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Ball Chair *vs.* Classic Office Chair in Dentistry: A Pilot Study

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Abstract

Background & Objectives: Spine is critically involved in normal orthostatic and sitting postures, being intensively engaged in routine professional activity among dentists. A suitable working posture is always required in order to reduce muscle fatigue and discomfort. The main objective of our study was to evaluate whether the ball-chair is associated with better outcomes (concerning pain, fatigue, muscles' activation in the lumbar spine) than ergonomic chair among dentists.

Methods: We performed a pilot study on a sample of 50 dentists classified in two groups based on their work with either the classic chair with an adjustable lumbar support (group A, 30 cases) or the ball chair in routine dental practice (group B, 20 cases). An Electromyography (EMG) using a flat electrode was done in all dentists in both groups paravertebral and abdominal muscles were tested twice, at the beginning and end of the workday as well. A specific questionnaire was applied to evaluate the sitting discomfort and working performance we focused on two main items that reflect the level of comfort or discomfort (item 1) and low back pain on a visual analogue scale of 0 to 10 cm (item 2).

Results: The EMG analysis support muscle activity performed during routine profession different phases of muscle involvement (muscle activation, amplitude of contraction, frequency and Maximal Voluntary Contraction (MCV)) are the subject of training, based on correctly exercises.

Interpretation & Conclusion: Electrophysiological studies using the detection EMG with surface electrodes revealed the role of spinal extensors and flexors, showing certain benefits of ball chair.

Keywords: Ball chair; Dental ergonomics; Dentist; Musculoskeletal disorders; Spine

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Introduction

Both static and dynamic postures of the spine exhibit critical role during various professional activities, such as dentistry, ultrasonography, but also the IT field, and everyday life as well. It is widely recognized that working from sitting postures is commonly associated with significant static load of the spine, particularly the lumbar segment, with subsequent musculoskeletal imbalance [1-3]. Moreover, prolonged static contractions lead to continuous activation of the small motor units and an increased level of activation. Low back pain illustrates not only vertebral dysfunction, but also expresses the disco-vertebral degenerative processes [4-6]. The neutral vertebral position, meaning lumbar lordosis (with a cut off level of 3 cm) with straight or slightly kyphotic back, is classically required in order to preserve the integrity of spine functioning [7,8].

Current ergonomic principles in dentistry promote working from sitting postures and different types of chairs were proposed over time, adapting the shape, lumbar support, arm rest and the seat pan to achieve better outcomes [9-11]. Emerging ergonomic studies emphasized the efficacy of a distinct chair the gym-ball chair with a specific design which incorporate an air-filled bladder component into the chair design [12,13].

The role of a rehabilitation ball in improving vertebral posture was considered in various settings, e.g. A novel subtype of exercise increasing the balance control, a therapeutic instrument

in patients with chronic pain in the lumbar spine or an assessment of trunk muscle activity [14,15].

The underlying concept of the novel gym ball type chair focus on the well known theory regarding the agonist antagonist relationship (flexor-extensor vertebral muscles) and necessity to maintain the training of the flexors with the intention to promote relaxing of the extensor; moreover, achieving a favorable thoraco-abdominal pressure is essential to decrease with about 30% the pressure on the vertebral disc [16-18].

Furthermore, the quite unstable surface of this particular type of chair is able to trigger the mobility of the spine, e.g. alternating contraction of the flexor-extensor muscles, and upper limbs. Various studies assessed the biomechanical behavior when sitting position on the gym-ball, probing the discomfort or the comfort experienced while exercising or working on a rehabilitation ball [19-23].

Assuming the benefits of active sitting during working, the aims of our study was to evaluate whether active sitting on a ball chair is associated with better outcomes in terms of pain, fatigue, muscles activation in the lumbar spine than classic ergonomic chair among dentists.

In contrast with the previous studies performed in the specialized literature, which fail to provide relevant data on a muscle-skeletal optimum condition at the level of the spinal extensors and flexors, as well as at the paravertebral level and abdominal muscles with dentists, in relation to the type of dental chair used, our study offers scientific arguments resulted from the electromyography analysis, correlated with the quantified results of the statistical processing of a customized questionnaire, designed for the subject of study.

In agreement with the current existing data related to the degree of affectation through muscle-skeletal pathology of the dentists who uses the classic ergonomic dental chair, we started from the hypothesis that the analysis related to the use of a modern ball type chair will lead to conclusive results, exclusive for the muscle-skeletal status under these labor conditions.

Materials and Methods

We performed a pilot study on a sample of 50 dentists classified in two groups based on their work with either the classic ergonomic chair with an adjustable lumbar support (group A, 30 cases) or the novel gym-ball chair in routine dental practice (group B, 20 cases) (Figure 1).

Group A reunites dentists who work exclusively on classic ergonomic dental units and group B reunites dentists working on a ball type dental chair. We mention that both groups practice general dentistry, reuniting maneuvers of dental prostheses, from the classic approach to the modern, minimally invasive one, odonto therapy, endodontics and certain maneuvers of dento-alveolar surgery, in agreement with the existing competences for this type of training.

Participants were enrolled according to a predefined set of inclusion and exclusion criteria, as follows: Age between 25 and 45 years, at least 5 years of activity, at least 7 working hours per day, 5 days per week; all dentists adopted both sitting and orthostatic postures during professional activity.

Dentists with a history of vertebral pathology spine, with abdominal surgery as well as neurological diseases were excluded, in order not to interfere with the potential symptomatology related to labor strains.

Table 1: Gym-Ball chair accommodation training schedule.

Day	Duration on Gym-Ball
1	30 minutes
2	60 minutes
3	90 minutes
4	120 minutes
5	150 minutes
6	180 minutes
7	210 minutes

Table 2: Demographic and anthropometric parameters.

Demographic and anthropometric parameters		
	Group A (n=30)	Group B (n=20)
Age (years)	35 ± 2.3	35 ± 1.1
Gender (male: female)	3: 02	2: 03
Body mass index	65 ± 5.1	67 ± 2.3
Height	1.61 ± 10.1 cm	1.62 ± 10.5 cm

Each dentist in group B was provided an accommodation training meaning a progressive escalation in working time on the gym-ball during one week, with an increase of 30 min per day as shown in Table 1.

An Electromyography (EMG) using a flat electrode was done in all dentists in both groups; paravertebral and abdominal muscles were tested twice, at the beginning and end of the workday as well, particularly the following muscles: *m. multifidius* (component surface), *m. latissimus dorsi* and *m. rectus abdominis* (Figure 2). In our study, it was used Biopac MP45 (Biopac Systems Inc USA), EMG equipment, the single use electrodes, gel as a type of substrate conductive medium, and AcqKnowledge 4.0, software dedicated to the acquisition and processing of biomedical signals. One week training was performed before the correct EMG testing of the flexors and extensors muscles.

As objective methods we used electromyography with flat electrodes, whose route was subsequently analyzed in corroboration with the specificities of each analyzed group, a valid method for the analysis of the muscular status investigated for both groups of dentists in the study, namely for Group A who works on classic ergonomic chairs and Group B who works on modern ball type chairs.

In addition, a specific questionnaire was applied in all cases, derived from the Cornell musculoskeletal discomfort questionnaire evaluating the sitting discomfort and working performance; we focused on two main items that reflect the level of comfort or discomfort (item 1) and low back pain on a visual analogue scale of 0 cm to10 cm (item 2). The subjects' answers were evaluated using the contingency tables and the chi-squared test with the Fisher's correction, with a significance level of 0.05. The statistical calculations were made in SPSS 20.0.

Dentists have signed an informed consent before their enrollment in the study and the project has received local Ethical Committee approval.

Results

There was no difference in demographics, comorbidities

Figure 1a: Dentist working in a sitting position on stable classic chair (Group A).

Figure 1b: Dentists working in a sitting position on ball chair (Group B).

Figure 2: Electromyography in the abdominal and paravertebral muscles using flat electrodes at dentists working in a sitting position on ball chair *vs.* classic chair.

Figure 3: The comparative answers in group A *vs.* group B regarding the two items.

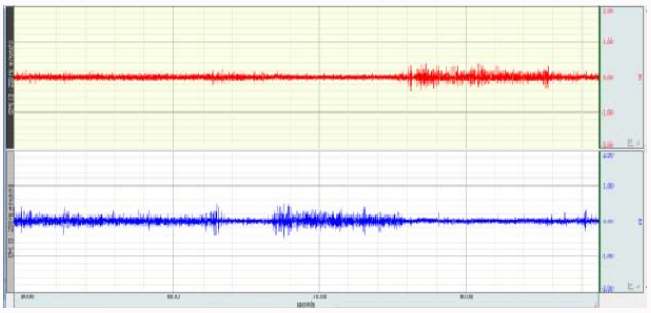

Figure 4: EMG showing paravertebral muscles activity (m. multifidus-right/left) Right paravertebral red channel A=0.23 mV; Left paravertebral blue channel A=0.48 mV.

background, a common field of dental activities and work experience as summarized in Table 2.

Firstly, we were interested in evaluating the overall impact of the classic ergonomic chair versus gym-ball chair utilized during working hours. 16 out of 30 dentists in group A considered that the ergonomic chair is comfortable, while 16 out of 20 sitting on a gym ball chair (group B) during routine practice responded favorable when asked about the comfort related to the new type of chair (p value =0.229, not significant) (Figure 3). The second item of the questionnaire referred to vertebral pain elicited by prolonged fixed working postures and repetitive movements, expressing overloading as well as vertebral wear. 22 dentists from group A complained about mechanical vertebral pain progressively exacerbated at the end of the working hours; pain was moderate in 20 cases, with an intermittent pattern in the last one.

Conversely, only 6 dentists among those using a gym-ball chair reported vertebral pain, classified as mild and sporadic (p value =0.048, statistically significant) (Figure 3). Secondly, muscle activation in the lumbar spine and their activity were assessed by the means of surface EMG registered during professional activity. As already mentioned, EMG with plain electrodes was systematically performed in all dentists, as such electrodes are less traumatic than the needle electrodes, permitting and getting information during activity.

Several muscle parameters were typically detected including length, shape, amplitude and frequency of the electrical potentials.

Discussion

The EMG analysis clearly support muscle activity performed during routine profession; different phases of muscle involvement like muscle activation, the amplitude of contraction, frequency and Maximal Voluntary Contraction (MCV) are the subject of training, based on correctly identified exercises.

Several examples of paravertebral and abdominal muscle activation during work as well as differences detected by the EMG in both work settings (classic ergonomic chair, gym-ball chair) are presented below (Figure 4-8). From the performed electromyography, correlated with the results of the items analyzed in the questionnaire, the benefits of the ball type chair are clear as far as the status of the flexor and extensor muscle status is concerned. Equally, this status is correlated with the use of the ball type chair and the type of minimally invasive modern maneuvers performed by the dentists.

It is widely recognized that the whole spine, particularly cervical and lumbar regions are involved in professional activity of a dentist [23-25]. Whatever the posture adopted during working, ergonomic or non-ergonomic, different vertebral regions are overstretched as demonstrated by the physiological biomechanics rules of the spine;

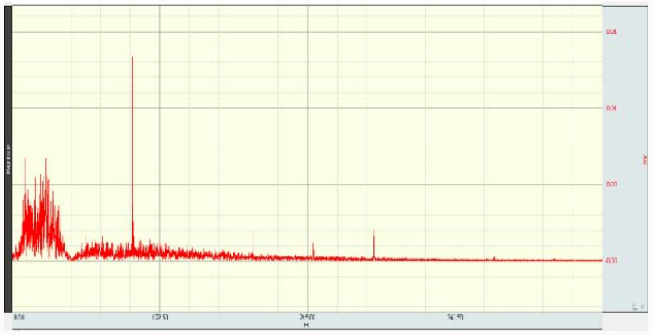

Figure 5: The frequency spectrum of the signal for left paravertebral muscles.

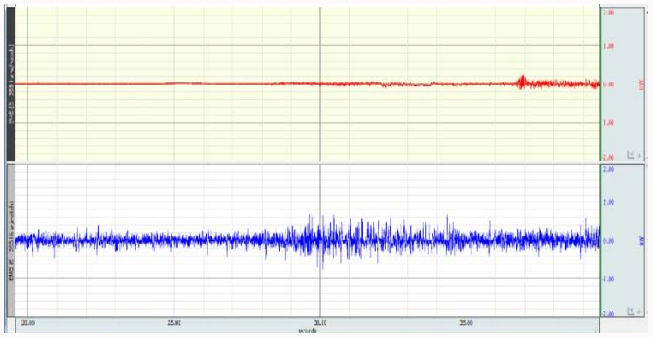

Figure 6: EMG for paravertebral muscles (m. multifidus) and lumbar muscles (m. latisimusdorsi) A1 paravertebral =0.30 mV; A2 lumbar =0.81 mV.

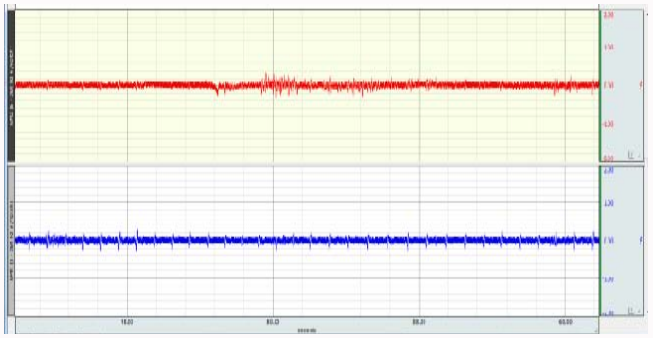

Figure 7: EMG for lumbar muscles (m. latisimusdorsi).

furthermore, spine biomechanics is extremely complex and only the neutral position (meaning lumbar and cervical lordosis, with a mild kyphotic upper back) is able to maintain the tolerance for exercise and a long-term normal functioning [8,10].

Emerging data concerning vertebral biomechanics support the critical role of thoraco-lumbar junction as the core stability region for both static and dynamic posture. Several muscles are classically responsible for spine stability, including *m. multifidus*, *m. spinalis*, *m. latissimus dorsi*, *right* and *transverse abdominal muscles*, and *diaphragm*, as well [13,17,19,21]. Their training is realized only through a well targeted activity, while the active sitting posture on a gym-ball type chair is thought to promote such a specific training.

In addition, sitting on a relatively unstable surface (e.g. the convex ball-type surface) is usually recommended in order to maintain balance and a better sitting posture, based on significant participation of postural muscles in the core stability area [17,23,26]. Hence,

Figure 8: The frequency spectrum for lumbar muscles.

this technique obviously helps to strengthen abdominal and back muscles, offering a better balance and posture. On the other hand, the upper belt muscles are also trained due to their specific involvement in routine dental practice.

Different studies involving the gym-ball in the field of fitness and spine rehab showed benefits related to low levels of muscle fatigue as well as increased productivity, promoting good physical health [12,14]. Moreover, this novel ball-type chair also significantly decreased the number of dentists declaring low back pain.

Finally, positive outcomes among subjects enrolled in group B clearly focus on gym-ball utility, as follows a stronger abdominal and back musculature, recognized as spine stabilizers; a locally improved blood flow; a better balance between flexors and extensors of the spine meaning the agonist-antagonist torque, typically leading to a correct posture; strengthening of the scapular belt muscles; as well as a favorable approach to reduce overall stress.

A closer look to ball-chair in rehab and particular working settings, including the dental medicine, revealed conflicting data. Most of the studies showed comparable levels of discomfort and muscle activity when using a conventional office chair versus sitting on ball-chair [14-16]. Moreover, no significant changes in the activity of trunk muscle or spinal postures, with no positive outcomes were reported if sitting on an unstable surface. Electrophysiological studies such as EMG suggested no difference between the activation of muscles while sitting on a chair and on a ball; muscle activity in individuals performing a sitting work was also low [26-28]. Conversely, other studies reported effective *m. multifidus* activation when subjects were sitting on the ball [21].

Although no additional benefit was demonstrated with the gym-ball chair among dental professionals, reduced activity of the rectus abdominis muscle and the external oblique muscle while sitting on the ball can favorably affect the functional recovery in different pathologies, including stroke. Furthermore, spasticity or rigidity may also benefit from specific rehabilitation using gym-balls as muscle tension may be reduced.

Conclusions

1. Spine is critically involved in normal orthostatic and sitting postures, and is intensively engaged in routine professional activity among dentists. A suitable working posture is always required in order to reduce muscle fatigue and discomfort, even if that means a frequent change of posture.

2. The correct vertebral posture is the neutral position, preserving precise curves in different settings. Latest research

highlighted the efficacy of a gym-ball type ergonomic chair to detriment of classic ergonomic office chair despite the lumbar and arm support in dentistry.

3. Electrophysiological studies using the detection EMG with surface electrodes revealed the role of spinal extensors and flexors (the so called agonist-antagonist torque), showing certain benefits of ball chair.

4. In order to prevent and to diminish the muscles fatigue, very common among dental practitioners, the best solution is to alternate the work sitting on ball-chair type with the work sitting on classic ergonomic chair.

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