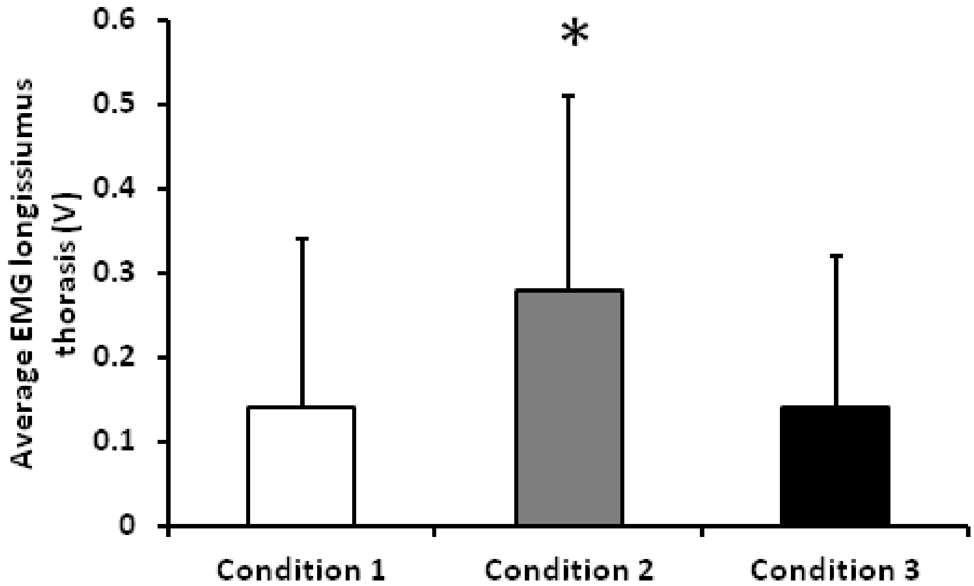


Figure 2a



Average EMG longissiumus thorasis (V)
0.6
0.5
0.4
0.3
0.2
0.1
0
*
Condition 1
Condition 2
Condition 3

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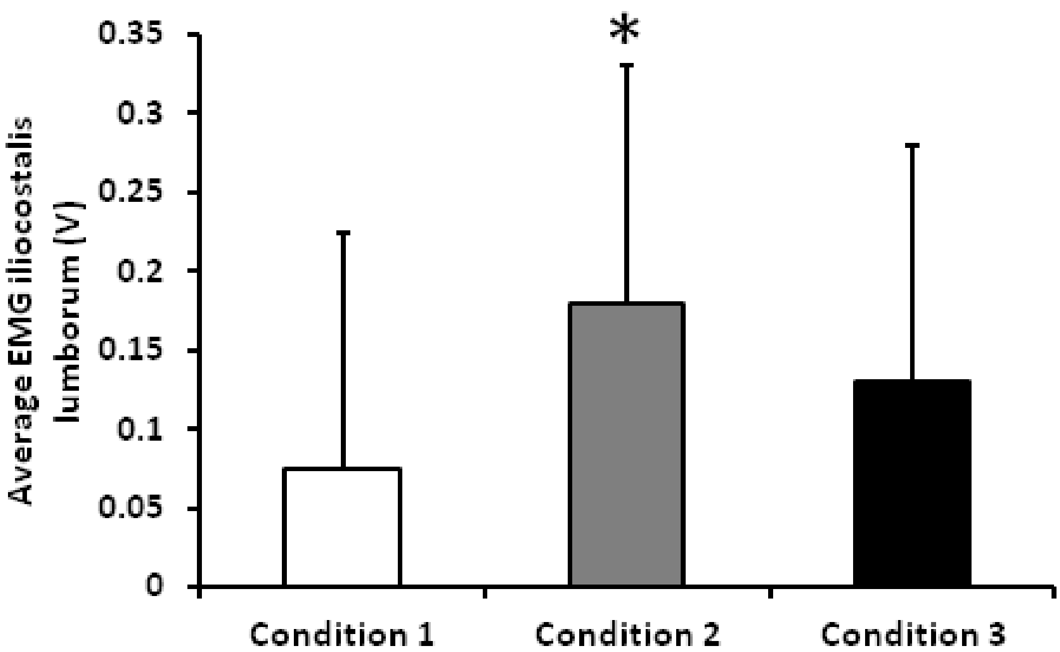

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