Effects of Nintendo Wii Fit Plus training on ankle strength with functional ankle instability

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Abstract. [Purpose] The objective of this study was to examine the effects of a training program using the Nintendo Wii Fit Plus on the ankle muscle strengths of subjects with functional ankle instability. [Subjects and Methods] This study was conducted using subjects in their 20s who had functional ankle instability. They were randomized to a strengthening training group and a balance training group with 10 subjects in each, and they performed an exercise using Nintendo Wii Fit Plus for 20 minutes. In addition, every participant completed preparation and finishing exercises for 5 minutes, respectively. [Results] The muscle strengths after conducting plantar flexion and dorsiflexion significantly increased at the angular velocities of 60° and 120° in the strengthening training group. Furthermore, the muscle strengths after conducting plantar flexion, dorsiflexion, eversion, and inversion significantly increased at the angular velocities of 60° and 120° in the balance training group. [Conclusion] The balance training group using Nintendo Wii Fit Plus showed better results than the strengthening training group. Consequently, it is recommended to add the balance training program of the Nintendo Wii Fit Plus to conventional exercise programs to improve ankle muscle strength in functional ankle instability at a low cost.

Key words: Nintendo Wii Fit Plus, Functional ankle instability, Strength

INTRODUCTION

Ankle sprain is the most frequent musculoskeletal disorder, which affects activities of daily living1). Furthermore, it can be accompanied by a fracture and eventually has adverse effects on activities of daily living2). According to Bendahou et al.3), ankle sprain is very frequent among emergency room patients and generates considerable treatment costs. Functional ankle instability (FAI) refers to the subject state in which the subject feels giving way as a result of repetitive ankle sprains3). The causes of FAI include lack of muscle force and lack of a sense of balance5). In a previous study on the relationship between ankle instability and strength, Abdel-aziem and Draz6) reported the muscle torque ratio of dorsiflexion and plantar flexion in chronic ankle instability increased compared to the control group, whereas the muscles torque ratio of inversion and eversion decreased compared to the control group. Furthermore, the eccentric muscle force was significantly lower in plantar flexion, inversion, and eversion. Therefore, the recovery of normal ankle strength is a precondition for the prevention and treatment of repetitive ankle sprains.

Exergames, which refer to video games that include elements for exercise, have been developed recently, enabling subjects to participate actively in the games, unlike conventional games in a sitting position7–9). As exergames are gaining greater popularity among youth, they have become very influential in health, education, and sports10, 11). One of the most widely used video game these days is Nintendo Wii™12). Nintendo Wii offers a wide variety of games, and Wii Fit Plus is one of them. Wii Fit Plus is being used in various applications, including clinical applications for subjects who need motor learning and feedback training13–15). Therefore, in this study, the effects of a training program in Nintendo Wii Fit Plus on the ankle muscle strength of subjects with FAI were examined.

SUBJECTS AND METHODS

Subjects

This study was conducted with subjects in their 20s (age = 23.3 ± 2.4 years) who had FAI (gender = 4 male and 16 female; height = 163.1 ± 7.4 cm; weight = 55 ± 10.2 kg). The subjects were selected among those who had experienced an ankle sprain in the past, who had no records of operations of their ankles, and who had not participated in other rehabilitation programs. FAI was measured with the Cumberland ankle instability tool (CAIT) and 20 subjects with a score of 24 or lower were selected (CAIT = 18.3 ± 5.4 score). They were randomized to the strengthening training group and the balance training group with 10 subjects in each, and they
performed an exercise using the Nintendo Wii Fit Plus for 20 minutes. Furthermore, every participant completed preparation and finishing exercises for 5 minutes, respectively. The intensity of exercise was adjusted to the needs of the subjects under the supervision of a physiotherapist.

This study was reviewed and received approval from the Gwangju Oriental Hospital of Dongshin University beforehand (IRB No. DSGOH-019). The purpose and intent of this study were explained to every participant who consented to voluntary participation.

Methods

The Nintendo Wii Fit Plus contains programs that aim to enhance muscle strength as well as those that aim to enhance the sense of balance. For muscle strengthening exercise, lunges, single leg extensions, sideways leg lifts, single leg twists, and rowing squats were performed. In the lunges, a player began with a posture of placing their feet with the knees flexed 90° in one cycle, and five cycles were measured for each patient. The angular velocity was set to 60° and 120°, to inversion as one cycle, and five cycles were measured for each patient. For inversion and eversion, the subject started from 30° inversion, moved on to 20° dorsiflexion, and then returned to plantar flexion in one cycle, and five cycles were measured for each patient. The angular velocity was set to 60° and 120°, and a one-minute recess was given between different angular velocities. The Biodex isokinetic dynamometer (Biodex Medical Systems, Shirley, NY, USA) was used to measure the muscle strength of the ankle. For the measurement of plantar flexion and dorsiflexion, the subject started from 40° plantar flexion, moved on to 20° dorsiflexion, and then returned to plantar flexion in one cycle, and five cycles were measured for each patient. For inversion and eversion, the subject started from 30° inversion, moved on to 20° eversion, and then returned to inversion as one cycle, and five cycles were measured for each patient. The angular velocity was set to 60° and 120°, and a one-minute recess was given between different angular velocities (Fig. 1).

The descriptive statistics of all the measurement data, including average and standard deviation, were calculated using the statistics application PASW version 18.0. The normal distribution was examined through the One Sample Kolmogorov-Smirnov test, and the significant differences of the results before and after the exercise were analyzed.
through the paired sample t-test. The statistical significance level $\alpha$ was set to 0.05.

**RESULTS**

The strengthening training group showed a significant increase in the muscle strength of plantar flexion at the angular velocities of $60^\circ$ ($t = -2.710$, $p = 0.024$) and $120^\circ$ ($t = -4.889$, $p = 0.001$) after the exercise. Furthermore, the balance training group also showed a significant increase in the muscle strength of plantar flexion at the angular velocities of $60^\circ$ ($t = -5.060$, $p = 0.001$) and $120^\circ$ ($t = -4.209$, $p = 0.002$) after the exercise (Table 1).

The strengthening training group showed a significant increase in the muscle strength of dorsiflexion at the angular velocities of $60^\circ$ ($t = -6.892$, $p = 0.000$) and $120^\circ$ ($t = -6.594$, $p = 0.000$) after the exercise. Furthermore, the balance training group also showed a significant increase in the muscle strength of dorsiflexion at the angular velocities of $60^\circ$ ($t = -2.736$, $p = 0.023$) and $120^\circ$ ($t = -2.863$, $p = 0.019$) after the exercise (Table 1).

The strengthening training group showed no significant differences in the muscle strength of eversion at the angular velocities of $60^\circ$ ($t = -1.93$, $p = 0.263$) and $120^\circ$ ($t = -0.758$, $p = 0.468$). On the other hand, the balance training group showed a significant increase in the muscle strength of eversion at the angular velocities of $60^\circ$ ($t = -8.459$, $p = 0.000$) and $120^\circ$ ($t = -5.303$, $p = 0.000$) (Table 1).

The strengthening training group showed no significant differences in the muscle strength of inversion at the angular velocities of $60^\circ$ ($t = -0.40$, $p = 0.969$) and $120^\circ$ ($t = 1.140$, $p = 0.284$). On the other hand, the balance training group showed a significant increase in the muscle strength of inversion at the angular velocities of $60^\circ$ ($t = -4.659$, $p = 0.001$) and $120^\circ$ ($t = -4.776$, $p = 0.001$) (Table 1).

**DISCUSSION**

As a result of the training with Nintendo Wii Fit Plus, the strengthening training group showed a significant increase in the muscle strength of plantar flexion at the angular velocities of $60^\circ$ and $120^\circ$ after the exercise. This result was the same as the result of the muscle strengthening exercise using Therabands for subjects with functional ankle instability in their 20s, which increased plantar flexion. Thus, this study found the muscle strength of plantar flexion could be increased through Nintendo Wii Fit Plus training as well. The balance training group showed a significant increase in the muscle strength of plantar flexion at the angular velocities of $60^\circ$ and $120^\circ$ after the exercise. It seems the repetition of back and forth movements in the balance exercises, such as Ski Slalom, Snowboard Slalom, and Table Tilt, increased plantar flexion. This is also supported by previous studies that found the Ski Slalom exercise allowed the repetitive learning of posture adjustment. According to the gait analysis to determine the importance of the exercise for plantar flexion, the delay of the maximum plantar flexion is associated with ankle sprain. Therefore, continuous consideration of plantar flexion is required for the effective rehabilitation of the ankle sprain.

The strengthening training group showed a significant increase in the muscle strength of dorsiflexion at the angular velocities of $60^\circ$ and $120^\circ$ after the exercise. The weakening of the muscle strength of dorsiflexion directly affects balance and gait, and the weakening of the ankle muscle strength is the most common neuromuscular disorder. Therefore, it is very meaningful that the muscle strength of dorsiflexion significantly increased in this study from the Nintendo Wii Fit Plus training. The balance training group showed a significant increase in the muscle strength of dorsiflexion at the angular velocities of $60^\circ$ and $120^\circ$ after the exercise. This indicates the balance exercise of this study can help strengthen the muscle strength of dorsiflexion. The weakening of dorsiflexion is a critical element of recurring ankle sprain. According to Crosbie et al., the weakening of dorsiflexion slows down the walking speed and shortens the step length and single support time, resulting in asymmetry. Furthermore, it is particularly important as a predictor of the possibility of gait. Considering these facts, the strengthening training of dorsiflexion is very important.

The balance training group showed a significant increase in the muscle strength of eversion at the angular velocities of $60^\circ$ and $120^\circ$ after the exercise. This seems to be due to the fact that the balance exercises of this study, i.e., Soccer Heading, Ski Slalom, Tight Rope Walk, Table Tilt, and Snowboard Slalom, have many motions in the medial-lateral direction. Son et al. insisted the ankle muscle strength exercise had a positive correlation with balance, and this seems...
to be the reason the balance training in this study improved muscle strength. However, the strengthening training group showed no significant difference in the muscle strength of eversion at the angular velocities of 60° and 120°. The reason for this result seems to be that even though Nintendo Wii Fit Plus can be used as a therapeutic tool for functional improvement, it was originally designed for entertainment. Among the five muscle strength exercises in this study, three exercises, i.e., Lunge, Single Leg Extension, and Rowing, seem to be related to the motions of dorsiflexion and plantar flexion. However, those exercises were insufficient in this study, as with the case of plantar flexion and dorsiflexion, the strength of these muscles is very important for gait. For those reasons, the strengthening training group showed insufficient intervention effects on inversion and eversion.

Considering the results of this study, physical therapy approaches, such as Therabands and resistance training, will be necessary to strengthen the muscles of inversion and eversion in subjects with FAI. Even though the strengthening of inversion and eversion muscles was insufficient in this study, the strength of these muscles is very important for gait. For example, eversion must occur in the subtalar joint during the first 30–35% of the gait cycle, and inversion must occur in the subtalar joint for 15–20% after the first 35% of the gait cycle to allow for natural gait. Furthermore, the peroneus longus and brevis muscles are often used for intervention in the inversion ankle sprain, because the eversion muscles of the foot can give stability to the lateral surface of the ankle.

This study has a few limitations. The natural ankle movement must occur at the oblique axis, rather than separately in plantar flexion, dorsiflexion, eversion, and inversion, and the terms pronation and supination are required for more accurate measurements. However, the measurements of muscle strength in this study were insufficient because they were made on the sagittal and horizontal planes. Future studies could present better results if they make improvements in this regard. In conclusion, Nintendo Wii Fit Plus training increased the muscle strength of plantar flexion and dorsiflexion in the strengthening training group, and the muscle strength of plantar flexion, dorsiflexion, eversion, and inversion in the balance training group. Thus, the balance training group showed better results than the strengthening training group. Consequently, it is recommended to add the balance training of Nintendo Wii Fit Plus to conventional exercise programs to improve ankle muscle strength at a low cost.

ACKNOWLEDGEMENT

This study was supported by research funds from Gwangju University in 2015.

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