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# Intervention Effect of Occlusion on the Straight Jump in Trampoline Gymnastics: Effect on T-score and H-score

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## Abstract

The purpose of the present study was to clarify the effect of an occlusal intervention involving a mouthguard on the T-score and H-score of straight jumps in trampoline competitions. The participants were 15 male trampoline gymnasts (17.6±2.5 years). Custom-made mouthguards were fabricated using a 2.0-mm-thick ethylene-vinyl acetate thermoplastic elastomer, and that were fitted to the participating trampoline gymnasts and adjusted so that all teeth made equal contact when the mouth was lightly closed. The gymnasts were instructed to wear the mouthguards about half the time during their six practice sessions per week. The trial comprised 10 consecutive straight jumps. Flight time (T-score) and landing position (H-score) were recorded using the HDTS all-in-one measurement system. Measurements were taken at three time points: before the mouthguard intervention, immediately after intervention, and 2 months after the intervention. Comparisons of T-score or H-score by measurement time point were analyzed using one-way analysis of variance with repeated measures or Friedman test, respectively. The T-score was observed between the before intervention and 2-month time points ($P<0.01$). The H-scores increased with the mouthguard intervention, with significant differences observed of the before intervention time point with the immediately after intervention ($P<0.05$) and 2-month ($P<0.01$) time points. The results of the present study suggest that an occlusal intervention involving a mouthguard affects flight time and landing position in straight jumps in trampoline competitions. The effects on the H-score were evident immediately after intervention, and the T-score was improved 2 months after the intervention.

**Keywords:** Trampoline competition; T-score; H-score; Flight time; Landing position; Occlusion; Mouthguard; Straight jump

## Introduction

Competitive trampoline is a gymnastics event that consists of 10 jumps performed after a preliminary jump and that incorporates various techniques within a total airborne time of approximately 20 s [1-4]. During flight, trampoline gymnasts must instantly recognize the position of the center of the trampoline bed and control their body movements. Accordingly, the competitive characteristics of trampoline gymnastics are the ability to control minute shifts in posture, spatial cognition, and sports vision. Scoring consists of four items: a performance score (E-score), which evaluates the execution of the technique; a difficulty score (D-score), which evaluates the number of rotations and twists; a jump time score (T-score), which evaluates the flight

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time; and a movement score (H-score), which evaluates the landing position. The T-score and H-score reflect postural control. If the jump height is low, the number of rotations during somersaults and twists will be affected and the D-score will decrease. Accordingly, elite level athletes tend to have higher T- and D- scores [1,5,6].

The straight jump, which is a basic exercise in trampoline competitions, is a movement that uses the strong repulsive force of the bed, transmitted from the soles of the feet, to maintain an upright posture during the aerial period [4]. The stability of the upright posture, that is, the static posture control function, can be evaluated using a center-of-gravity sway meter and is assumed to directly affect the motor function of trampoline gymnasts. In addition, inputs from various sensory organs are integrated in the central nervous system and then output to the neuromuscular system to achieve postural stability [7-10]. Therefore, interventions that affect sensory input may have an impact on the physical function of trampoline gymnasts. Our research interest is occlusion, which can affect deep sensation and vestibular sensation, the main sensory inputs for postural control, with a particular focus on the relationship of occlusion with postural stability and motor function [3,11-13]. These studies clarified that the occlusal contact state (occlusal balance) and occlusal correction using oral appliances affect the physical function of trampoline gymnasts.

The purpose of the present study was to clarify the effect of an occlusal intervention involving a mouthguard on the T-score and H-score of straight jumps in trampoline competitions. The null hypothesis was that mouthguards have no effect on the motor function of trampoline gymnasts.

## Materials and Methods

### Ethical approval and informed consent

This study was approved by the Ethics Committee of The Nippon Dental University School of Life Dentistry at Niigata (approval no. ECNG-R-443). All participants were given full explanations regarding the study details and they provided written informed consent prior to their participation.

### Participants

The participants were 15 male trampoline gymnasts (mean age, 17.6±2.5 years) with no subjective or objective morphological or functional abnormalities in the stomatognathic system. Individuals with missing teeth other than third molars and/or undergoing dental treatment were excluded. The trampoline gymnasts had a mean duration of competitive experience of 10.9±2.4 years and trained 3 h/day, 6 times a week.

### Mouthguard fabrication

Mouthguards were fabricated using a 2.0-mm-thick ethylene-vinyl acetate thermoplastic elastomer (Sports Mouthguard; Keystone Industries, Cherry Hill, NJ) and a pressure molding machine (Model Capture Try; Shofu Inc., Kyoto, Japan). After trimming and polishing, the mouthguards were fitted to the participating trampoline gymnasts and adjusted so that all teeth made equal contact when the mouth was lightly closed [11,14,15]. The occlusal contact state of the mouthguard was confirmed by occlusal examination, using blue silicone (Bite Eye; GC Co., Tokyo, Japan) [15]. The gymnasts were instructed to wear the mouthguards about half the time during their six practice sessions per week.

### T-score and H-score measurement in straight jumps

The trial comprised 10 consecutive straight jumps. T- and H-scores were measured using the HDTS all-in-one measurement system (EU-7100; Eurotramp Trampoline Kurt Hack GmbH, Weilheim, Germany) (Figure 1) [12,13,16,17]. After calibration, the flight time and landing position were recorded for each jump, and the totals for each of the 10 jumps were displayed as T- and H- scores (Figure 2). Measurements were taken at three time points: before the mouthguard intervention, immediately after intervention, and 2 months after the intervention.


**Figure 1:** Measurement of flight time and landing position, using an all-in-one measurement system (HDTS EU-7100).

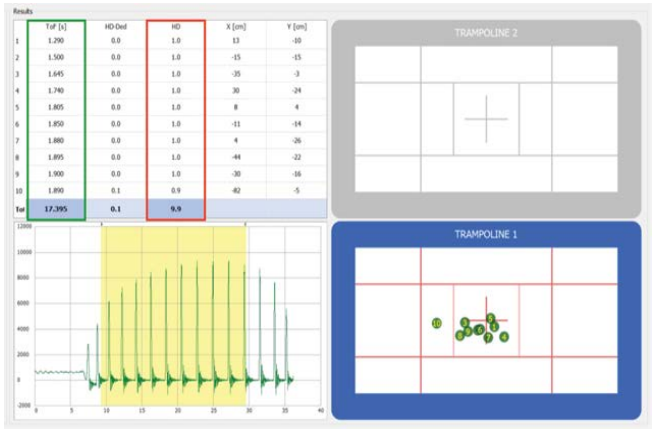


**Figure 2:** Example of the measurement results obtained using the HDTS EU-7100 all-in-one measurement system. The green square indicates the flight time, and the bottom line shows the T-score. The red square indicates the landing position, and the bottom line shows the H-score.

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### Statistical analysis

Statistical analysis was performed with SPSS ver. 17.0 software (SPSS Japan Inc., Tokyo, Japan), and the significance level was set at P<0.05. The Shapiro–Wilk test was used to test for normality.

Normality was observed for each level of the T-score. Mauchly's test of sphericity was not significant, ensuring homogeneity of variances. Therefore, differences between measurement time points were analyzed using one-way ANOVA with repeated measures. Next, multiple comparison tests between levels were performed using the Bonferroni method.

In H-scores, a three-level comparison was conducted using the Friedman test because normality was not observed at immediately after intervention and 2 months after the intervention, as well as a multiple comparison test between levels using the Bonferroni method.

## Results

The change in T-score at each measurement point is shown in figure 3. The T-score exhibited a tendency toward a gradual increase with the mouthguard intervention, and a significant difference was observed between the before intervention and 2-month time points (P<0.01).

Figure 4 shows the change in the H-score by measurement time point. Overall, H-scores gradually increased with the mouthguard intervention, with significant differences observed of the before intervention time point with the immediately after intervention (P<0.05) and 2-month (P<0.01) time points.

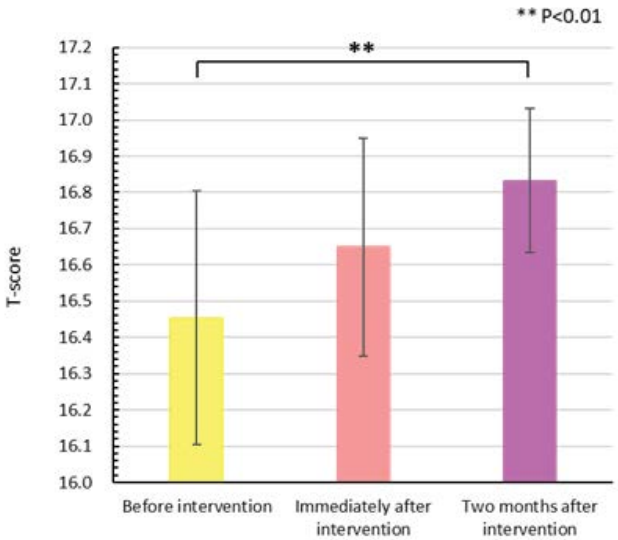


**Figure 3:** Change in T-score (flight time) according to the duration of mouthguard wearing.

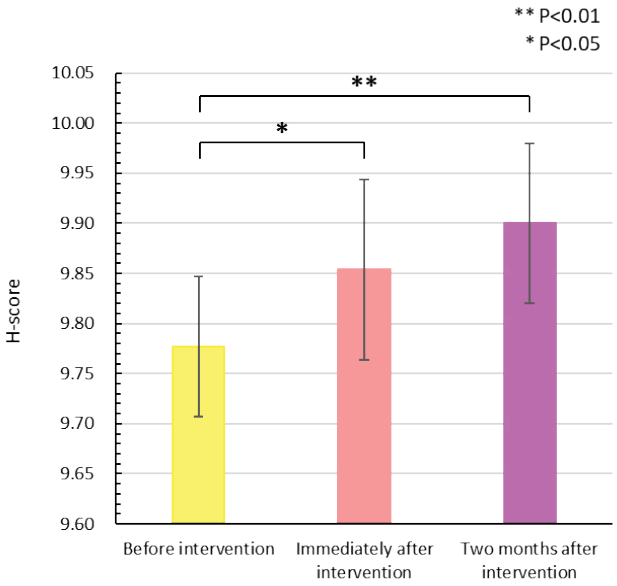


**Figure 4:** Change in H-score (landing position) according to the duration of mouthguard wearing.

## Discussion

Our results show that an occlusal intervention involving a mouthguard improves the T-score and H-score of straight jumps in competitive trampoline gymnasts. Therefore, the null hypothesis that mouthguards do not affect the motor function of trampoline gymnasts was rejected.

Postural stability is one of the essential physical functions in many sports and events. Occlusion directly stimulates the sensation of the periodontal ligament, muscle spindles of jaw-closing muscles, and the positional and kinesthetic sensation of the temporomandibular joint, so it is a factor that influences somatosensory input for postural control. On the other hand, in relation to vestibular sensory input, stimulation of the semicircular canal ampulla, which is a receptor for vestibular sensation, excites the motor neurons of the jaw-closing and -opening muscles. In addition, the vestibular nucleus has neural connections with the trigeminal motor neurons that innervate the masseter muscle and also participates in various postural reflexes. Therefore, it may be a factor in being affected by occlusion [8,9,14]. Based on these assumptions, our previous results showed that center-of-foot-pressure displacement is reduced by occlusal correction using a mouthguard [11,14] and that the landing position and direction of center-of-foot-pressure displacement are correlated in trampoline gymnasts with good occlusal balance [12]. Moreover, it was revealed that occlusal correction can increase flight time for trampoline gymnasts with poor occlusal balance [13]. In the present study, to clarify the effect and timing of the correction of occlusal balance on motor function, the T-score and H-score were evaluated before an occlusal intervention and at immediately after intervention

and 2 months afterward. The gymnasts targeted in this study included both those with good occlusal balance and those with poor occlusal balance but, due to the small number of participants, it was not possible to compare the two subgroups. In addition, even if no discomfort is felt when a mouthguard is being worn, a prolonged change from the usual occlusal contact can put strain on the temporomandibular joints and jaw-closing muscles. For that reason, the participants were asked to wear the mouthguard for about half of the practice time.

The T-score and H-score are scoring items in trampoline competitions that reflect postural control [1], and previous studies have shown that jumping posture is affected by occlusion [12,13,17]. The straight jump was chosen as the test in the present study because, as a technique not involving rotation and twisting, measurements are more likely to be influenced by the gymnast's effective side and musculoskeletal system than by postural control [18,19].

The results of this study showed that the occlusal intervention improved both the T- and H- scores, but the timing at which the effects appeared tended to differ. Flight time is assumed to be significantly affected by landing position and takeoff motion. During takeoff, gymnasts try to lower their center of gravity to the extent possible, sinking into the bed. Then, using the repulsive force of the bed, the force transmitted from the soles of the feet bounces the body vertically and is used as energy for the next jump [20]. The elasticity of the bed can be used efficiently when gymnasts land in the center of the bed, and the bed will bounce their body vertically, thereby increasing flight time [13]. If the repellent lands off-center, the repulsive force of the bed bouncing off both feet will be uneven in the front, back, left, and right directions, and the flight time will tend to be shorter because the repellent will lift off in the direction of the tilt of the long axis of the body. The fact that the effect of the occlusal intervention appeared in the H-score before the T-score in this study is not consistent with the physical evidence that the flight time is longer when the landing position is appropriate. One possible reason for this may be that the study was conducted on gymnasts with long competitive careers. Although the use of a mouthguard made it easier to land in the center of the bed, several gymnasts felt that the timing of entering the next landing position differed from what they had learned due to the longer flight time. The fact that some gymnasts adjusted their take-offs in order to time their landings may be why their T-scores were not significantly affected immediately after intervention.

This study revealed that the effect of an occlusal intervention on the straight jump in trampoline gymnastics competitions is reflected in the T- and H-scores. In other words, it was suggested that the motor function of trampolinists could be improved by strengthening or correcting factors that affect postural control. With the exception of skeletal factors, the condition of occlusal contact has a large number of factors that can be guided in a better direction in young athletes in their formative years through dietary habits, oral hygiene management, or appropriate dental treatment. In the case of athletes who have a full set of permanent teeth, it is possible to correct the occlusal contact condition with intraoral devices such as mouthguards. Therefore, it is necessary to inform the parents of junior athletes and those involved in the sport that oral condition is related to competitive skill.

The main limitation of this study was the small number of participating gymnasts and the fact that it was not possible to compare the effects of the occlusal intervention due to differences in occlusal contact conditions. We plan to increase the number of participants and conduct further research over the next few years. Another limitation was that the trials were limited to straight jumps. During actual competitions, acrobatic techniques involving rotation and twisting are performed continuously, so it is important to clarify the influence of the occlusal intervention on real-world performance.

## Conclusion

The results of the present study suggest that an occlusal intervention involving a mouthguard affects flight time and landing position in straight jumps in trampoline competitions. The effects on the H-score were evident immediately after intervention, and the T-score was improved 2 months after the intervention.

## Data availability

The datasets collected and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Acknowledgments

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## Conflicts of interest statement

The authors have no conflicts of interest relevant to this article.

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