Advances in Physical Education, 2023, 13, 234-243
https://www.scirp.org/journal/ape
ISSN Online: 2164-0408
ISSN Print: 2164-0386

Influence of Voluntary Clenching on Spinal Range of Motion Depends on Occlusal Contact State

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How to cite this paper: Takahashi, M., Bando, Y., & Fukui, T. (2023). Influence of Voluntary Clenching on Spinal Range of Motion Depends on Occlusal Contact State. *Advances in Physical Education, 13,* 234-243.
https://doi.org/10.4236/ape.2023.134020

Received: September 8, 2023
Accepted: November 18, 2023
Published: November 21, 2023

Abstract

Purpose: The aim of this study was to clarify the effects of voluntary moderate clenching on the range of motion of the spine depending on the occlusal contact state. **Method:** Participants were 46 healthy men with no missing teeth except for wisdom teeth, and no medical history of musculoskeletal neurological or orthopedic surgery. Using a pressure-sensitive film, the participants were divided into those with a lateral difference in occlusal contact area of less than 10% (good occlusal balance group) and those with 10% or more (occlusal imbalance group). A spinal shape analyzer was used to measure the curvature of the spine in the static standing posture and the standing forward bending posture. The evaluation indices were thoracic kyphosis angle (TKA), lumbar lordosis angle (LLA), sacral inclination angle (SSA), and spinal inclination angle (SIA), and the range of motion for each alignment configured on the analyzer software. Two measurement conditions were compared: mandibular resting position (RP) and voluntary 50% maximal clenching (50% MVC) in the intercuspal position. Differences in range of motion for each spinal alignment due to occlusal balance and clenching were analyzed with a split-plot design. **Results:** LLA, SSA, and SIA showed significant differences in occlusal balance and clenching factors. In the good occlusal balance group, LLA, SSA, and SIA were significantly lower in 50% MVC condition than in RP condition. In the occlusal imbalance group, there was no difference between the presence or absence of clenching in any spinal alignment. **Conclusion:** As a result of this study, it was clarified that the effect of clenching on the range of motion of the spine during trunk flexion differs depending on the occlusal contact state. In other words, it was suggested that voluntary clenching restricts trunk flexion in participants with good occlusal balance.

Keywords

Occlusal Contact State, Clenching, Spinal Range of Motion, Trunk Flexion

1. Introduction

In humans, the center of gravity is located at about 55% of the body height and moves with changes in posture, but a constant posture can be maintained by continuous activity of the posture-maintaining muscles (Ghamkhar & Kahlaee, 2019). Part of the reason why occlusion is involved in physical function (Alghadir et al., 2015; Takahashi & Bando, 2018) is that it forms a fascial chain with the postural muscles (Thomas, 2016; Robert & Amanda, 2019). The fascia is connected to all locomotory structures—including muscle spindles, Golgi tendon organs, nerves, retinaculum, and joints—as lines of tension running from one point of attachment to another, from one end to the other. The masseter, temporalis, and medial pterygoid muscles, which are active during clenching, belong to the deep front line (DFL), while the sternocleidomastoid muscle belongs to the lateral line (LL) and the superficial front line (SFL). These muscles contribute to the stabilization of the body. In other words, the maxillofacial and neck muscles that control occlusion are responsible for postural control in conjunction with the activity of the postural muscles. Furthermore, these muscles enhance the sensitivity of somatosensory and vestibular sensory inputs related to postural (Takahashi & Bando, 2018; Takahashi et al., 2020).

Many studies on the relationship between occlusion and postural control have reported the effects of clenching or wearing oral appliances on body sway (Alghadir et al., 2015; Takahashi et al., 2020, 2023b). Those results clarified that the occlusal state and clenching affect center-of-gravity sway, and that good occlusal contact state and appropriate clenching strength enhance postural stability. We previously investigated the effects of clenching on postural alignment, with the aim of clarifying the relationship between occlusion and postural control from the morphological characteristics of the body (Takahashi et al., 2021). It was clarified that postural alignment was not affected by clenching in a static standing posture but was affected by clenching in the standing forward-bending posture; however, the degree of clenching was arbitrarily determined by the participants and the classification of participants by occlusal contact was uncertain.

The purpose of the present study was to clarify the effects of voluntary moderate clenching on the range of motion of the spine depending on the occlusal contact state. The null hypothesis was that spinal range of motion is unaffected by voluntary clenching and the occlusal contact state.

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 criteria for selecting participants were healthy men with individual normal occlusion and no morphological or functional abnormalities in the stomatognathic system. Exclusion criteria were tooth defects other than in the wisdom teeth, ongoing dental treatment, presence of musculoskeletal pain or severe low back pain within the past 12 months, or a history of surgery in the lower limbs, spine, or pelvis (Takahashi et al., 2021). Forty-six healthy men (mean age: 25.8 ± 4.6 years) who met these conditions were selected as participants in this study.

2.3. Measurement of Occlusal Contact State

The occlusal contact state of each participant was measured using a pressure-sensitive film (Dental Prescale, 50H-R type; Fujifilm Co., Ltd., Tokyo, Japan) and evaluated using a dedicated analyzer (Occluzer FPD-709; Fujifilm Co., Ltd.). The participant was placed in a sitting position, the pressure-sensitive film was inserted into the mouth so that the occlusal plane was parallel to the floor, and the participant was instructed to clench their teeth at maximum intensity for 3 s in the intercuspal position. After that, the pressure-sensitive film was taken out of the mouth and analyzed using the dedicated analyzer (Takahashi & Bando, 2018; Takahashi et al., 2023a, 2023b, 2023c). The distribution of the occlusal contact area on the left and right sides is displayed by the dedicated analyzer. In the present study, the group with a lateral difference of less than 10% in total area was defined as the good occlusal balance group (n = 24), and the group with a lateral difference of 10% or more was defined as the occlusal imbalance group (n = 22) (Takahashi et al., 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). By aligning the spinal column shape analyzer baseline on the 7th cervical vertebra and moving it along the paraspinal line to the 3rd sacral vertebra, the relative position of each vertebra and the distance and angle between the vertebrae were recorded. The evaluation indices were thoracic kyphosis angle (TKA), lumbar lordosis angle (LLA), sacral inclination angle (SSA), and spinal inclination angle (SIA) (**Figure 1**). Measurements were taken in the static standing posture and the standing forward-bending posture (**Figure 2**), and the range of motion for each alignment configured on the analyzer software (**Figure 3**) was used for analysis. Two measurement conditions were used: mandibular resting position (RP) and voluntary 50% maximal clenching (50% MVC) in the intercuspal position. Surface electromyography (DSP wireless electromyography sensor; Sports Sensing Ltd., Fukuoka, Japan) was performed to measure clenching strength. Electromyographs were attached to the center of the masseter muscles on both sides of the participant, and they were instructed to clench at maximum intensity (100% MVC) for 5 s (**Figure 4**). Next, 50% MVC was marked on the personal computer as a moderate degree of clenching. When measuring spinal alignment under the condition of 50% MVC, clenching intensity was adjusted according to visual feedback, using a personal computer screen. One measurement was performed for about 5 s, and the subsequent rest interval was 1 min.

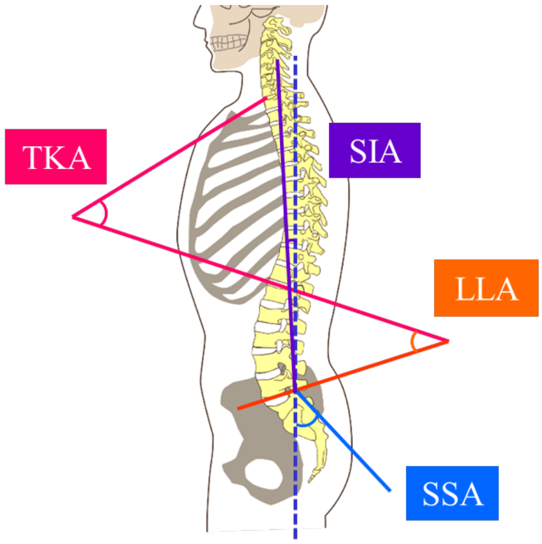


Figure 1. Each spine alignment used as an evaluation index. TKA; thoracic kyphosis angle, LLA; lumbar lordosis angle, SSA; sacral slope angle, SIA; spinal inclination angle.

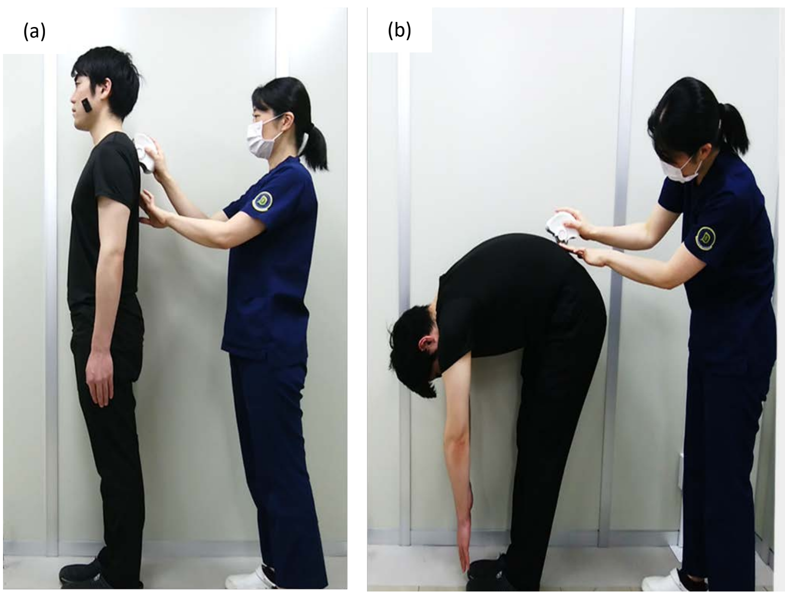
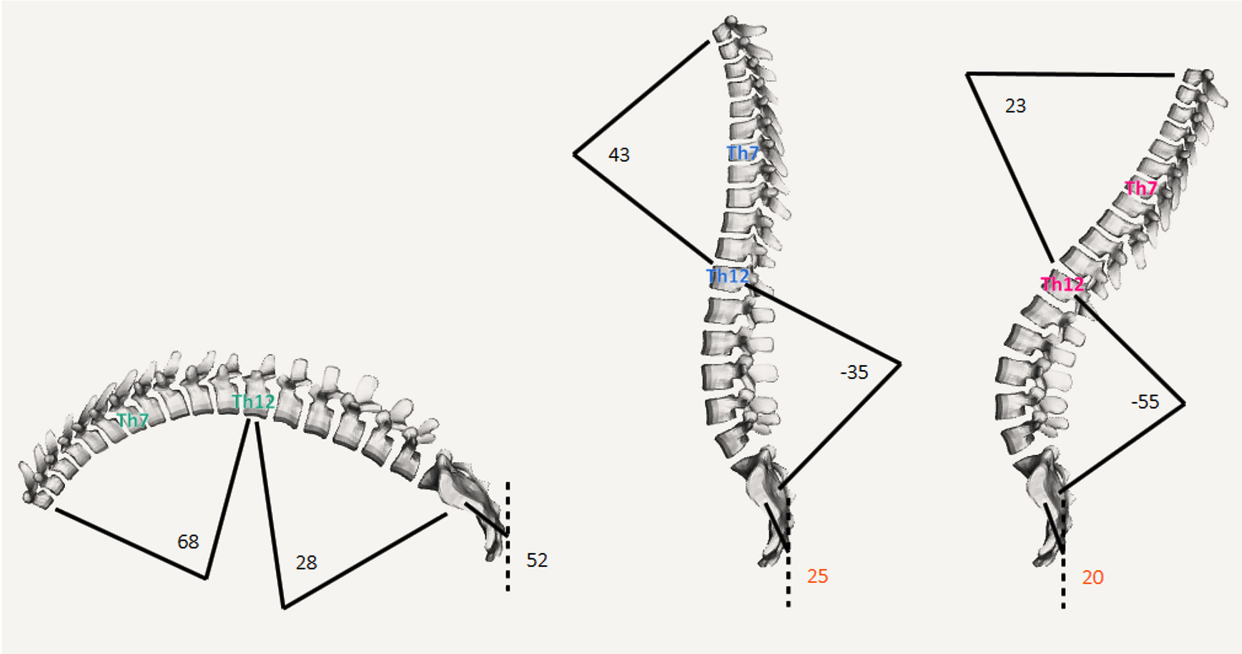


Figure 2. Measurement posture for each spinal alignment. (a) Static standing posture, (b) Standing forward bending posture.



vertebral body	Posture									Mobility								
											→			→			→	
Th1/2	-1	9	7	3	2	11	-1	8	9	-2	-7	8	-2	-1	4	-5	-6	9
Th2/3	0	10	8	1	4	7	-1	0	7	-4	-6	4	-3	-10	1	-3	4	5
Th3/4	1	6	7	0	10	8	0	7	6	-4	4	4	-4	1	2	-3	3	5
Th4/5	2	3	6	-1	5	9	0	-1	6	-5	2	5	-3	-4	1	-4	6	6
Th5/6	1	3	5	3	5	9	1	2	5	0	2	6	-1	-1	3	-1	3	5
Th6/7	1	3	5	1	6	5	0	3	4	-2	3	2	-3	0	1	-1	3	3
Th7/8	3	2	7	2	6	6	1	5	5	-3	4	1	-3	3	1	-2	1	4
Th8/9	4	2	8	4	3	8	3	3	7	-1	1	3	-3	1	1	-2	0	4
Th9/10	3	4	9	6	8	10	1	3	9	0	4	4	-4	-1	2	0	5	6
Th10/11	1	3	7	6	8	12	-1	0	7	1	5	9	-4	-3	2	1	8	11
Th11/12	-2	0	4	3	11	9	-5	-7	3	1	11	9	-4	-7	2	1	18	11
Th12/L1	-3	-4	1	1	6	7	-4	2	0	2	10	8	-3	6	1	3	4	11
L1 / 2	-4	-1	0	1	4	7	-9	-9	-3	4	5	10	-7	-8	1	6	13	14
L2 / 3	-7	-7	-1	5	4	13	-11	-14	-5	8	11	18	-7	-7	-1	12	18	22
L3 / 4	-10	-7	-4	6	6	12	-13	-17	-7	13	13	19	-5	-10	-1	15	23	23
L4 / 5	-10	-21	-6	4	1	10	-16	-16	-8	13	22	17	-8	5	0	15	17	23
L5 / S1	-9	5	-1	0	7	8	-11	0	-5	4	2	14	-7	-5	1	9	7	15
sacral inclination angle	8	25	18	47	52	73	-13	20	7	34	27	60	-26	-5	-6	46	32	80
thoracic vertebrae Th12	34	43	52	50	68	70	22	23	48	6	25	28	-22	-20	6	7	45	43
lumbar vertebrae Th12	-35	-35	-21	26	28	48	-56	-55	-38	56	63	74	-28	-20	-10	71	83	97
spinal inclination	0	5	4	92	93	118	-42	-23	-24	90	88	116	-45	-28	-25	121	116	155
length		622			748			555			126			-67			193	

Figure 3. Range of motion for each alignment configured on the software of Spinal Mouse.

2.5. Statistical Analysis

Statistical analysis was performed using IBM SPSS 24.0 software (IBM Corp, Armonk, NY) and significance was set at $P < 0.05$. Differences in range of motion for each spinal alignment due to occlusal balance and clenching were analyzed with a split-plot design. Factors with significant differences were compared using paired *t*-test or Student's *t*-test.

Figure 4. Measurement of clenching strength by surface electromyography. Under the 50% MVC condition, clenching strength was adjusted by visual feedback, using surface electromyography.

3. Results

Figure 5(a) shows a comparison of the range of motion of the thoracic spine according to the factors of occlusal balance and clenching. No significant differences were observed in either factor.

Figure 5(b) shows a comparison of the range of motion of the lumbar spine according to the factors of occlusal balance and clenching. In the good occlusal balance group, LLA was significantly lower in the 50% MVC condition than in the RP condition ($P < 0.05$). In the occlusal imbalance group, there was no significant difference in LLA between the presence and absence of clenching.

Figure 5(c) shows a comparison of the sacral range of motion according to the factors of occlusal balance and clenching. In the good occlusal balance group, SSA was significantly lower in the 50% MVC condition than in the RP condition ($P < 0.01$). In the occlusal imbalance group, there was no significant difference in SSA between the presence and absence of clenching.

Figure 5(d) shows a comparison of spinal range of motion according to the factors of occlusal balance and clenching. In the good occlusal balance group, SIA was significantly lower in the 50% MVC condition than in the RP condition ($P < 0.05$). In the occlusal imbalance group, there was no significant difference in SIA between the presence and absence of clenching.

4. Discussion

The results of this study showed that lumbar range of motion, sacral range of motion, and spinal range of motion decreased with moderate voluntary clenching only in the group with good occlusal balance. Therefore, the null hypothesis was rejected.

In examining the effect of clenching on the range of motion of each alignment of the spine, our previous study was limited by the fact that the strength of clenching was set arbitrarily by the participant, and the median value was used for grouping according to occlusal balance (Takahashi et al., 2021). Additionally,

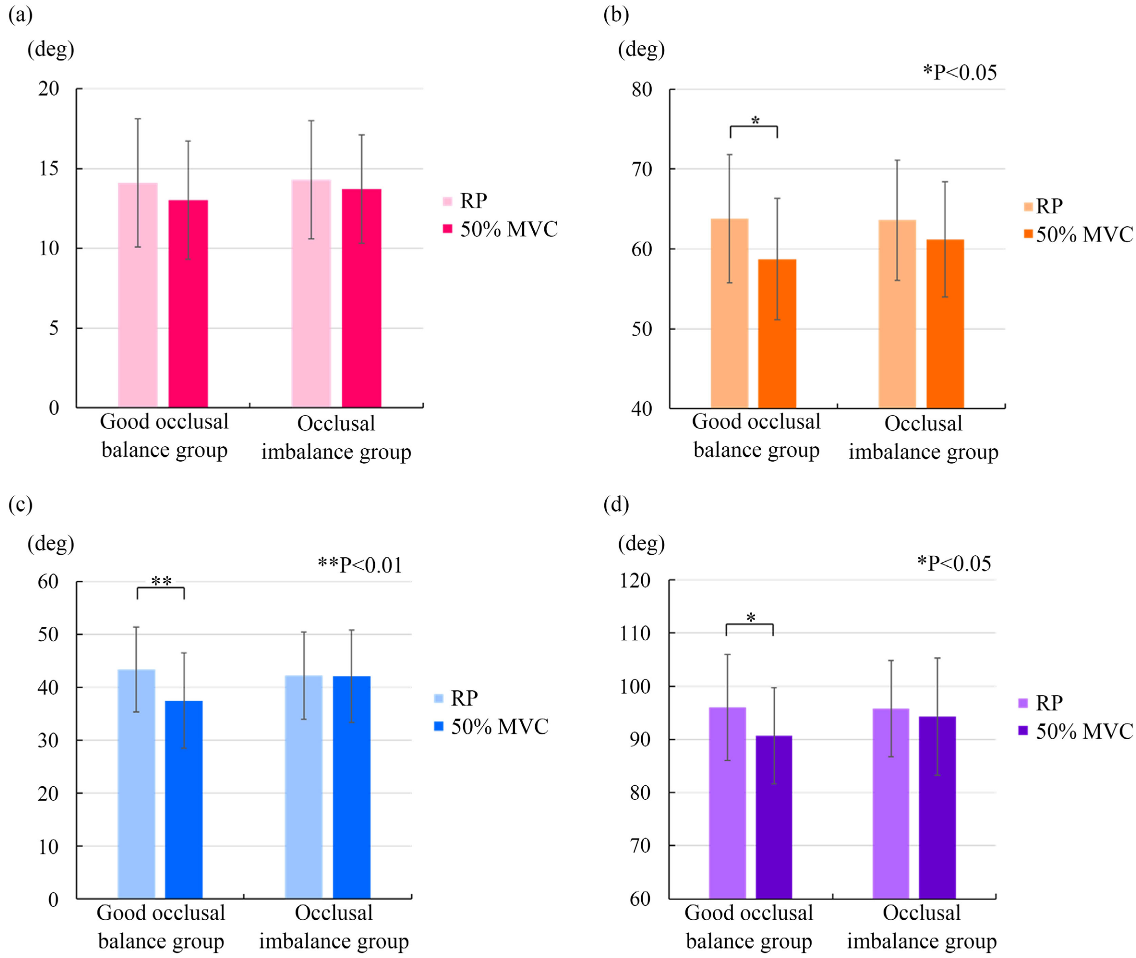


Figure 5. Comparison of range of motion of the spine according to occlusal balance and clenching factors. (a) Range of motion of the thoracic spine, (b) Lumbar range of motion, (c) Sacral range of motion, (d) Spinal range of motion. RP; mandibular resting position, 50% MVC; voluntary 50% maximal clenching.

the static standing posture and the standing forward-bending posture were evaluated separately, and the amount of change between them was not investigated. Therefore, in the present study, we used visual feedback so that the participants could adjust the clenching strength by themselves. However, because the head position was lowered when the trunk was bent forward, it was not possible for the participants to keep looking at the computer screen, so we instructed them to perform 50% MVC before starting the measurement and instructed them to continue bending forward. Regarding the grouping according to occlusal balance, based on a previous report, we classified the cases according to the difference in the occlusal contact area between the left and right sides of less than 10% and those with more than 10% (Takahashi et al., 2023a). Furthermore, the range of motion of each alignment of the spine was analyzed by using the range of motion of each alignment configured on the analyzer software.

This study revealed that the occlusal imbalance group was not affected by clenching for any range of motion of spinal alignment. In our previous study (Takahashi et al., 2021), when the occlusal stable and the unstable groups were divided into groups with a lateral difference in occlusal contact area of less than 5% and of 5% or more, both groups were affected by clenching. However, in the present study, the range of motion of each alignment was affected by clenching only in the good occlusal balance group with a lateral difference in occlusal contact area of less than 10%. One of the reasons for this difference is that the measurement environment was modified to keep the clenching strength constant. In addition, the main cause is thought to be the appropriate classification of the two groups according to the state of occlusal contact. Previous research has revealed that the outer peripheral area and unit area trajectory length are affected by occlusal balance in the evaluation of postural stability, using static center-of-gravity sway as an index (Takahashi et al., 2020, 2023b). In other words, the group with good occlusal balance has a smaller center of foot pressure displacement and a superior postural control function. An evaluation based on the center-of-gravity sway is a functional index for evaluating the postural control function, and the evaluation of the spinal alignment performed in this study is a morphological index for evaluating the postural control function. For this reason, spinal alignment may have been affected by occlusal balance in the participant groups, as in previous reports. In other words, for participants with good occlusal balance, clenching had a large effect on postural stability in evaluations based on morphological indices as well as functional indices, suggesting that clenching supported the stability of the trunk.

In the good occlusal balance group, anatomical features are considered to be the cause of the differences in the range of motion of each alignment. Because the movement of the thoracic spine is restricted by costovertebral joints and thoracic costal joints, the effect of the muscles and fascia associated with clenching on the range of motion of the thoracic spine was very small, and no significant difference was observed. The lumbar spine moves greatly during trunk flexion and extension, and is easily affected by adjoining muscles. In particular, as a characteristic of muscles related to the spine, those that originate and terminate in the spine in the deep layers of the trunk belong to the DFL and tend to be involved in regulating the curvature of the lumbar spine and the mechanical stability between the vertebral bodies. Because the masseter, temporalis, and medial pterygoid muscles, which are active during clenching, belong to the DFL (Thomas, 2016; Robert & Amanda, 2019), it is possible that they act to limit the range of motion of the lumbar spine. In addition, the neck muscle group and the abdominal muscle group are connected to the fascia, and the activity of the sternocleidomastoid muscle, which belongs to the SFL, increases in proportion to the strength of clenching (Thomas, 2016; Robert & Amanda, 2019). Therefore, clenching contributes to the stabilization of the trunk, showing a significantly lower value in the 50% MVC condition. The sacral tilt angle reflects the pelvic tilt, and the measurement result with the knee joint extended corresponds to the movement of the jointed hip joint (Takahashi et al., 2021). Because the muscles and fascia surrounding the sacrum belong to the superficial back line (SBL), and the SBL keeps the body upright and limits the flexion of the trunk (Thomas, 2016; Robert & Amanda, 2019), it was speculated that clenching may have restricted the movement of the hip joint during trunk flexion. The spinal column inclination angle is a value that comprehensively reflects all alignments, and the results of this study showed that the range of motion of the spinal column in the good occlusal balance group was significantly lower under the condition of clenching. Given that trunk flexion is an action that relaxes the muscles and fascia, it is possible that clenching restricted the flexion of the body and contributed to stabilization of the trunk. The muscles and fascia belonging to the SBL function mainly in the extended posture (Thomas, 2016; Robert & Amanda, 2019), but there is a small fascial linkage with the maxillofacial muscle group that activates when the mouth is closed, and this linkage was not verified in this study. However, the range of motion of the sacrum and hip joints as well as the pelvic tilt are alignments that greatly affect changes in posture, and we plan to verify the effects of these factors in a future study.

The main limitation of this study is that the participants were limited to healthy adult males without medical history of musculoskeletal neurological or orthopedic surgery. Because spinal alignment would be affected by gender and age, future research should consider gender and age to compare the effects of clenching on spinal range of motion. Furthermore, changes in occlusal balance caused by wearing intraoral appliance such as mouthguards and splints might affect clenching phase. It is also necessary to consider the effect of wearing an oral appliance on spinal range of motion.

5. Conclusion

This study revealed that the effect of clenching on the range of motion of the spine during trunk flexion differs depending on the occlusal contact state. Therefore, it was suggested that voluntary clenching restricts trunk flexion in participants with good occlusal balance.

Fund

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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