The Effect of Teeth Clenching on Dynamic Balance at Jump-Landing: A Pilot Study

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The aim of this study was to analyze the effect of teeth clenching on dynamic balance at jump landing. Twenty-five healthy subjects performed jump-landing tasks with or without teeth clenching. The first 3 trials were performed with no instruction; subsequently, subjects were ordered to clench at the time of landing in the following 3 trials. We collected the data of masseter muscle activity by electromyogram, the maximum vertical ground reaction force (vGRFmax) and center of pressure (CoP) parameters by force plate during jump-landing. According to the clenching status of control jump-landing, all participants were categorized into a spontaneous clenching group and no clenching group, and the CoP data were compared. The masseter muscle activity was correlated with vGRFmax during anterior jump-landing, while it was not correlated with CoP. In comparisons between the spontaneous clenching and the no clenching group during anterior jump-landing, the spontaneous clenching group showed harder landing and the CoP area became larger than the no clenching group. There were no significant differences between pre- and postintervention in both spontaneous clenching and no clenching groups. The effect of teeth clenching on dynamic balance during jump-landing was limited.

Keywords: dynamic balance, teeth clenching, ground reaction force, center of pressure, electromyogram

Teeth clenching is performed in a voluntary manner by the contraction of mandibular muscles. These muscles receive innervation from the motor area of the cerebral cortex, the same as skeletal muscles of the limbs.¹ Recently, it has been reported that chewing activity has a positive effect on attention, mood improvement, and stress relief.^{2,3} Moreover, positive correlation between muscle strength of the skeletal muscles and teeth clenching was reported. Sasaki et al⁴ reported that teeth clenching force had a positive correlation with isometric gastrocnemius muscle strength. A number of studies have demonstrated that voluntary teeth clenching facilitated the H-reflex in both the agonist and antagonist muscles of the lower limb,⁵⁻⁹ suggesting that teeth clenching contributed to stabilization of body orientation by strengthening the skeletal muscles of the limb.

There were also several reports that confirmed the oral motor activity relations on postural control,¹⁰⁻¹⁵ revealing the superior effect of teeth clenching on body balance control against body sway. However, these pieces of research were subjected to static balance, and there were few reports that investigated the effect of teeth clenching on dynamic balance.

Stabilization of dynamic balance is important for sport activity and injury prevention. Although the effects of teeth clenching on sport performance and injury prevention were investigated in several pieces of research,¹⁶⁻¹⁸ they remain controversial. Additionally, the subsequent occlusion status (presence and force of teeth clenching) in various sports is also unknown. In this study, we investigated the occlusion status and the effect of teeth clenching

on dynamic balance during jump-landing trials. The first question before beginning this study was that the frequency of spontaneous teeth clenching during jump-landing. The second question was the relationship between the masseter muscle activity and the dynamic balance parameters. The third question was that the effect of teeth clenching on the dynamic balance parameters. The first hypothesis of this study was that voluntary clenching during jump-landing had a positive effect on dynamic balance. The second hypothesis was that the appropriate occlusal intervention contributed to better dynamic balance control.

Methods

Twenty-five healthy subjects (10 female, 15 male) between the ages of 20 and 30 who regularly engage in athletic activity participated in this study. None of the subjects had any history of leg injury. This study was approved by our institutional review board in 2014, and all the participants provided written informed consent.

The myoelectric sensor (NIHON KOHDEN Corp., Tokyo, Japan) was set on the right mandibular muscles (Figure 1), and the electromyogram was recorded by WEB-1000 telemeter system (NIHON KOHDEN Corp., Tokyo, Japan) and analyzed using Microsoft Excel (Microsoft Corp., WA, USA) for electromyogram analyses. A 20-cm high step was placed 60 cm from the center of the force plate (260AA6, Kistler Instrumente AG, Winterthur, Switzerland). The height of the force plate surface was 5 cm above ground level. After performing a 5-minute bicycle warm-up, a single-leg jump-landing trial was performed onto the center of the force plate with the dominant leg. We performed 2 tasks: (1) First, 3 trials were performed with no order (control jump-landing); (2) subsequently, subjects were ordered to clench at the time of landing in the following 3 trials (clenching

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Figure 1 — Electromyogram settings. The myoelectric sensor was set at the midpoint between the anterior end of zygoma and the retromandibular portion by dedicated double-faced tape.

jump-landing). The direction of jump was set to anterior and lateral (side of dominant leg) for every task. For accurate intervention, clenching anterior and lateral jump-landing were performed following control anterior and lateral jump-landing.

We collected the data of maximum vertical ground reaction force and center of pressure parameters that were recorded by the force plate. All data of maximum vertical ground reaction force and center of pressure (CoP) were analyzed by TRIAS software (DKH Corp., Tokyo, Japan). The was standardized by body weight. The CoP data was analyzed according to total length and total length per unit area. The analyzing period was set to 500 milliseconds after the time (Figure 2A). The electromyogram voltage of the masseter muscle was activated at the time of landing (Figure 2B).

To analyze spontaneous occlusion status, we regarded it as positive clenching when the electromyogram activity average of 3 trials appears over 20% of maximum biting. To assess the effect of teeth clenching on dynamic balance, the correlation between average electromyogram activity of the masseter muscle and the and the CoP parameters during control jump-landing were evaluated. According to the clenching status of control jump-landings, all participants were categorized into 2 groups: spontaneous clenching group and no clenching group. The parameters of the CoP data were also compared between these groups. Finally, we investigated the difference of each parameter before and after teeth clenching to reveal the effect of teeth clenching intervention.

For statistical analyses, the comparison of the frequency of spontaneous clenching was analyzed by a chi-square test. The and the CoP data were analyzed by the Mann-Whitney U test. Spearman's correlation coefficient was used to assess the correlation between data from electromyogram activity of the masseter muscle and the and the CoP. The significance was determined at $P < .05$. All data were analyzed using SPSS version 22.0 (IBM Inc., Armonk, NY, USA). The effect size was calculated post-hoc using G*Power 3.1.9.2.

Results

The spontaneous teeth clenching frequency is higher during anterior jump-landing. Nineteen out of 25 subjects clenched spontaneously in anterior jump, and 10 out of 25 clenched spontaneously in lateral jump. Spontaneous teeth clenching frequency was significantly higher in anterior jump-landing than in lateral ($P = .009$).

The higher masseter muscle activity leads hard landing during anterior jump-landing. The masseter muscle activity did not affect

Figure 2 — Representative force plate data and synchronized electromyogram of the masseter muscle activity. (A) Vertical ground reaction force data (left) and center of pressure trajectory data (right). The parameters were calculated automatically by TRIAS software. (B) The examinees were ordered to put their hands on their chest and not to look at the ground during jump-landing tasks. The electromyogram activity of the masseter muscle was activated at the time of landing during clenching jump-landing. EMG = electromyogram.

Figure 3 — Correlation between the masseter muscle activity and maximum vertical ground reaction force during anterior jump-landing. The average of 3 trials of electromyogram activity and were analyzed. The masseter muscle activity was correlated with during anterior jump-landing. EMG = electromyogram (%); vGRFmax = maximum vertical ground reaction force (%); r = correlation coefficient; p = p -value.

the and the CoP during lateral jump-landing. On the other hand, the masseter muscle activity was correlated with the during anterior jump-landing (Figure 3), while it was not correlated with the CoP parameters.

Table 1 Dynamic balance analyses in control and clenching jump-landing, average (SD)

		Control Trials	Clenching Intervention Trials	P Value
Anterior	vGRFmax (%)	361.1 (54.6)	359.8 (56.9)	.909
	LNG (cm)	46.8 (24.9)	49.8 (24.7)	.661
	LNG/area (cm/cm ²)	3.7 (1.6)	3.6 (1.4)	.889
Lateral	vGRFmax (%)	368.2 (58.1)	365.4 (61.3)	.775
	LNG (cm)	59.8 (21.3)	61.8 (22.4)	.457
	LNG/area (cm/cm ²)	2.9 (1.1)	2.9 (1.1)	.925

Abbreviations: LNG = total length of center of pressure; LNG/area = LNG per unit area; vGRFmax = maximum vertical ground reaction force.

Table 2 Dynamic balance analyses in control and clenching jump-landing between spontaneous clenching and no clenching groups, average (SD)

		Spontaneous Clenching Group	No Clenching Group	P Value
Anterior jump-landing				
Control trials	vGRFmax (%)	369.0 (62.6)	336.4 (55.8)	.004
	LNG (cm)	49.9 (23.3)	37.7 (26.5)	.049
	LNG/area (cm/cm ²)	3.5 (1.4)	4.1 (1.7)	.048
Clenching intervention trials	vGRFmax (%)	363.6 (59.4)	345.8 (62.5)	.103
	LNG (cm)	51.4 (20.3)	46.2 (30.6)	.400
	LNG/area (cm/cm ²)	3.8 (1.5)	3.6 (1.4)	.550
Lateral jump-landing				
Control trials	vGRFmax (%)	366.8 (57.8)	374.5 (57.3)	.562
	LNG (cm)	58.5 (17.6)	61.4 (22.5)	.106
	LNG/area (cm/cm ²)	3.1 (1.1)	2.8 (1.0)	.088
Clenching intervention trials	vGRFmax (%)	364.6 (56.5)	366.9 (62.0)	.930
	LNG (cm)	59.3 (20.3)	63.6 (22.8)	.141
	LNG/area (cm/cm ²)	2.9 (0.9)	2.9 (1.2)	.984

Abbreviations: LNG = total length of center of pressure; LNG/area = LNG per unit area; vGRFmax = maximum vertical ground reaction force.

Table 3 Effect of teeth clenching intervention during jump-landing

		P Value (Effect Size) Between Control Trials and Clenching Intervention Trials	
		Spontaneous Clenching Group	No Clenching Group
Anterior jump-landing	vGRFmax (%)	.482 (.138)	.574 (.158)
	LNG (cm)	.888 (.146)	.285 (.299)
	LNG/area (cm/cm ²)	.165 (.281)	.205 (.349)
Lateral jump-landing	vGRFmax (%)	.957 (.486)	.404 (.126)
	LNG (cm)	.757 (.046)	.755 (.098)
	LNG/area (cm/cm ²)	.308 (.271)	.484 (.136)

Abbreviations: LNG = total length of center of pressure; LNG/area = LNG per unit area; vGRFmax = maximum vertical ground reaction force.

The spontaneous clenching group had worse dynamic balance during control anterior jump-landing. There were no significant differences in a simple comparison of dynamic balance parameters between control jump-landing and clenching jump-landing (Table 1). During control anterior jump-landing, the and total length were significantly higher and total length per unit area was significantly lower in the spontaneous clenching group (Table 2). These results indicated that the spontaneous clenching group showed harder landing and the area of the CoP became larger than the no clenching group. In control lateral jump-landing, these

parameters had no significant difference between the spontaneous clenching and no clenching group. In clenching anterior and lateral jump-landing, there were no significant differences between the spontaneous clenching and the no clenching group.

The effect of teeth clenching intervention was limited. There were no significant differences between pre- and post-intervention in both spontaneous clenching and no clenching groups (Table 3). These results indicated that there were no clear effects of teeth clenching intervention on jump-landing dynamic balance.

Discussion

Jump-landing is one of the basic motions in various sport activities and is important for physical agility. On the other hand, jump-landing is a common cause of lower limb injury. Management of body balance during jump-landing will contribute to enhancing not only sport performance^{19,20} but also injury prevention.²¹ There are few reports investigating the relationship between teeth clenching and sport performance or injury prevention. Several studies report the relationship between teeth clenching and static balance.^{10–15} Fujino et al¹¹ investigated the effect of voluntary teeth clenching on static balance. They showed that voluntary teeth clenching contributed to stabilization of the postural stance perturbed transiently by electrical stimulation. These studies mention static balance, but there is no information about the relationship between teeth clenching and dynamic balance. This study is a first report to investigate the relationship between teeth clenching and dynamic balance during jump-landing.

Dynamic balance is evaluated by many objective methods. Pau et al²² evaluated the dynamic balance by vertical ground reaction force and the center of pressure, and they discovered that the dynamic and static balance should be considered a different factor. Vertical ground reaction force, total length, and total length per unit area are considered commonly used parameters for balance measurement,^{23,24} therefore we investigated these parameters in this study. Vertical ground reaction force indicates the ability of absorption of the vertical force.^{23,25} Total length is the total distance traveled by the center of pressure. Increased total length indicates the decreased ability of postural control.^{24,26} Total length per unit area reflects minute postural adjustments controlled by the spinal proprioceptive reflex of the lower extremities. It indicates the fine control of posture by proprioceptive reflexes.²⁴

The results of this study indicated that teeth clenching status during jump-landing was different according to the individual and direction of jump. The frequency of spontaneous teeth clenching at anterior jump-landing was significantly higher than that at lateral jump-landing. Moreover, there was a significant difference of dynamic balance control pattern between the spontaneous clenching and no clenching group during anterior jump-landing. The spontaneous clenching group showed harder landing and a wider area of the center of pressure locus than the no clenching group. From these results, it is speculated that the spontaneous clenching group sways the body wider to absorb the moment for control of dynamic balance. Therefore, it seems that the dynamic balance control pattern of the spontaneous clenching group is coarser than that of the no clenching group.

According to the positive results of a previous study on static balance or muscle strength, we hypothesized the results of this study would be positive. However, there were no significant differences in dynamic balance between pre- and postteeth clenching interventions during jump-landing. Moreover, as mentioned above, the spontaneous clenching group showed poor dynamic balance control. Therefore, these results indicated that a teeth clenching intervention might provide no improvement to dynamic balance during jump-landing.

To achieve better dynamic balance control during jump-landing, it is important to absorb the landing shock efficiently by quick and smooth coordinated movements of the trunk, hip, knee, and ankle.^{27–32} Several recent studies revealed the positive effects of teeth clenching on static balance.^{10–15} However, it is suggested that teeth clenching during jump-landing may adversely affect dynamic balance control in this study. Previous studies indicate

that teeth clenching affects the skeletal muscles of the limb, and contributes to stabilization of body orientation.^{5–9} In particular, Takada et al⁶ investigated the H reflex of lower leg muscles during voluntary teeth clenching by the electromyogram analyses, and concluded that teeth clenching might contribute to increasing joint stability in stance rather than to smoothness of joint movements. The positive correlation between teeth clenching force and the in our current study supports these reports; that is, teeth clenching might inhibit the smooth shock absorption ability of the lower limb joints, and leads to negative effects on dynamic balance control.

According to the Yerkes-Dodson law, too great or too low stress for a particular task may result in impaired performance.³³ Oxendine applied this law in several sports and indicated that there was appropriate stress for maximum performance in each sporting activity.³⁴ In this study, we placed an inordinate stress on the jump-landing task. Conversely, if the stress is too low, the dynamic balance may be worse in a similar way. Moreover, there is the potential to produce the best balance performance by coordinating appropriate occlusion status with splints.

There are some limitations in this study. First, the instruction “clench at the time of landing” was ambiguous. However, in comparison of the electromyogram and vertical ground reaction force data, the timings of teeth clenching were concentrated around 100 milliseconds before and after initial contact. Second, the number of subjects in the no clenching group in anterior jump-landing trials was smaller than expected. More accurate results would be provided if we could analyze more subjects. Third, the significant difference was provided only in anterior jump-landing. We cannot generalize these results to all sport activity.

In conclusion, the positive effect of a teeth clenching intervention on dynamic balance during jump-landing was limited.

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