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ORIGINAL RESEARCH

The effect of different jaw positions on upper extremity performance, core endurance, and postural stability: A cross-sectional study

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Abstract

The jaw sensorimotor system has functional relationships with other parts of the body through neuroanatomical and biomechanical interactions. The aim of this study was to examine the effects of different jaw positions on upper extremity performance, core endurance, and postural stability. This cross-sectional study included 49 healthy young adults aged 18-28 years. Upper extremity performance was evaluated using the push-up test, core endurance was evaluated using McGill's Trunk Flexion and Extension Test and postural stability was evaluated using the Balance Error Scoring System. All assessments were made with resting jaw and clenching jaw positions. There was no significant difference in the Push-up test and Balance Error Scoring System scores in different jaw positions ($p>0.05$). The McGill trunk flexion test and extension test performance were found to be better in the clenched jaw position ($p=0.017$, $p=0.035$, respectively). The results of this study showed that jaw clenching increases core endurance time. This result should be taken into account when planning an evaluation and rehabilitation program for the core area.

Keywords: Jaw, physical functional performance, postural balance.

Introduction

Activities that require continuous muscle contraction, such as jaw clenching, increase the corticospinal excitability of distant muscles with the "remote effect" (Sugawara et al., 2005). Jaw clenching is a frequently used manoeuvre in daily life, in jobs requiring high effort or sports activities (Kawakubo et al., 2014). Voluntary jaw clenching increases distal muscle activation (Ebben et al., 2010). This effect is thought to be due to a decrease in reciprocal innervation (Sugihara et al., 2020; Takada et al., 2000).

There has been a recent increase in studies focusing on the effect of jaw position on postural stability, dynamic balance, motor activity, and muscle endurance (Alghadir et al., 2022; Alghadir et al., 2020; Tomita et al., 2021; Zafar et al., 2020). While there is evidence that jaw clenching increases cortical activation, there is also evidence that jaw position does not affect hand-motor activity during writing (Alghadir et al., 2020; Kawakubo et al., 2014). Although there is evidence that jaw clenching increases the isometric activities of upper extremity muscles, the effect of jaw position on upper extremity functional performance is not clear (Ferrario et al., 2001; Takahashi et al., 2003).

Proximal stability is required for distal mobility (Kibler et al., 2006). Core stability supports efficient body mechanics by minimizing the load on the proximal joints and increasing force production. Impairment of core endurance is associated with lower back pain and risk of injury, especially during high-level physical activities (Abdelraouf & Abdel-Aziem 2016). Core endurance facilitates force generation and transmission during activities of daily living and sports, providing a better quality of movement (Santos et al., 2019). Therefore, core

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endurance and influencing factors should be well understood. It has been stated that jaw clenching increases trunk muscle activity (Ehrlich et al., 1999). Dental occlusion has been shown to affect the biomechanical and viscoelastic properties of neck and trunk muscles (Julià-Sánchez et al., 2020). Jaw clenching may affect core endurance as it can increase motor system excitability (Boroojerdi et al., 2000).

Postural control, which is important for many activities of daily living, is controlled by the visual, vestibular and somatosensory systems and requires multiple neural-motor interactions (Cuccia & Caradonna 2009). The jaw influences body posture due to its proprioceptive and muscular chain connections, in addition to the neuroanatomical and biomechanical relationships (Cuccia & Caradonna, 2009; Saito et al., 2009). It has been reported that jaw clenching affects plantar load distribution, which is important for postural control (Cuccia, 2011; Yoshino et al., 2003). Although there are studies reporting that jaw clenching increases postural stability, there are also studies reporting that it has no effect on postural stability (Alghadir et al., 2015; Tomita et al., 2021). If a deterioration in postural control leads to balance errors, the risk of adverse events may increase. In the current study, the effect of jaw position on postural stability was examined by evaluating balance errors.

Knowing the effect of jaw position on functional performance tests will both reveal the effects of the jaw sensorimotor system on other parts of the body and show how much attention should be paid to the jaw position during evaluation and rehabilitation. It has been reported that the stomatognathic system is in contact with other parts of the body through the muscle-fascial chains (Cuccia & Caradonna, 2009). Voluntary teeth clenching facilitates motor system excitability (Boroojerdi et al., 2000). Accordingly, in the current study, it was hypothesized that jaw clenching could improve upper extremity performance, core endurance, and postural stability. The aim of this study was to examine the effects of different jaw positions on upper extremity performance, core endurance and postural stability.

Methods

Participants

This cross-sectional study included 49 healthy young adult volunteers aged 18-28 years. Those with tooth or jaw pain, a history of temporomandibular joint disorders, balance problems, low back pain, musculoskeletal injury in the last year, or orthopedic or neurological disease were not included in the study. Individuals who met the inclusion criteria were invited to the study after being informed about the study. A signed consent form was obtained from the individuals who agreed to participate. The study was carried out between May-June 2022 at the University of Health Sciences Turkey, Gülhane Faculty of Physiotherapy and Rehabilitation. This study was approved by the University of Health Sciences Gülhane Scientific Research Ethics Committee in accordance with the Declaration of Helsinki (Decision number: 2022-142).

Procedure

After recording the descriptive information of the participants such as age, height, weight, and gender, the performance tests were performed in the resting jaw position and the maximum voluntary jaw clenching position. No instructions were given regarding the jaw position in the resting jaw position. In the maximum voluntary jaw clenching position, the subject was asked to clench their teeth and keep them clenched throughout the test. The order of the jaw positions was decided randomly to avoid the learning effect and influence of fatigue. Upper extremity performance was evaluated using the push-up test, core endurance using McGill's flexor and extensor tests, and postural stability using the Balance Error Scoring System (BESS) test. Before the performance tests, all the individuals were informed about the tests and there were several trials to teach the test. The order of the tests was determined randomly. The tests were administered in the same environment, with the same instructions given to each participant. Each test was explained to the participants, demonstrated, and a trial was given. Physical performance was recorded when the test was performed correctly.

Outcome Measures

The push-up test was used to evaluate upper extremity performance. This test evaluates the strength and endurance of the upper arm and shoulder girdle. The push-up test was applied to male subjects in the standard position (on the fingers and toes), and to females in the modified position in which the individuals took the hand and knee positions. The participants began in the “up” position with their elbows fully extended, lowering the body towards the floor, bending their elbows until the upper arm was parallel to the test surface. The participants were instructed to avoid head and trunk movements as much as possible. A warm-up attempt was made before starting the test, then push-ups were performed as quickly as possible for 15 seconds.

The number of push-ups completed in 15 seconds was recorded. The test-retest reliability of this test has been found to be high (Intraclass correlation coefficient = 0.96) (Negrete et al., 2010; Negrete et al., 2011).

Core endurance was evaluated using McGill's flexor and extensor tests. In the McGill's trunk flexion test, the participants were positioned with their hands crossed on their chest, trunk flexed to 60° and knees flexed to 90°. Trunk flexion was adjusted to 60° with the help of a stretcher with adjustable head. It was ensured that there was no support behind the subject during the test, and they were instructed to hold the test position for as long as possible. The test was terminated when the trunk deviated anteriorly or posteriorly from the 60° flexion position. The maximum time that the test position could be held was recorded in seconds. In the McGill trunk extension test, the participants were positioned prone on a table with the spina iliaca anterior superior on the edge of the table. The subjects were allowed to support themselves with their hands on a chair placed at the edge of the table until the test began. The individual's legs are fixed on the table. When starting the test, the subjects were asked to raise their hands from the chair, cross them on their chest and maintain a position with the legs parallel to the ground for as long as possible. The test was terminated when the straight position of the trunk was disturbed. The test time was measured using a stopwatch, recorded in seconds (Ambegaonkar et al., 2014; McGill et al., 1999). Core endurance tests are the most reliable tests for evaluating core stability (Waldhelm & Li, 2012).

The BESS test is a reliable test commonly used in healthy adults. In this test, the subject is asked to hold three different positions on foam and firm surfaces for 20 seconds. These positions are feet together, tandem stance and single-leg stance. During the test, the eyes should be closed and the hands should be on the hips. An error identified during the tests is scored with 1 point. These errors include opening the eyes, raising the hands from the iliac crest, stumbling or falling, stepping, raising the forefoot or heel, flexing or abducting the hip more than 30° or staying out of the test position for more than 5 seconds. A maximum of 10 errors are calculated in each position, with a possible maximum total score of 60. The order of test positions was determined randomly (Bell et al., 2011; Finnoff et al., 2009).

Data Analyses

Data were analyzed using SPSS version 25.0 software (SPSS Inc. NY, USA). The Kolmogorov-Smirnov test and visual methods (histogram and probability plots) were used to evaluate the normal distribution of data. The Wilcoxon test was used to compare functional test performances in the resting jaw and clenched jaw positions and to compare the BESS test performances on foam surface and firm surface. A value of $p<0.05$ was considered statistically significant.

Results

Evaluation was made of 49 healthy young adults, comprising 34 (69.4%) females and 15 (30.6%) males with a mean age of 20.79±1.49 years. The demographic characteristics of the participants are presented in Table 1.

Table 1

Demographic characteristics of the participants (n=49)

Variable	Mean	SD
Age (years)	20.79	1.49
Height (cm)	168.75	9.95
Weight (kg)	64.97	14.89
Body Mass Index (kg/m^2)	22.71	4.35

n: Number of participants; SD: Standart Deviation.

There was no significant difference between the resting jaw and clenched jaw positions in respect of the push-up test and BESS test performances ($p>0.05$). The McGill's flexor and extensor tests performances were determined to be significantly better in the clenched jaw position ($p=0.02$ and $p=0.035$, respectively; Table 2).

In the resting jaw position and the clenched jaw position, the number of errors made on the BESS test foam surface was higher than on the firm surface ($p<0.001$; Table 2).

Discussion

This study was planned to examine the effects of different jaw positions on upper extremity performance, core endurance and postural stability. The results demonstrated that jaw clenching, which is assumed to improve physical functional performance, increased core endurance time, but had no effect on upper extremity performance and postural stability evaluated with the balance error score.

Table 2
The Push-up Test, McGill's flexor and extensor tests and BESS test results of participants during resting jaw and clenching jaw (n=49).

	Resting Jaw Position		Clenched Jaw Position		
	Median	Interquartile Range (1-3)	Median	Interquartile Range (1-3)	p
Push-up Test	8	7-11	9	6-10.5	0.200
McGill's Flexor Test (sec)	104	49-180	138	64.5-180	0.020*
McGill's Extansor Test (sec)	72	51.5-121.5	92	58-119.5	0.035*
BESS Test Firm Surface	4	2-6	4	2-8.5	0.279
BESS Test Foam Surface	13	10-16	13	10-15	0.328
BESS Test Total Score	17	13-22.5	17	14-23	0.996

BESS: Balance Error Scoring System; Sec: Second; * p<0.05

It has been reported that jaw position affects biceps brachii muscle endurance time, forearm muscle motor activity, isometric strength during shoulder abduction, and deltoid muscle isometric strength (Abdallah et al., 2004; Ferrario et al., 2001; Takahashi et al., 2003; Wang et al., 1996). Churei et al. demonstrated that jaw clenching increased grip strength (Churei, 2003). These studies appear to evaluate isometric strength and endurance, and the results can be explained by the facilitation of H-reflexes during jaw clenching (Takahashi et al., 2003). Similarly, it has been stated that teeth clenching contributes to stability rather than smoothness of movements, increases the isometric force, but does not affect the isokinetic force (Sasaki et al., 1998; Takada et al., 2000). Dias et al. (2018) reported that dental occlusion did not affect upper extremity muscle activity in pistol shooters. In the current study, upper extremity performance was evaluated using the push-up test, which is a functional assessment, and the results showed that the jaw position did not affect the push-up test performance. This result suggests that although the jaw position affects the isometric muscle activity of the upper extremity due to its anatomic and functional connections, it does not create a difference in the functional performance of the upper extremity. The reason for this may be that the performance of complex movements such as push-ups that require the coordinated work of different muscles may be affected by different factors.

Musculoskeletal system disorder in the jaw has been associated with long-term neck, shoulder and/or low back pain (Wiesinger et al., 2007). Jaw clenching has been shown to increase muscle activity of neck and trunk muscles (Ehrlich et al., 1999). The results of the current study confirmed the jaw position-trunk relationship. The fact that jaw clenching increases neuromotor stimulation may have led to this result (De Souza et al., 2021). As jaw clenching increased the core endurance test performance, this suggests that it would be appropriate to use jaw clenching during core endurance training. In addition, the results of the current study suggest that attention should be paid to the jaw position during core endurance assessment.

Zafar et al. (2020) stated that jaw clenching had a limited relationship with dynamic postural control. In previous studies, postural control has generally been assessed by measuring postural sway. The effect of jaw clenching to increase postural stability has been demonstrated in some studies (Alghadir et al., 2015; Hosoda et al., 2007). However, there are also studies stating that jaw clenching did not increase postural stability (Tomita et al., 2021). In the current study, postural stability was evaluated by scoring balance errors, and it was observed that jaw clenching did not cause a significant change in the number of balance errors. This shows that jaw clenching has no significant effect on balance errors. The foam test surface caused a significant increase in balance errors. Similarly, Alghadir et al. found that different jaw positions on hard and soft surfaces did not affect postural stability, but each jaw position had better postural stability on hard surface (Alghadir et al., 2022).

Laboratory tests have generally been used in studies examining the effect of jaw position (Alghadir et al., 2022; Alghadir et al., 2015; Ehrlich et al., 1999; Ferrario et al., 2001; Sugihara et al., 2020; Tomita et al., 2021). Although these tests provide objective data, they are difficult to apply in a clinical setting. Functional performance tests, which can be easily applied in the clinic, measure functional abilities or limitations in the context of activities of daily living (Reiman & Manske, 2009). For rehabilitation professionals who aim to improve functional performance, it is important to understand the impact of different conditions on performance. The present study provides important results about effect of jaw position on the functional performance of different body parts. However, the fact that the study was conducted only in healthy young adults limits the generalizability of the results. Due to the nature of body biomechanics, the jaw can be clenched during an action. This situation is difficult to control and is an limitation for study. In future studies, investigating the effect of jaw position on functional performance in different age groups and individuals with different clinical characteristics will help to better understand the effect of jaw position. Moreover, the effectiveness of core endurance training performed in different jaw positions can be examined in future studies.

Conclusion

It was found that the clenched jaw position had a positive effect on core endurance, and it did not have a significant effect on push-up test performance and postural stability, which was measured by evaluating balance errors. The results of this study show the effect of the jaw sensorimotor system on performance related to other body systems. It is recommended to consider the jaw position when planning an evaluation and rehabilitation program for the core muscles.

Authors' Contribution

Study Design: SD, GG, ÖG; Data Collection: SD, GG, ÖG, BK; Statistical Analysis: SD; Manuscript Preparation: SD, GG, ÖG, BK; Funds Collection: SD, GG, ÖG, BK

Ethical Approval

The study was approved by the University of Health Sciences Turkey Gülhane Scientific Research Ethics Committee (2022-142) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki.

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Conflict of interest

The authors hereby declare that there was no conflict of interest in conducting this research.

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