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ORIGINAL ARTICLE

The Relationship Between Postural Stability and Forward Head Posture

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ABSTRACT

Background: Musculoskeletal disorders of the neck and shoulders are the most commonly reported complaints in sedentary occupations such as dentistry. These disorders not only cause pain but can also impair postural control mechanisms. The aim of this study was to investigate the relationship between postural stability disorders and forward head posture (FHP) in dentists.

Materials & Methods: In this cross-sectional study, 70 dentists from two dental centers in Tehran were investigated. Individual and job characteristics were collected via questionnaire. The head position was examined using clinical testing for forward head posture. The Romberg equilibrium test and its three modified versions were used to evaluate static stability, and the stepping test was applied to evaluate dynamic stability. Pearson's correlation coefficient and the independent t-test were used to examine the relationship between variables and to investigate the difference in stability variables between the FHP and healthy groups.

Results: Based on the results, 57.1% of the studied dentists were diagnosed with forward head posture. According to the results of the independent t-test, there were significant differences in the average holding time in the static stability tests and the deviation degrees from the normal range in the dynamic equilibrium test between the FHP and healthy groups (p= 0.013).

Conclusion: FHP could negatively affect the postural equilibrium of dentists. Suitable interventions such as ergonomic redesign of workstations and/or corrective exercises are strongly recommended.

KEYWORDS: *Forward head posture, Static stability, Dynamic stability, Dentists, Ergonomics*

INTRODUCTION

Work-related musculoskeletal disorders (WMSDs) encompass a wide range of inflammatory and degenerative conditions affecting muscles, tendons, ligaments, joints, peripheral nerves, and supporting blood vessels, primarily caused by workplace risk factors [1,2]. According to the Bureau of Labor Statistics (BLS), the annual rate of WMSDs increased from 2008 to 2010. This report also revealed that health care workers have the highest prevalence of musculoskeletal disorders among different occupation groups [3]. The involved body regions mainly depend on the physical demands of the job. For example, the neck and shoulders are the most affected regions for those in dental care work, largely due to the precise nature of dental tasks conducted in a small area (the

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patient's mouth) with a prolonged static posture. Despite significant technological advancements in dental equipment and major changes in work methods, such as transitioning from standing to sitting positions, using adjustable chairs, and employing dental assistants (four-handed dentistry), the expected reduction in the prevalence of WMSDs among dental care workers has not been observed [4-10].

Forward head posture (FHP) is one of the most common upper trunk disorders in dentists. The upper trunk includes the neck and shoulder girdle, which are closely related both anatomically and functionally [11, 12]. FHP is caused by the overactivity of the sternocleidomastoid (SCM) and inhibition of the neck deep flexor muscles and thoracic extensor muscles.

When the shoulders round forward, as they tend to do after many consecutive hours of sitting at a computer or dental stool, the head moves forward because the upper back supports the neck and head. FHP occurs when the head is positioned forward of the gravity line [13]. In the sitting job position of dentists, the trapezius and SCM muscles are often injured [14-16]. McKnee et al. showed that the activity of trapezius and SCM muscles was significantly higher in working task positions compared to resting positions and non-work activities [14]. Additionally, electromyography (EMG) results in Fincens's study confirmed that the level of trapezius muscle activity during dentistry tasks was significantly higher than in the resting position [15]. Due to the pathophysiological importance of the trapezius muscle and its crucial role in connecting the shoulder girdle and neck region, damage to this muscle can lead to various skeletal disorders in the kinematics of the upper trunk chain [14-16].

Moreover, many studies have confirmed the importance of head position in postural control due to the effect of vestibular sensory and proprioceptive information related to head position on central postural responses [17-19]. Proper performance of the body equilibrium system in postural control depends on the complex coordination and interaction between vestibular, visual, and somatosensory systems, whose disorders can affect the body's static and dynamic stability in various working and non-working positions [20-23]. Static stability is the ability to maintain the body's center of gravity on the base of support, while dynamic stability refers to maintaining the body's center of gravity within the equilibrium limit during body displacement or limb movements. Good stability is vital for accomplishing all types of activities properly and appropriately [24, 25].

The somatosensory system is a network of sensory nerves that transmits proprioceptive information (the body position in space, the speed, and direction of motion) to the central system of body balance control [26]. The neck region, with a high density of muscle spindles and mechanoreceptors, is a major area of the body's proprioception system. Because of the close relationship between cervical afferent nerves and the vestibular equilibrium system, any pathology in the skeletal and muscular structures of the neck can affect human equilibrium performance [23, 26]. Treleaven (2007) found that any pathology in the musculoskeletal structure of the neck region (e.g., pain, inflammation, alteration of muscle spindles sensitivity, functional disorder, morphological changes in cervical muscles, and damage of skeletal structure) can negatively affect postural stability control [27]. A significant difference in postural sway indexes was found between healthy individuals and patients suffering from chronic non-specific neck pain in single leg standing, regardless of the positional task difficulty. Thus, it seems that postural stability in patients with neck pain is lower than in healthy subjects [28]. Additionally, previous studies have demonstrated the influence of head position on postural stability control. In the study by Smetanin et al. (1993), applying vibration to the posterior cervical muscles disrupted postural stability responses [29].

In the current study, we assumed that FHP in dentists can negatively affect the proprioceptive information of cervical afferents transmitted from cervical mechanoreceptors to the vestibular nucleus. This leads to fluctuations in the central integrated image of the body position in the environment. As a result, we expect to observe postural stability disorders following head position disorders in workers whose jobs force them to sit with a flexed neck for most of their working time. To our knowledge, this hypothesis has not been previously evaluated in occupational groups. Therefore, the purpose of this study was to investigate the relationship between postural stability disorder and FHP in dentists.

MATERIALS AND METHODS

Seventy dentists volunteered to participate in this cross-sectional study. They worked in two dental clinics in Tehran. Participants read and signed the consent form after being given adequate information about the aims and methods of the study. They were aged between

Table 1. Demographic and occupational data of participants (n=70)

Variable	Mean	SD	Min-max
Age(year)	41.65	6.23	29-55
Height(cm)	172/61	8.21	153-187
Weight(kg)	73.96	9.47	53-94
BMI(kg/m^2)	24.76	2.13	19.38-29.40
Job experience(year)	16.01	6.08	5-32
Work days in week(day)	5.37	0.96	2-7
Work times in week(h)	37.24	12.47	15-55

Table 2. Descriptive statistics related to FHP and holding time of the equilibriums tests. (n=70)

Variable	Mean	SD	Min-max
FHP(cm)	8.31	1.86	5-13
Static ET p1(s)	29.92	0.59	25-30
Static ET p2(s)	29.50	2.56	12-30
Static ET p3(s)	17.76	11.07	2-30
Static ET p4(s)	23.14	9.84	2-30
Dynamic ET(degree)	42.68	24.62	5-117

25 and 55, had at least 3 years of job experience, and worked more than 15 hours per week. Participants with neuropathic diseases, diabetes, ankle sprains, trauma and fractures in the vertebral column or lower limbs, vestibular infections and diseases, dizziness, whiplash injuries, or visual problems were excluded. Persons who had participated in assessment and/or balance training during the past 6 months were also excluded. None of the participants were professional athletes.

In each dental clinic, one room was arranged to perform assessment tests (described below). The study protocol was approved by the local research ethics committee (IR.SBMU.RAM.REC.1394.188).

Assessment of forward head posture:
A valid and clinical test was used to evaluate the FHP [30]. Each participant stood against a wall in a relaxed position while the apex of the thoracic spine and heels slightly contacted the wall. They were asked to position their feet so that the distance between them would be equal to shoulder width. They were also asked to flex and extend their neck a few times to find the best headrest position, hang their arms beside their body, and look forward. The distance from the deepest part of the cervical curve/lordosis to the wall was measured in centimeters using a standard ruler [31]. According to the Rocabado method, distances equal to or less than 8 cm were considered normal, while more than 8 cm was considered FHP [32].

Assessment of static stability
We used the Romberg equilibrium test as well as its three modified versions to assess static stability:
1. Stand with both feet together, eyes closed, and knees straight.
2. Stand with both feet together, eyes closed, and knees bent.
3. Stand on a single foot, eyes closed, and knee bent.
4. Tandem position with eyes closed and knee bent [33-37].

All test positions were performed barefoot on a firm surface. Subjects were asked to cross their upper limbs on their chest and hold each position for 30 seconds. The tests were ended if balance disturbances such as arm extension, opening the eyes, extending the flexed knee, or foot motion occurred. The exact holding time in each position was recorded by chronometer in seconds. The test sequences were the same for all participants, and a reset time of 30 seconds was respected between the tests.

Table 3. Relationship between forward head position with Static and dynamic stability tests (n=70).

FHP / Equilibrium tests	r	p-value
Static ET p1(s)	-0.24	0/044
Static ET p2(s)	-0.27	0.023
Static ET p3(s)	-0.80	0.0001
Static ET p4(s)	-0.61	0.0001
Dynamic ET(degree)	0.84	0.0001

Table 4. compare the mean results of equilibrium tests between patients (FHP) and healthy subjects (n=70).

Variable	Mean(FHP)±SD	Mean(healthy)±SD	Difference mean between two groups ±SD	p-value
Static ET p1(s)	29.87±0.79	30.00±0.0	0.12±0.12	0.323
Static ET p2(s)	29.12±3.37	30.00±0.0	0.87±0.62	0.160
Static ET p3(s)	8.57±3.90	30.00±0.0	21.42	0.0001
Static ET p4(s)	18.00±10.40	30.00±0.0	12.00±1.90	0.0001
Dynamic ET(degree)	59.62±18.13	20.10±8.75	29.52±0.59	0.0001

Assessment of dynamic stability

To evaluate dynamic stability, we used a stepping test in which participants did 50 steps while walking with closed eyes, holding their arms in front of their body [38]. The degree of deviation from the starting position was considered as the subject's ability to control dynamic stability. If, at the end of the test, the subject deviated more than 30 degrees from the start plane, they were considered to suffer from dynamic instability.

We used the Pearson correlation coefficient and independent t-test to analyze the obtained data. The significance level was set at 0.05. Data was analyzed using SPSS software version 20.

RESULTS

Based on the results obtained from the K-S test, the distribution of data was normal (P>0.05). Participants' demographic and occupational data are shown in Table 1.

Participants included 17 females (24.3%) and 53 males (75.7%). Forty participants (57.1%) were recognized as FHP patients.

The results of the static equilibrium assessment tests showed that most participants correctly performed the first and second positions of the static equilibrium tests (69 participants (98.6%) and 67 participants (95.7%), respectively). However, the number of subjects who were able to successfully accomplish the other static tests was 30 (42.9%) for the 3rd test and 46 (56.7%) for the 4th test.

The results of the stepping test also showed varying degrees of deviation from the starting position. The descriptive results concerning the holding times of equilibrium tests and the FHP are shown in Table 2.

According to the results of the Pearson correlation test, a positive correlation was found between FHP and working experience (p=0.039, r=0.26) and the number of working days per week (p=0.005, r=0.33). FHP was not related to age and height. However, FHP had a significant positive correlation with weight (p=0.013, r=0.29) and BMI (p=0.027, r=0.26). FHP was found to be significantly correlated with static and dynamic stability in all positions (Table 3).

Table 4 shows that the average holding time in the healthy group was significantly higher compared to the FHP group in the 3rd and 4th static stability tests. The same result was found in the dynamic equilibrium test.

DISCUSSION

The aim of this study was to examine the relationship between static and dynamic postural disorders and FHP in dentists. We observed that dentists who suffer from forward head posture are significantly less able to maintain stability. In concordance with previous studies, this finding confirms the hypothesis that FHP has a negative effect on postural stability in patients [17].

In FHP, the biomechanical relationship between the skeletal and muscular components of the head and neck region is disturbed. Due to the high density of muscle spindles in the cervical region, changes in the length-tension relationship of cervical muscles cause an alteration in muscle spindle sensitivity, which in turn affects the sensory impulses to the central nervous system. This could create an inconsistency between sensory information sent from other sensory-equilibrium resources, resulting in disruption of the stability adjustment mechanism of the central position [39].

According to our results, the prevalence of FHP disorder in dentists was 57.1%. None of the previous studies have focused on this topic. The prevalence of FHP in office workers was reported as 67.3% by Nejaty et al. [40] and 60.5% by Chou et al. [41]. From an ergonomic point of view, the risk factors for musculoskeletal neck disorders are comparable between office and dental work. One could suggest that both are exposed to prolonged static sitting postures, in which the head and neck are placed in a flexed and forward position for the majority of the working time.

In some studies, postural photography methods and EMG have been used to evaluate working postures and the rate of muscle activity in dentists [14-16]. These studies reported an average flexion of 15 to 30 degrees in dentists' head and neck posture while working. Indeed, the SCM and trapezius muscles were found to be significantly more contracted when performing dental work compared to resting time [15]. These results could mainly explain the high probability of incidence of musculoskeletal neck disorders in dentists. The prevalence of neck and shoulder MSDs among dentists has been reported to range from 34% to 90% in various studies [15, 42, 43]. Studies conducted on Iranian dentists confirm a prevalence rate of 47% to 66% for shoulder and neck pain (65% in Birjand, 65.6% in Shiraz, 66.6% in Tabriz, 47.1% in Yazd) [44-48].

Our results showed that there was a negative correlation between FHP and the ability to perform static postural stability tests. In other words, the ability to maintain static postural stability decreases as FHP increases. This result aligns with Smetanin et al., who previously demonstrated the effect of head position on postural stability control [29]. In our study, the 3rd static position test showed the highest correlation with FHP (r=0.80). One explanation is that this test is the most difficult to accomplish, as suggested by Donatelli et al. [49]. The base of support is reduced in the single-leg stance, making it more challenging to maintain the center of body mass within a smaller area. Other literature supports this finding [28].

Moreover, our results showed a significant positive correlation between FHP and the degree of deviation from the starting position. This means that the ability to control dynamic stability decreases with increasing FHP. This result can be explained by the close relationship between cervical sensory afferents and vestibular nuclei. Since we used the closed eyes condition in both dynamic and static balance tests, and vestibular infection and dizziness were exclusion criteria, body imbalance would more likely result from somatosensory system inefficiency and proprioceptor function disorder [38]. Previously, Saremi et al. showed that proprioceptive deprivation would positively and significantly affect the working postures of dentists [10].

CONCLUSION

In conclusion, our results provide evidence of the relationship between FHP and postural stability adjustment mechanisms. It seems that postural stability disorders increase with the development of FHP. One of the most important side effects of postural stability mechanism disorders is a reduction in eye-hand coordination. This could negatively affect the working performance in highly demanding jobs such as dentistry, which simultaneously require accuracy, hand skillfulness, and fine movements.

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