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Assessment of core endurance and shoulder proprioception in dental students with and without forward head posture

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Abstract

Background One of the most prevalent musculoskeletal issues in dentistry is forward head posture (FHP). Proprioception and core endurance are crucial for maintaining proper posture.

Objective The aim of this study was to compare dental students with and without FHP in terms of their core endurance and shoulder proprioception.

Methods Using kinovea software, a cross-sectional study was conducted on 30 dental students who had FHP with a craniovertebral angle less than 49 degrees. The control group consisted of 30 additional dental students without FHP. Trunk anterior flexor, posterior extensor, right and left flexors were tested using the McGill method to determine core endurance. The isokinetic Biodex system was used to measure shoulder proprioception.

Results Independent t-test results revealed that core endurance was significantly lower in the group with forward head posture compared to the control group (p 0.05), while shoulder proprioception did not differ significantly between groups ($p > 0.05$).

Conclusion In comparison to dental students without forward head posture, male dental students with FHP have normal shoulder joint proprioception and impaired core endurance holding time. This could be a risk factor for a variety of musculoskeletal issues in dentists.

Keywords Forward head posture, Craniovertebral angle, Core endurance, Shoulder proprioception

Introduction

Dentistry is one of the professions where therapy intervention requires a high level of concentration [1]. Because of their jobs, those in the oral health industry are more likely to experience musculoskeletal problems than those in other healthcare professions because they are hunched over during work practices most of the day [2]. Long periods of time spent sitting for dentists and dental students during practical training causes their cervical spines to flex and rotate forward, placing a significant static strain in the neck region and primarily causing neck pain [3]. A recent study found that dental students had a high prevalence of musculoskeletal symptoms, particularly neck and low back pain [4].

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The forward head posture (FHP) is a postural misalignment in which the head stays in front of the plumb line that runs from the tip of the shoulder to the ear [5]. Due to this postural deviation, the lower cervical vertebrae are flexed while the head and upper cervical vertebrae are extended. The external moment arm's lengthening causes a greater load to be placed on the posterior neck muscles by moving the head's center of gravity away from the movement's axis of rotation [6]. FHP was long believed to be a risk factor for disorders of the neck and shoulders [7]. Since dental students must work with their heads forward for longer periods of time than other students, Naz et al. [8] came to the conclusion that FHP is more common in dental students than in students in other specialties.

Numerous studies revealed that FHP was linked to a wide range of health issues, including chronic low back pain [9], carpal tunnel syndrome [10], impaired respiratory function [11], temporomandibular joint dysfunction [12], uneven weight distribution in the plantar arches [13], and emotional stress [14]. FHP also has adverse effects on dynamic balance [15], cervical spine range of motion [16], and the strength and endurance of the neck muscles [17].

The core, which serves as a link between the upper and lower limbs, is important for maintaining balance, functional mobility, and postural stability [18]. Core strength and endurance may be influenced by a variety of factors, such as spinal alignment, neural control, level of exercise and training, as well as the presence of lower back pain [19–21]. The muscle imbalance brought on by FHP can alter the alignment of the lumbar and trunk vertebrae, which in turn affects the cervical region and other levels of the spine in terms of muscular performance [22, 23]. Poor core muscle endurance, particularly in young people, can lead to postural misalignments [24].

Proprioception is a sensory feedback system that aids the body's nervous system in maintaining proper alignment of the body parts. In comparison to other body muscles, the neck muscles have a higher muscle spindle density. As a result, the neck muscles play a significant role in providing proprioceptive sensory information [25]. It has been noted that while mild exercise or warm-up exercises improve proprioceptive acuity, aging, cryotherapy, and exercise-induced fatigue negatively affect joint proprioception [26]. Afferent input to the muscle spindles is disrupted as a result of the length changes in muscles brought on by FHP, which has a negative impact on joint position sense [27]. Previous studies found that the FHP group had lower cervical spine proprioception than their peers [28–30]. According to Krause et al.'s systematic review, tension can be transferred between some of the nearby anatomical structures. This force transfer may have an effect on postural misalignment and overuse conditions [31].

Previous research has largely concentrated on shoulder proprioception and core strength in general populations rather than occupational groups [23, 32]. It will be easier to create effective preventive and rehabilitation programs for this postural condition with the identification of FHP predictors. Therefore, the purpose of this study was to evaluate endurance and shoulder proprioception in male dental students with FHP.

Materials and methods

Participants

Thirty dental students with FHP served as the study group in this observational cross-sectional study. These participants were matched with dental students without FHP as the control group in terms of number, level of physical activity, earned semester hours, and demographic characteristics including age, height, weight, and BMI [33] The participants were all between the ages of 19 and 25, and all were recruited from local medical schools in Jeddah city, KSA using student e-mail lists and open announcements on the local newsgroups. Before being assigned to the study or control group, students were first screened to ensure that they were eligible to take part in the study. This was followed by a photographic assessment of the craniovertebral angle (CVA). Students who have a craniovertebral angle (CVA) less than 49 degrees, which indicates the presence of FHP, were included in the study group [34, 35] while others included in the control group. Students who have cervical trauma, congenital anomalies, vestibular pathology, or dizziness were excluded [36].

Each participant was given information on the goals of the study prior to participating, and they all signed consent forms. The selection of participants is explained in the flow diagram (Fig. 1). G*Power 3.1 was used to calculate the sample size, which was found to be 36 participants based on alpha = 0.05, power = 0.90, and effect size = 0.8. The local college's institutional ethical committee (Res-2021–0017) approved the study, which was carried out in accordance with the Declaration of Helsinki. into the study or control group. Students were included in the study group if they have a craniovertebral angle (CVA) < 49° which indicates the presence of FHP [34, 35] while they were excluded if they have cervical trauma, congenital anomalies, vestibular pathology, or dizziness [36].

All participants were informed about the aim of this study and signed a consent form before their participation. Selection of participants explained in the flow diagram (Fig. 1). Sample size was determined using G*Power 3.1 to be 36 participants according to alpha. Alpha = 0.05,

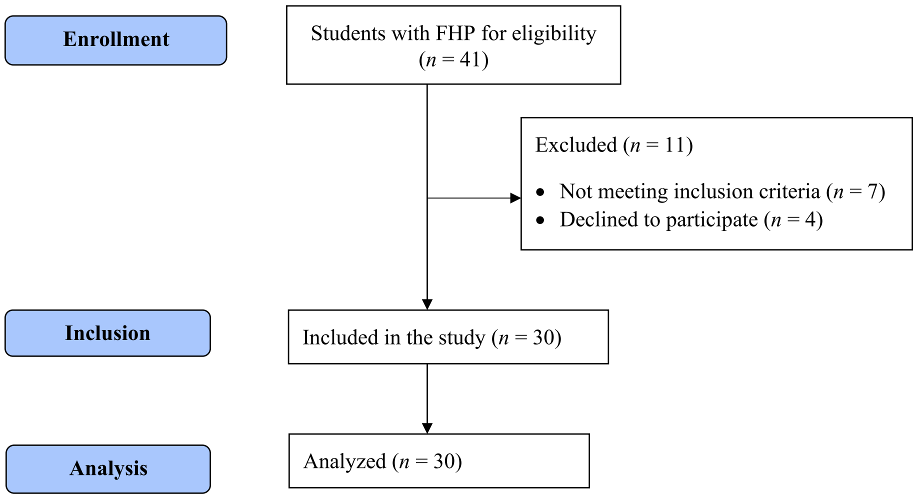

Fig. 1 The flow diagram of the students with FHP during the study

power = 0.90, and effect size = 0.8. The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Ethical Committee of the local college (Res-2021–0017).

Evaluative procedures

All assessments were taken by qualified experts with at least 5 years of experience in photographic and musculoskeletal assessments who were blinded to both the purpose of the study and group assignment

Photographic CVA measurement

The subject was asked to stand on a fixed point with no movement. First, the participant's tragus of the ear, and seventh spinous process (C7) were identified and marked. Digital Camera (Sony Alpha a6000 Mirrorless with 15–20 mm zooning lens) placed 1.5 m from the subject was used to take a lateral view photo for each participant. The CVA was measured using Kinovea Software (version 0.8.24) at the intersection point of two lines. Then, the subject was photographed, and the photo was exported to kinovea software. The marked anatomical landmarks were connected to make an intersection (CVA) between two lines. The first line was connected between the 7th cervical vertebra to the tragus of the ear, and the second line was passed horizontally through the 7th vertebra [23, 37] (Fig. 2). The average of two measurements of CVA was taken. Kinova is a valid and reliable software method with ICC as high as 0.99–1.00 which measure in accurate way at distances up to 5 m from the subject with angle range of 90˚–45˚ [38].

Assessment of core endurance by McGill tests

McGill's torso muscular endurance test battery, which is valid and reliable [39], was used to measure the endurance of core muscle. These tests consisted of four positions: the trunk anterior flexor test, trunk posterior extensor test, the right and left lateral plank with ICC of 0.66, 0.79, 0.74, and 0.96 respectively [40].

Fig. 2 Measurement of CVA: (**a**) Student with FHP, (**b**) Student without FHP

For familiarization purposes, one trial was permitted for each test position prior to the actual recording. The maximum holding time in seconds was then noted while assuming the four test positions using a stopwatch. The test was started and stopped by the examiner using the commands "begin" and "stop," and the times were recorded by a research assistant who was a therapist with at least two years of experience in the field of musculoskeletal research using a stopwatch. If the trunk angle deviates 10 degrees from the starting point, the examiner will end the test. All testing positions were subjected to this criterion. Standard rest intervals between tests and trials were set at 5 and 1 min, respectively [41].

In a random order, the four testing positions were evaluated. In the trunk anterior flexor test, participants sat with their hands over their chest, their trunks flexed to sixty degrees, and both of their legs bent to sixty degrees. A goniometer was used to measure the participants' trunk and knee flexion degrees, and time started when they assumed the measured posture and ended when the trunk veered away from sixty degrees. During the trunk posterior extensor test, the research assistant held straps to support the participant's lower body as he lay on his stomach on the plinth with his waist level at the edge of the plinth and his hands crossed on his chest.

In the right lateral musculature plank test, the test subject was lying on his right side with his left foot on top of his right, his right elbow flexed 90 degrees and supported on the mat, his left arm crossed over his chest, and his left hand resting on his right shoulder. Similar steps were taken to perform the plank test on the left lateral musculature. When the examiner noticed a disturbance in the line connecting the trunk or lower body segments, time was stopped [42].

Assessment of shoulder proprioception by isokinetic dynamometer

According to the findings of a 2017 systematic review, it is valid and most reliable to evaluate shoulder proprioception using an isokinetic dynamometer choosing a protocol for internal rotation at 90° of shoulder abduction with an ICC of 0.88 [43]. The shoulder repositioning accuracy was evaluated using a Biodex isokinetic dynamometer (Biodex Medical Inc., Shirley, New York, USA).

On the Biodex chair, each participant sat comfortably with the knees and hips flexed to about 85 degrees and the trunk straight. The trunk was stabilized by a firm back that supported it up to the scapular level and two anterior straps stretched diagonally from just above the shoulder level to the opposing pelvic side. The thigh of the tested side was crossed by a single strap in a horizontal position. The arm was supported and abducted 90 degrees in the scapular plane. Prior to data collection, each participant underwent two familiarization trials. The first step involved passively moving the tested extremity to a target angle of 75 degrees of shoulder internal rotation while keeping the eyes open. The target angle was an average 90% of the available internal rotation range of all participants [44]. The participant was then instructed to hold the position for 10 s as part of the learning process. The device then enabled the limb to return to its initial position. The participant was given instruction to actively return to the target angle of 75 degrees after a 30-s break and do so with their eyes closed. The participant asked the examiner to stop the apparatus when he felt he had reached the target angle actively. For each participant, three trials were recorded and the average was calculated. The deficit in repositioning accuracy was measured as the angle difference between the target angle position and the participants' perceived end range position [32]. Because it is more accurate than the dominant shoulder when moving into internal rotation, measurements were taken for the non-dominant shoulder [45].

Statistical analysis

The Statistical Package for Social Sciences (SPSS) for Windows version 20.0 (SPSS, Armonk, NY, IBM Corp). Unpaired t-test was used to determine the difference in age, height, weight, and BMI between both groups ($p > 0.05$). The independent t-test was used to compare the mean values for core endurance and shoulder proprioception between both groups. Four presumptions were confirmed in order to guarantee the validity of independent t-test results. These presumptions included that variables in both groups were independent, that samples were drawn at random, that observations were distributed normally, and that the variance was homogeneous as verified by Shapiro–Wilk and Levene's tests. By default, SPSS excludes any missing values and bases results on the number of non-missing values. The significance level of a p-value of ≤ 0.05 was considered statistically significant using 95% confidence intervals.

Results

Sixty dental male students (30 with FHP, and 30 without FHP) with an age range from 19 to 25 years were participated in this study. Demographic data comparisons showed non-significant difference in age, height, weight, and body mass index (BMI) ($P > 0.05$) between groups, while there was a significant difference in the value of the CVA ($P < 0.05$) which was main criteria for group allocation. These demographic data were presented in the Table 1. Between group comparisons using independent t-test revealed that dental students without FHP have a significantly higher holding time in all tested core endurance tests ($P < 0.05$): trunk anterior flexor test, trunk

Table 1 The demographic data of dental students with and without FHP

Groups	Students with FHP group Mean ± SD	Students without FHP group Mean ± SD	*p*-Value
Age (years)	22.33 ± 4.21	22.67 ± 4.42	0.624
Height (m)	1.74 ± 0.07	1.76. ± 0.06	0.660
Weight (kg)	79.22 ± 25.92	77.33 ± 18.41	0.408
BMI	26.39 ± 8.29	24.66 ± 4.92	0.431
CVA	40.78 ± 2.28	59.78 ± 1.99	0.007*

Data are illustrated as mean ± standard deviation, FHP (forward head posture), CVA (Craniovertebral angle)

* *p* value > 0.05 means statistical significant difference

posterior extensor test, right lateral musculature test, and left lateral musculature test. On the other hand, there was no significant difference between groups regarding shoulder proprioception ($P > 0.05$). These comparisons are showed in Table 2.

Discussion

The purpose of this study was to assess shoulder proprioception and core strength in dental students with FHP. More than any other professional medical worker, dentists are more likely to experience musculoskeletal problems, which is why they were the study population in several previous studies [4, 8, 41].

The study's findings revealed that the FHP group experienced a significant reduction in core endurance as measured by position holding time in all directions, while there was no significant difference between the two groups' shoulder proprioception. These findings might shed light on the significance of FHP preventive programs, which concentrate on core training and may help to lower the incidence of job-related musculoskeletal issues in dental students. However, these core exercises may be seen as being more important than those that target shoulder joint proprioception.

These results are consistent with those of Salahzadeh et al. [23], who found that recreationally active participants with FHP had significantly lower trunk muscle endurance than controls. Poor core endurance in the FHP group can be attributed to the associated neck, shoulder, and trunk postural malalignments [7]. FHP may be accompanied by upper cervical hyperextension [23], shoulder flexion to the front [46], and thoracic hyperkyphosis [47]. The proper length-tension relationship may be impacted by these various postural abnormalities [17], which would reduce the strength and endurance of the core muscles.

This explanation is supported by the work of Gong et al. [48], who found that individuals with FHP had weak deep neck flexor endurance. Additionally, Takasaki and Okubo reported that during movement, the muscles in one region of the human body can influence the muscles in other regions; this relationship can be seen between the head and neck region and the lumbopelvic region [49]. In the hook-lying position [50], abdominal hollowing [51], and prone bridging [6], the impact of trunk control based on head conditions has been noted.

According to Hlavenka et al. [22], lifting a moderate load with a retracted neck position that corrects FHP causes increased lumbar erector spinae and external oblique EMG activity, which creates a safer lower back posture. Moreover, Yu et al.'s [6] research results showed that head extension increases the activation of the lumbar multifidus muscles.

The changes in electromyographic activity of the stabilizing muscles can be used to identify weak core muscles. The EMG activities of the middle trapezius and splenius muscles, which are thought of as stabilizers, were significantly different between the control and FHP groups, according to Lee et al. [52], whereas there were no significant differences between the two groups'

Table 2 Comparison between core endurance and Isokinetic dynamometer proprioceptive tests in dental students with and without FHP

	Students with FHP Mean ± SD	Students without FHP Mean ± SD	*p*-Value	MD (95% CI)	Effect size Measures	
					Cohen's d	Glass's details
Core endurance test (in seconds)						
• Trunk anterior flexor	46 ± 23.2	74 ± 34.7	0.008*	28 (23.88 – 32.11)	0.84	1.20
• Trunk posterior extensor	41.6 ± 25.9	60.2 ± 21.8	0.004*	18.6 (17.13 – 20.06)	0.77	0.71
• Rt lateral musculature	23.7 ± 12.4	35.8 ± 8.7	0.008*	12.1 (10.77– 13.42)	1.29	0.97
• Lt lateral musculature	22.77 ± 14.07	37.3 ± 17.14	0.005*	14.6 (13.50 – 15.69)	0.92	1.03
Isokinetic dynamometer test (in degrees)	6.23 ± 2.52	5.98 ± 2.83	0.086	0.25 (0.33 – 0.56)	0.25	0.31

Data are illustrated as mean ± standard deviation, *FHP* forward head posture, *MD* mean difference, *CI* confidence interval

* *p* value > 0.05 means statistical significant difference

EMG activities of the upper trapezius muscle, which is thought of as a global mobilizer muscle, during protraction and retraction of the neck.

Although a number of earlier studies showed that people with FHP had lower cervical proprioception [29, 30], the results of the current study showed that there was no significant difference between the FHP and control groups in terms of shoulder proprioception. Our results support those of Anwar et al. [32], who discovered no statistically significant difference in shoulder proprioception between the FHP group and control group.

The density of proprioceptive innervation in each area is what distinguishes cervical proprioception from shoulder proprioception. The upper cervical region's proprioceptive organs are extremely sensitive to changes in postural alignment and work closely with the vestibular system to maintain equilibrium and balance [27]. The cervical region is thought to play a significant role in information transmission, and that is why the muscles of the neck have a large number of mechanoreceptors [53].

The present study has some limitations. The study was first conducted on male dental students; consequently, results cannot be applied to female students. It is suggested that both sexes be included in future studies. Second, uncontrolled factors during the McGill endurance tests, such as individual variations in muscle activation or in the amount of force required to maintain the testing positions, may result in measurement bias. Third, poor vision was not a factor in the exclusion process. Also, although the nondominant shoulder's proprioception was assessed in accordance with recommendations from the literature, this does not necessarily reflect the participant's functional abilities in their daily activities. Finally, there was no comparison of dental students to those in other fields. Future research should examine the impact of core stability training on dental students' levels of FHP.

Conclusion

Given the limitations of the study, the results of the present investigation suggest that dental male students with FHP have lower levels of core endurance than dental male students without FHP. However, the current study's findings revealed that FHP had no negative effects on the population's shoulder joint proprioception. To provide stronger evidence for clinical implementation, it is advised that future research be conducted with a larger sample size and both sexes.

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Authors' contributions
Conception and design of the study by RSD and ORA, Methodology by RSD and ORA, Data collection by SM and EEM and, Software by SM and EEM, Data analysis and interpretation by ORA, Drafting by RSD and EEM, Critical revision by RSD and ORA. All authors read and approved the final manuscript.

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Availability of data and materials
Available on request.

Declarations

Ethics approval and consent to participate
The study was approved by the Ethical Committee of the Local College (Res-2021–0017). All participants were informed about the aim of this study and signed a consent form.

Consent for publication
Photograph release forum was obtained from participants.

Competing interests
The authors declare that they have no competing interests.

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