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Research on Jumping Height of Straight Jumps and Barani Jumps in Competitive Trampoline Gymnasts: Influence of Occlusal Correction

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Abstract

The purpose of this study was to clarify the influence of occlusion on jumping height in trampoline gymnasts. Participants were 13 male trampoline gymnasts. To improve the occlusal contact state, a custom mouthguard was fabricated. Postural control function was evaluated by using a cross-test and the R/E value was calculated. Measurements were conducted both before and after the mouthguard intervention. Trials comprised straight jumps and barani jumps. The flight time of the jumps was measured, and the jump height was calculated. Measurements were taken at three time points: before the mouthguard intervention, immediately after the mouthguard intervention, and 2 months after the mouthguard intervention. Differences in R/E values before and after the mouthguard intervention were analyzed. A comparison of the jump height increase rate immediately after the intervention and 2 months after the intervention in straight- and barani jumps was analyzed. Correlation with the jump height increase rate 2 months after the intervention for each trial was analyzed. The R/E value was significantly higher after the mouthguard intervention. For both trials, the rate of increase in jump height was significantly greater 2 months after the mouthguard intervention than immediately after the intervention. A significant positive correlation was found between the rate of increase in R/E value and the rate of increase in jump height for each trial. The results of this study suggest that occlusal correction using a mouthguard improves the postural control function of trampoline gymnasts and thereby improves the jump height of straight- and barani jumps.

Keywords: Trampoline competition; Jump height; Straight jump; Barani jump; Posture control; Occlusion correction

Introduction

The human body is always slightly swaying, and the body's posture-control function maintains posture against this swaying [1]. Postural control involves sensory inputs from vision, vestibular sensation, somatosensation, and other sources. Information from these receptors is integrated in the central nervous system and output to the postural muscles to maintain postural stability [1-3]. The sensory input priority depends on the environment and situation, and there are interindividual differences [1]. When muscles are fatigued or damaged, sensory input from that area decreases while the contribution of other sensory inputs increases, and thus the importance of each sensory input for an athlete depends on the characteristics of the sport or event and the competitive level [4,5]. Somatic sensations are broadly divided into surface sensations and deep sensations. In addition, the periodontal ligament receptors, temporomandibular joint receptors, and muscle spindles of the jaw and neck muscles, which are

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related to occlusion, are affected by the occlusal contact state and clenching and may affect postural control.

Gymnastics is an athletic competition that emphasizes postural stability. Because gymnasts focus on balance training [6], their balance ability tends to be superior to that of the general public and athletes of other sports [4,5,7-10]. Gymnastics disciplines include artistic gymnastics, rhythmic gymnastics, trampoline, acrobatic gymnastics, and parkour [11], and the gymnasts that participate in each discipline have characteristic body shapes appropriate to their discipline [6,12]. Trampolines are used by athletes in various sports and events for training. From this, it can be inferred that the postural control functions of trampoline gymnasts have different characteristics from those of athletes in other sports.

The purpose of this study was to clarify the influence of occlusion, which is related to somatosensory input, on jumping height in competitive trampoline gymnasts. The null hypothesis was that occlusal correction has no effect on jumping height in trampoline gymnasts.

Materials and Methods

Participants

The participants were 13 male trampoline gymnasts (mean age, 17.5 ± 2.4 years) with normal occlusion and no subjective or objective morphological or functional abnormalities in the oral-maxillofacial system. They had an average duration of competitive experience of 11.8 ± 2.6 years and trained 6 times a week for 3 h per session.

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

Occlusal correction method

To improve the occlusal contact state, a custom mouthguard was fabricated for each gymnast. 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 mouthguard was then adjusted to ensure even contact across all teeth with light clenching [10,12,13].

Measurement of postural control function

Postural control function was evaluated by using a cross-test with a center of gravity sway meter (GRAVICORDER GS-7; Anima Co., Ltd., Tokyo, Japan) [14,15]. Measurements were conducted both before and after the mouthguard intervention. During the measurement, the gymnasts were not instructed to close their mouth or clench; this was left to the gymnast's discretion. The evaluation indices were the rectangular area calculated by multiplying the forward/backward and left/right movement distances of the center of foot pressure on the center of gravity trajectory diagram and the R/E value, which was the rectangular area divided by the outer circumferential area [14,15].

Recording the flight time of jumps and calculating the jump height

The trampoline trials comprised two types of jumps: straight jumps and barani jumps. For straight jumps, the gymnasts were instructed to perform 10 consecutive jumps after one preliminary jump. The barani jump is a trampoline technique in which the gymnast performs a 1/2 turn to the side while performing a 1-turn forward somersault. In this study, 10 consecutive barani jumps performed after one backward somersault were considered one trial. The flight time of the jumps was measured using an HDTS all-in-one measurement system (EU-7100; Eurotramp Trampoline Kurt Hack GmbH, Weilheim, Germany) [16,17]. The jump height (h) was calculated using the formula [$h = 1/8 \times$ acceleration (g) $\times$ flight time $(t)^2$]. Measurements were taken at three time points: before the mouthguard intervention, immediately after the mouthguard intervention, and 2 months after the mouthguard intervention. The rate of increase in jump height immediately after the intervention or 2 months after the intervention was calculated compared with the before mouthguard intervention time point. No instructions on clenching or occlusion were given during the measurements. Gymnasts were instructed to wear the mouthguards a little less than half of the time during their practice days.

Statistical analysis

Statistical analysis was performed using SPSS ver. 17.0 (SPSS Japan Inc., Tokyo, Japan) and a P-value below 0.05 was considered significant. The Shapiro–Wilk test was used to test for normality. Normality was not observed in the rate of increase in jump height immediately after the intervention in straight jumps. Normality was met for all other variables.

Differences in the rectangular area or R/E values before and after the mouthguard intervention were analyzed using paired *t*-tests. A comparison of the jump height increase rate immediately after the intervention and 2 months after the intervention in straight jumps and barani jumps was analyzed using the Wilcoxon signed rank test or a paired *t*-test, respectively.

The rate of increase in the R/E value after the mouthguard intervention was calculated, and the correlation with the jump height increase rate 2 months after the intervention for each trial was analyzed using Pearson's product–moment correlation coefficient. In addition, Pearson's product–moment correlation coefficient was used to analyze the correlation

between the rate of increase in jump height in straight jumps and barani jumps 2 months after the intervention.

Results

A comparison of the rectangular areas before and after the mouthguard intervention is shown in Figure 1 while a comparison of the R/E values is shown in Figure 2. The rectangular area was not significantly affected by the mouthguard intervention. In contrast, the R/E value was significantly higher after the mouthguard intervention (P<0.01).

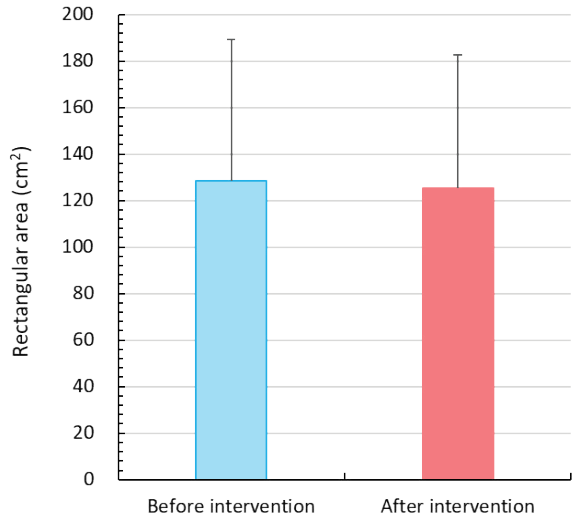

Figure 1: Comparison of the rectangular area before and after the mouthguard intervention.

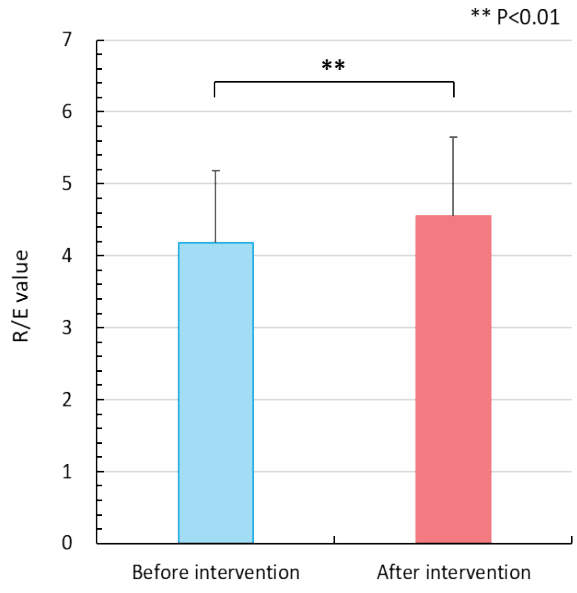

Figure 2: Comparison of the R/E value before and after the mouthguard intervention.

Figure 3 shows a comparison of the rate of increase in jump height immediately after the mouthguard intervention and 2 months after the intervention. For both straight jumps and barani jumps, the rate of increase in jump height was significantly greater 2 months after the mouthguard intervention than immediately after the intervention (P<0.01).

Figure 4 shows the results of a correlation analysis between the rate of increase in the R/E value and the rate of increase in jump height 2 months after the intervention. For straight jumps, the higher the rate of increase in the R/E value, the higher the rate of increase in jump height, with a significant positive correlation (R=0.645, P<0.05). Similarly, for the barani jump, the higher the rate of increase in the R/E value, the higher the rate of increase in jump height (R=0.699, P<0.01).

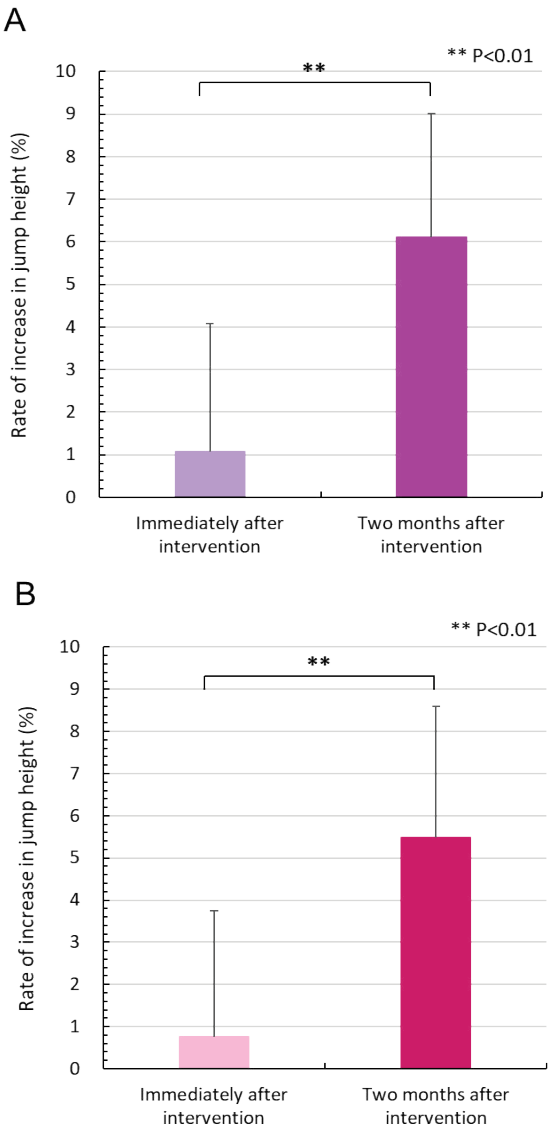

Figure 3: Comparison of the rate of increase in jump height. A: Straight jump. B: Barani jump.

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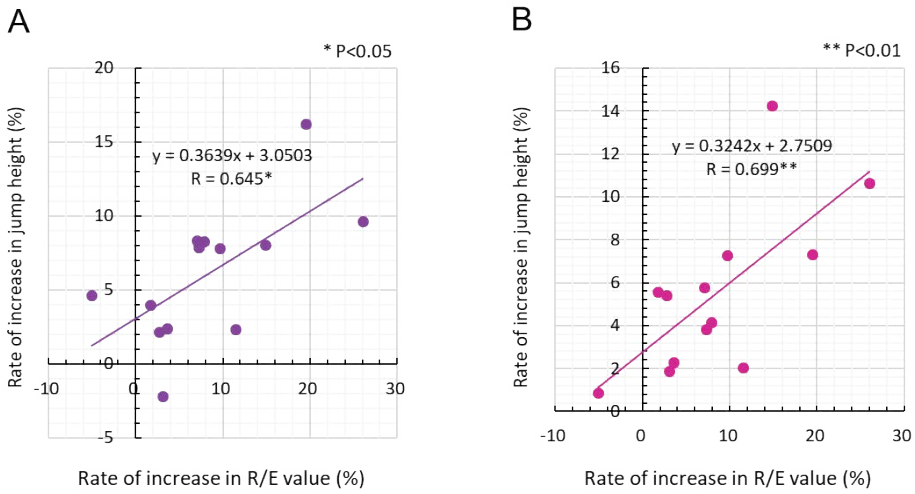

Figure 4: Correlation between the rate of increase in the R/E value and the rate of increase in jump height. A: Straight jump. B: Barani jump.

Figure 5 shows the results of a correlation analysis of the rate of increase in jump height 2 months after the intervention for the straight jump and barani jump. A significant positive correlation was found: the greater the rate of increase in straight jump height, the greater the rate of increase in barani jump height (R=0.546, P<0.05).

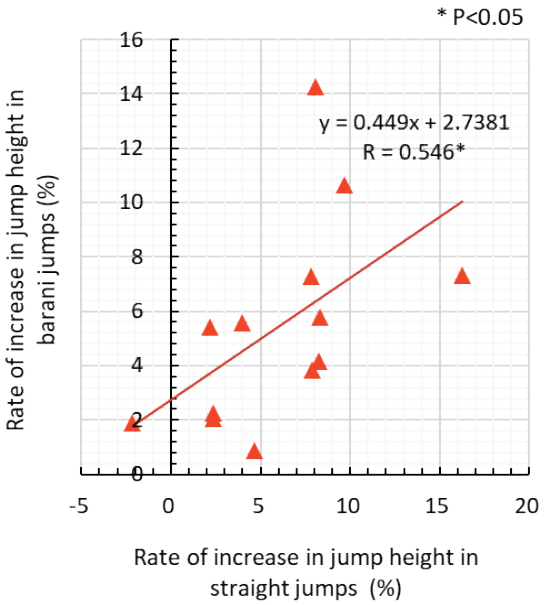

Figure 5: Correlation between the rate of increase in jump height in straight jumps and barani jumps.

Discussion

The results of this study showed that occlusal correction through a mouthguard intervention improved postural control function, which, in turn, significantly improved jump heights in straight jumps and barani jumps in competitive trampoline gymnasts. Therefore, the null hypothesis was rejected.

Studies of postural stability and performance in gymnasts have found that balance ability is related to competition level, with elite gymnasts having better balance ability and significant relationships between balance ability and many performance indicators [5,18-22]. However, with regard to trampoline competitions, there are few reports regarding performance and postural control function, even though the sense of balance is emphasized in gymnastics events [23,24]. Our previous work has examined trampoline gymnasts by focusing on sensory input through occlusion. These studies revealed that occlusal correction using a mouthguard improves static balance [12] and that, in gymnasts with a good left–right balance of occlusal contacts, there is a correlation between the landing position and the direction of the displacement of the center of foot pressure in a straight jump [25]. In addition, the results showed that occlusal correction for gymnasts with poor left–right balance of occlusal contacts increases the flight time of straight jumps [17]. Based on these findings, the present study aimed to verify the effect of occlusal correction on dynamic stability in postural control and to examine its relationship with jumping skills.

In the evaluation of postural control function, no significant effect was found of the mouthguard intervention on the rectangular area, which reflects the displacement amount of the center of foot pressure. For the same rectangular area, the better the postural control function, the clearer the cross on the center of gravity trajectory diagram, and the R/E value has been reported as a numerical index of this relationship [14]. The R/E value was significantly higher after the mouthguard intervention, indicating that the occlusal intervention improved postural control function. Based on this, the relationship between the jump skill of competitive trampoline gymnasts was investigated based on the increase in the R/E value (i.e., improvement in postural control function) with the occlusal intervention.

The rate of increase in jump height for each trial due to the mouthguard intervention was significantly greater 2 months after the intervention than immediately after the intervention. Because the rate of increase showed a positive value immediately after the intervention, it can be assumed that occlusal correction using a mouthguard has a positive effect on trampoline competition skills. In addition, the significant improvement 2 months after the intervention indicates that a certain period of practice is necessary for each gymnast to become accustomed to the changes in occlusal sensation caused by the mouthguard and to acquire the skills to match their own jumping posture and movement timing. In particular, the improvement in jump height may be due not only to the augmentation of occlusal contact balance by the occlusal intervention method but also to the viscoelasticity of the mouthguard material [26]. In other words, compared with individuals not wearing the mouthguard, when clenching occurs in various jaw positions, more occlusal contact is possible using the mouthguard, which may be advantageous in stabilizing the body.

A positive correlation between the rate of increase in the R/E value and the rate of increase in jump height was observed in both trials. Additionally, as shown in Figure 2, the R/E value increased with the mouthguard intervention. These results revealed that improved postural control function contributes to improved jumping height. As a preliminary experiment, surface electromyographs were attached to the masseter muscles of gymnasts to record muscle activity during jumping. Muscle activity was observed from just before landing until the take-off motion in all gymnasts. The results suggest that occlusion may affect jumping skills in trampoline competitions during the phase from landing to taking off (i.e., during the take-off motion). This is also supported by the fact that the rate of increase in jump height for both straight jumps and barani jumps showed a positive correlation. Therefore, it is expected that occlusal correction will have a positive effect on the take-off movement regardless of the type of jump and may even have an effect on the overall score of trampoline routines.

This study used a mouthguard as a means of occlusion correction. Because the intervention was used with the aim of improving occlusal contacts, if the athlete's own occlusal contacts are good, the intervention may have little impact or effect. This is the main limitation of this study and, in the future, we would like to increase the number of subjects and conduct additional studies to examine differences based on the occlusal contact state of athletes and the effects of the intervention on athletes with a good occlusal contact state.

Conclusion

The results of this study suggest that occlusal correction using a mouthguard improves the postural control function of trampoline gymnasts and thereby improves the jump height of straight jumps and barani jumps. It was also revealed that the effectiveness increased after 2 months of training.

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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