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Influence of different stool types on muscle activity and lumbar posture among dentists during a simulated dental screening task

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ABSTRACT

Whereas in the past dental stools typically facilitated a 90° hip angle, a number of currently available alternative designs allow for a more extended hip posture. The present study investigated the influence of different stool types on muscle activity and lumbar posture. Twenty five participants completed a simulated dental procedure on a standard stool, a saddle and the Ghopec. The latter stool comprises a seat pan consisting of a horizontal rear part for the pelvis and an inclinable sloping down front part for the upper legs, with a vertically and horizontally adjustable back rest. Lumbar posture was most close to neutral on the Ghopec, whereas sitting on a standard/saddle stool resulted in more flexed/extended postures respectively. Sitting with a 90° angle (standard stool) resulted in higher activation of back muscles while sitting with a 125° angle (saddle and Ghopec) activated abdominal muscles more, although less in the presence of a backrest (Ghopec). To maintain neutral posture during dental screening, the Ghopec is considered the most suitable design for the tasks undertaken.

1. Introduction

1.1. Musculoskeletal disorders in dentistry

Oral health care providers are vulnerable to work-related musculoskeletal disorders (MSDs) (Hayes et al., 2009; Leggat et al., 2007; Puriene et al., 2007; Yamalik, 2007) and female oral health care workers seem to be even more susceptible to these MSDs than their male colleagues (Hayes et al., 2009; Puriene et al., 2007). Prevalence numbers of general musculoskeletal pain between 64 and 93% have been documented and regions most often affected in dentists were found to be the back (36.3–60.1%) and the neck (19.8–85%) (Hayes et al., 2009), whereas musculoskeletal pain affects between 13.5 and 47% of the general population (Cimmino et al., 2011).

Despite technical advances in dentistry, occupational health problems persist (Leggat et al., 2007). Repeated non-neutral, deviated or inadequate working postures, forceful hand movements, inadequate equipment and workplace designs and inappropriate workplace patterns have been identified as risk factors for occupational health problems in dentistry (Rucker and Sunell, 2002; Valachi and Valachi, 2003; Yamalik, 2007). MSDs have also been associated with prolonged static postures, as overall dynamic loads are low in dentistry (Leggat et al., 2007).

1.2. Sitting

To avoid potentially painful end-range positions and to facilitate activation of trunk muscles during sitting, the potential benefits of neutral lumbar spine postures have been emphasized (O'Sullivan et al., 2012d). Such a neutral posture is obtained through positioning the lower lumbar spine into slight anterior tilt and slight lumbar lordosis while relaxation of the thoracic spine is maintained (O'Sullivan et al., 2010). In practice, habitual sitting postures have been found to be more flexed than neutral sitting posture (O'Sullivan et al., 2010). Nevertheless it appears that pain-free subjects can reliably assume a neutral sitting posture when asked (O'Sullivan et al., 2010).

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Attaining a neutral spine can be reached in an active way when trunk muscles are engaged (Bendix et al., 1996). However, this position is hard to maintain on most chairs and the lumbopelvic musculature in pain-free subjects has been found to be more active while maintaining an optimally aligned, erect posture compared to passive postures (O'Sullivan et al., 2002) – effectively meaning that 'good' seated postures require more effort than 'poor' postures. To solve the latter problem a lumbar support (to facilitate lumbar lordosis) or an increase in hip angle (to raise anterior pelvic tilt) is often suggested (Bendix et al., 1996; Michel and Helander, 1994). However, if the backrest is not pushed toward the lower back, kyphosis of the lumbar spine might occur when the trunk is stabilized against the backrest (Bendix et al., 1996). To accommodate an open hip angle, a tilted seat pan with a gripping surface or a seat with a horizontal rear portion to accommodate the ischial tuberosities and a sloping front part supporting the upper legs is needed, followed by an increase in seat height to allow forward and downward inclination of the upper legs (Corlett, 1999; Mandal, 1981). Without the horizontal rear part there is a risk of sliding forward on a downward sloping seat. Compared to sitting on a conventional chair, this way of sitting was found to result in more anterior tilt of the pelvis and increased lordosis (Bridger, 1988; Bridger et al., 1989).

Dentists most of the time sit during work and sitting is considered an aggravating factor in lower back pain (O'Sullivan et al., 2010). Conventional sitting results in flattening of the lumbar curve, posterior tilt of the pelvis and increased low back compressive loads (Adams et al., 2007; Callaghan and McGill, 2001; Harrison et al., 1999; Keegan, 1953). Upright sitting (i.e. neutral posture) is associated with high muscle activity, which during prolonged sitting has been associated with muscle fatigue and pain (Grooten et al., 2013). Conversely, slump sitting has been associated with increased spinal loading due to the posterior tilt of the pelvis which is then counterbalanced by excessive contractions of the dorsal spinal muscles (Grooten et al., 2013). Slump sitting has also been associated with greater head/neck flexion, anterior translation of the head and increased cervical erector spinae muscle activity in comparison with upright sitting (Caneiro et al., 2010). Due to the nature of dental work, in which the working field is often hard to reach, maintaining a neutral posture during work is difficult. Despite clear recommendations concerning working posture (Hokwerda et al., 2006; Skovsgaard, 2013), high risk level postures related to neck and lower back pain have been found in dentists (Rafeemanesh et al., 2013).

Outside dentistry, it has been shown that sitting posture influences trunk muscle activation and spinal-pelvic curvature (O'Sullivan et al., 2006) and chairs inducing different sitting postures have been associated with differences in trunk muscle activation and lumbar flexion (O'Sullivan et al., 2012b). Standard dental stools allow an angle of 90° for both the hips and the knees. With a view to reduce back problems by promoting lumbar lordosis, standard stools found in dentistry are regularly replaced by stools that allow for a larger trunk-to-thigh angle. Among these are the saddle stools which most often are available without lumbar support. The use of a saddle seat, which leads to greater trunk-to-thigh angles, has been shown to reduce posterior rotation of the pelvis and consequently to facilitate the maintenance of a lumbar lordosis (= natural curve of the spine) (Gadge and Innes, 2007). The Ghopec (Gaining Height on Professional Ergonomic Chair) (JPG Ergonomics, Utrecht, the Netherlands) is another chair which can be adjusted to a larger trunk-to-thigh angle.

1.3. Aim

Both saddle stools and Ghopec chairs are available in dentistry, but until now no data have been published on their use in dentistry and it is unclear if indeed the chairs have the positive effect, suggested by their manufacturers, on muscle activity and lumbar posture during dental tasks. Therefore the purpose of the present study is to evaluate the influence of different stool types on muscle activity and lumbar posture in dentists during work, and to answer the following questions:

- During dental work, does sitting on a dental stool, which induces a trunk-to-thigh angle larger than 90°, result in different activity of muscles contributing to this sitting posture compared to sitting on a standard dental stool?
- During work, does sitting on a dental stool, which induces a trunk-to-thigh angle larger than 90°, result in less flexion of the lumbar spine compared to sitting on a standard dental stool?

2. Materials and methods

2.1. Study design

A one-session within subjects study was performed. During this study, dentists/dental students performed a 15-min simulated dental screening on a phantom head, i.e. a fake head used for dental training, whilst sitting on 3 different stools. Each participant completed the same protocol except for the order in which they used the different stools. The combination of 3 different stools resulted in 6 possible sequences. Each participant blindly selected a paper with the sequence from a pile of turned-down papers. Differences in muscle activation and lumbar posture between the 3 dental stools were evaluated. Independent variables were dental stool type and dependent variables muscle activation and lumbar posture.

Ethical approval was obtained from the independent Commission for Medical Ethics of the University Hospital Ghent (B670201317498) and the University of Derby and all participants received an information letter after which they signed an informed consent form.

2.2. Participants

In total 25 participants, 8 male and 17 female, were recruited from the dentists (n = 15) and dental students (n = 10) at Ghent University (Hospital) on a voluntary basis. Participants were pain-free at the time of the investigation, aged >18 years and not pregnant. They had a Body Mass Index from 18 to 25 and could speak/understand Dutch. People with persistent lower back pain in the last 2 years, previous spinal surgery or currently on pain medication were excluded. Also people with a pacemaker or people smaller than 5th percentile female (1.53 m) or taller than 95th percentile male (1.89 m) were excluded, the latter because average chair design is based on the principle 'design for all', which excludes these ranges. To make sure all participants were familiar with the screening task, only fourth- and fifth-year dental students and graduated dentists were selected.

The participants' mean (SD) age was 24.5 (3.9) years, body mass was 64.2 (7.9) kg, height was 170.4 (6.7) cm and body mass index was 22.1 (2.1) kg/m^2. Two participants were left-handed, the other 23 were right-handed.

All data on participants were obtained by self-report.

2.3. Materials

2.3.1. Experimental conditions

Data were collected for 3 different types of stool: a standard dental stool allowing an angle of 90° for both the hips and the knees

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