Advances in Physical Education, 2023, 13, 288-295
https://www.scirp.org/journal/ape
ISSN Online: 2164-0408
ISSN Print: 2164-0386

Effect of Wearing an Oral Appliance on Range of Motion of Spine during Trunk Flexion

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How to cite this paper: Takahashi, M., Bando, Y., Kitaoka, K., & Hata, K. (2023). Effect of Wearing an Oral Appliance on Range of Motion of Spine during Trunk Flexion. *Advances in Physical Education, 13,* 288-295.
https://doi.org/10.4236/ape.2023.134023

Received: October 23, 2023
Accepted: November 26, 2023
Published: November 29, 2023

Abstract

Purpose: The aim of this study was to clarify the effect of wearing an oral appliance on the range of motion of the spine during trunk flexion in elite-level athletes. **Method:** Participants were 15 elite-level female handball players (24.9 ± 2.0 years). A single-layer mouthguard was fabricated using a 2.0-mm-thick thermoplastic sheet that all teeth were adjusted to make even contact upon light clenching. Spinal curvature was measured in the static standing posture and standing forward-bending posture by using a spinal shape analyzer. The evaluation indices were thoracic kyphosis angle (TKA), lumbar lordosis angle (LLA), sacral inclination angle (SSA), and spinal inclination angle (SIA). Measurements were made under three conditions: mandibular resting position (RP), clenching in the intercuspal position (ICP), and clenching while wearing a mouthguard (MG). Differences in spinal curvature due to occlusal conditions were compared using repeated measure analysis of variance. **Results:** LLA, SSA, and SIA showed significant differences between RP and ICP, and between RP and MG, with RP having the greatest range of motion. There was no significant difference in any spinal alignment between ICP and MG. TKA was not significantly affected by occlusal condition. **Conclusion:** This study was clarified that lumbar lordosis angle, sacral inclination angle, and spinal inclination angle during trunk flexion decreased with clenching, regardless of the presence or absence of an oral appliance. Therefore, it was suggested that clenching contributes to trunk stabilization and may affect flexibility.

Keywords

Spinal Alignment, Spinal Range of Motion, Clenching, Oral Appliance, Mouthguard, Trunk Flexion

1. Introduction

Posture is maintained by the sustained activity of the trunk muscles, which are primarily located in the front and back of the body (Ghamkhar & Kahlaee, 2019). When maintaining an upright posture, there is little activity of the postural muscles: instead, posture is maintained mainly through fascial tension. When the trunk is flexed or extended, postural muscles play a role in maintaining posture by resisting the movement of the center of gravity (Ghamkhar & Kahlaee, 2019). In particular, muscle groups located on the ventral side of the body (i.e., neck flexors, abdominal muscles, iliopsoas, quadriceps, tibialis anterior) and located on the dorsal side of the body (i.e., neck extensors, spinal erectors, gluteus maximus, hamstrings, and triceps surae) contribute substantially to posture maintenance. These muscles have a fascial linkage with the maxillofacial and neck muscles, which are involved in occlusion, and play a major role in postural control (Thomas, 2016; Robert & Amanda, 2019). Furthermore, clenching or occlusion stimulates vestibular sensation, which is one of the sensory inputs for postural control (Takahashi et al., 2021). From these findings, it was speculated that the muscle group involved in occlusion affects spinal motion during trunk flexion and extension.

During sports, various posture changes including special action occur repeatedly. In many cases, postural stability during competition is maintained by predictive postural control or reflexive postural control. However, if the execution of this postural control is delayed, the body loses its balance and excessive load is applied to muscle tissue, tendon organs, and joints, and in excessive cases, may even lead to injury. One of the ways to protect the stomatognathic area from these situations is to wear a mouthguard.

We previously investigated the effect of clenching on spinal curvature in healthy men (Takahashi et al., 2021). It was clarified that clenching had almost no effect on spinal alignment in the upright posture, but it did reduce spinal curvature in trunk flexion. In other words, spinal motion was restricted by the postural muscles associated with clenching and the effects of the fascial chain involved. The purpose of this study was to clarify the effect of wearing an oral appliance on the range of motion of the spine during trunk flexion in elite-level athletes. The null hypothesis is that wearing an oral appliance affects the range of motion of the spine during trunk flexion.

2. Materials and Methods

2.1. Ethical Approval of Studies and Informed Consent

This study was approved by the Ethics Committee of The Nippon Dental University School of Life Dentistry at Niigata (ECNG-R-443). The details of the study were described in full to all participants, and written informed consent was obtained prior to their participation.

2.2. Participants

The participants were 15 elite-level female handball players (average age: 24.9 ± 2.0 years) with normal occlusion and no subjective or objective morphological or functional abnormalities in the stomatognathic system.

2.3. Mouthguard Fabrication

A single-layer mouthguard was fabricated using a 2.0-mm-thick thermoplastic sheet (Sports Mouthguard; Keystone Industries, Cherry Hill, NJ) and a pressure molding machine (Model Capture Try; Shofu Inc., Kyoto, Japan). The amount of occlusal elevation was set within the range of the resting space, and all teeth were adjusted to make even contact upon light clenching (Takahashi et al., 2020, 2023a).

2.4. Measurement of Spinal Alignment

A spinal column shape analyzer (Spinal Mouse; Index Ltd., Tokyo, Japan) was used to measure spinal alignment (Takahashi et al., 2021). The spinal column shape analyzer was baselined at the 7th cervical vertebra and moved along the paraspinal line to the 3rd sacral vertebra in order to record the relative position of each vertebra as well as the distance and angle between the vertebrae. Spinal curvature was measured in the static standing posture and standing forward-bending posture (**Figure 1**). The evaluation indices were thoracic kyphosis angle (TKA), lumbar lordosis angle (LLA), sacral inclination angle (SSA), and spinal inclination angle (SIA) (**Figure 2**). The range of motion of each index was calculated using the analyzer software. Measurements were made under three conditions: mandibular resting position (RP), clenching in the intercuspal position (ICP), and clenching while wearing a mouthguard (MG). Each measurement lasted about 5 s, and there was a rest interval of 1 min between each measurement.

2.5. Statistical Analysis

Statistical analysis was performed using SPSS 17.0 software (SPSS Japan Inc., Tokyo, Japan) and significance was set at $P < 0.05$. The Shapiro–Wilk test was used for normality testing, and normality was confirmed for each level. Mauchly's sphericity test was performed to ensure homogeneity of variances. Differences in spinal curvature due to occlusal conditions were compared using repeated measure analysis of variance. Subsequently, multiple comparison tests between levels were performed using the Bonferroni method.

3. Results

Figure 3(a) shows a comparison of TKA by occlusal condition. There was no significant difference in the range of motion of the thoracic spine among occlusal conditions.

Figure 3(b) shows a comparison of LLA by occlusal condition. A significant difference was observed between RP and ICP as well as between RP and MG ($P < 0.01$), with RP having the greatest lumbar range of motion.

Figure 3(c) shows a comparison of SSA by occlusal condition. A significant difference was observed between RP and ICP as well as between RP and MG ($P < 0.01$), with RP having the greatest sacral range of motion.

Figure 3(d) shows a comparison of SIA by occlusal condition. A significant difference was observed between RP and ICP as well as between RP and MG ($P < 0.01$), with RP having the greatest spinal range of motion.

Figure 1. Measurement of spinal shape. (a); static standing posture, (b); standing forward-bending posture.

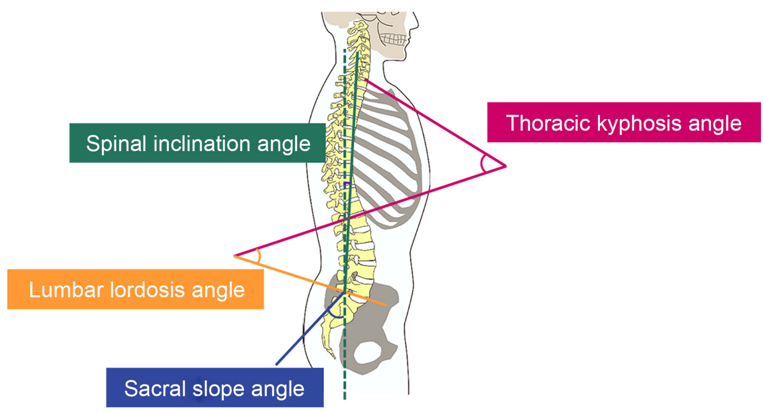

Figure 2. Each spine alignment used as an evaluation index.

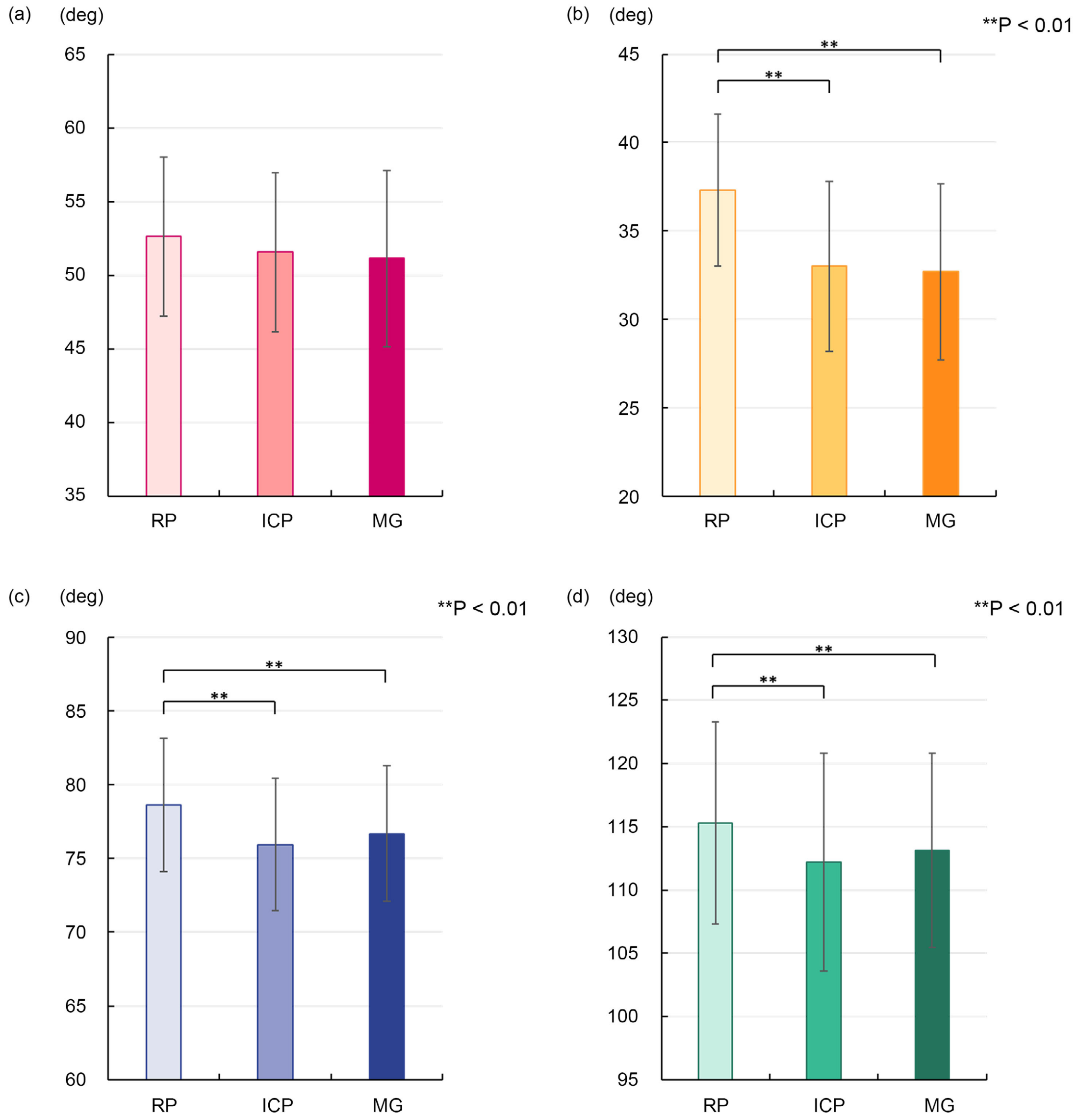

Figure 3. Comparison of spinal alignment according to occlusal condition. RP; mandibular resting position, ICP; clenching in the intercuspal position, MG; clenching while wearing a mouthguard, (a) Thoracic kyphosis angle (TKA), (b) Lumbar lordosis angle (LLA), (c) Sacral slope angle (SSA), (d) Spinal inclination angle (SIA).

4. Discussion

No significant difference was observed between ICP and MG in the range of motion of each spinal alignment during trunk flexion; that is, the range of motion was not affected by the wearing an oral appliance. Therefore, the null hypothesis was rejected.

This study had three main reasons for examining the range of motion of each spinal alignment by wearing a mouthguard, which is an intraoral appliance. The first is that we targeted collision sports athletes who are recommended to wear mouthguards. In other words, the aim is to promote the use of mouthguards. Second, a previous study revealed the effect of wearing a mouthguard on physical performance (Takahashi et al., 2020). According to that report, uniformity of occlusal contact by wearing a mouthguard improved test scores during movements involving changes in body direction that require agility, explosive power, and muscular strength. Third, the use of mouthguards was considered to be an appropriate means of improving occlusal contact state without causing any invasiveness to the participants. Therefore, in this study, to clarify the effect of wearing a mouthguard on trunk stability, we compared clenching between ICP and MG, with RP as a control. The participants were selected from elite handball athletes because they are collision sports athletes who are recommended to wear mouthguards and because they have a high baseline of trunk stability and frequently perform cutting movements during competition.

Significant differences were observed between RP and ICP as well as between RP and MG in LLA, SSA, and SIA, and the range of motion of the spinal column was smaller in the ICP and MG than in RP. This result was similar to a previous report (Takahashi et al., 2021). During clenching, the masseter, temporalis, and medial pterygoid muscles are active. These muscles belong to the deep front line (DFL) and contribute to body stabilization through fascial linkage with trunk muscles (Thomas, 2016; Robert & Amanda, 2019). This anatomical feature may have influenced the results of the present study. Compared with other fascial chains, the DFL has a three-dimensional structure from the front to the back of the body (Thomas, 2016). The DFL occupies the deep layers of the body and passes through the front of the hip joint, pelvis, and lumbar vertebrae, supporting them from the front. In addition, the muscles and fascia linked to the fascia chain influence and regulate each other, providing support for the body (Thomas, 2016). The four alignments used as evaluation indices in this study are TKA, LLA, SSA, and SIA, all of which belong to the DFL. In addition, the SSA reflects the pelvic tilt, and the measurement result with the knee joint extended corresponds to the movement of the linked hip joint (Takahashi et al., 2021). The lumbar spine and pelvis are the core parts of the DFL, and muscles that originate and terminate in the spinal column gather in the deep layers of the trunk. For this reason, during clenching (ICP or MG), the activity of the mouth-closing muscles affected LLA and SSA, which had significantly lower values compared with RP. In addition, because SIA is a value that comprehensively reflects all alignments, it is considered that there was a difference in SIA due to the presence or absence of clenching under the influence of the amount of change in LLA and SSA. However, the motion of the thoracic spine tends to be restricted by the costovertebral and sternocostal joints. Therefore, although TKA belongs to the DFL, it is speculated to be less affected by clenching.

LLA, SSA, and SIA, which differed depending on the presence or absence of clenching, did not show any significant differences between ICP and MG. The main reason for this is likely the occlusal contact state of the participants. Because the mouthguards were adjusted so that all teeth were in even contact upon light clenching, there should be little difference between MG and ICP if the participants' occlusal contact was even on the left and right. When the occlusal contact state of the participants was analyzed in advance using a pressure-sensitive film and a dedicated analyzer (Takahashi & Bando, 2018; Bando et al., 2019; Takahashi et al., 2020, 2023b, 2023c), the average difference between the left and right occlusal contact areas was about 8.5%. If a difference in occlusal contact area between left and right of less than 10% was defined as good occlusal balance (Takahashi et al., 2023b), then 11 participants in the present study had good occlusal balance. Therefore, it is possible that there was no significant difference between ICP and MG during clenching. It has been reported that individuals with good occlusal balance tend to have a more stable center of gravity than those with poor occlusal balance, and that wearing a mouthguard stabilizes the center of gravity for those with poor occlusal balance (Bando et al., 2019; Takahashi et al., 2020, 2023a). In the future, it will be necessary to investigate the relationship between clenching and spinal alignment due to occlusal balance, and to compare the effects of wearing a mouthguard in greater detail.

There are two main limitations of this research. First, due to the small number of participants, we could not compare the participants with other athletes who had poor occlusal balance. Second, some the participants had a history of neurological or orthopedic surgery. Collision sports athletes may be more likely to have a history of sports injuries, dependent on their elite status or the length of their competitive careers. In the future, we need to clarify the differences among individuals, including comparisons with athletes in other sports. Furthermore, we plan to investigate the effects of trunk stabilization on physical performance.

5. Conclusion

This study investigated the effects of oral appliances on spinal range of motion during trunk flexion in elite-level handball players. It was clarified that lumbar lordosis angle, sacral inclination angle, and spinal inclination angle during trunk flexion decreased with clenching, regardless of the presence or absence of an oral appliance. Therefore, it was suggested that clenching contributes to trunk stabilization and may affect athletic abilities such as muscle strength, explosive power, and flexibility.

Acknowledgements

This work was supported by JSPS KAKENHI Grant Number JP23K10617 and the Nippon Dental University Intramural Research Fund (NDU Grants N-21004).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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