Original article

Effect of Wii Balance Board and motor imagery on balance and muscle strength in football players

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Background: Football is a dynamic sport that requires frequent direction changes, which may increase the players' risk of injury. Balancing is a basic skill in football, and given that balance is correlated with the strength of the thigh muscles; Wii Balance Board training may improve balance. Motor imagery enables the translation of imagination to motion without the actual performance of the motion, which may increase players' ability to learn the motions or skills they need to play football. This study is aimed to prevent and rehabilitate balance-related injuries in football players.
Objectives: This study aimed to compare the effects of Wii Balance Board training and Wii Balance Board with motor imagery training on the balance and muscle strength of football players.
Methods: Sixteen football players aged 18 to 23 years old were divided into the Wii Balance Board (WBB) group (n = 8) and the Wii Balance Board with motor imagery (WBB+MI) group (n = 8), and the groups received WBB or WBB+MI for four weeks, respectively. Balance was evaluated using a Posturomed device, and a wireless muscle strength tester that was used to measure the strength of the participants' knee extensor muscles before and after the fourth week training period.
Results: The balance and muscle strength of the WBB group before and after the four-week training program significantly differed ($P < 0.05$). The WBB+MI group did not show any significant difference in balance ($P > 0.05$), but their muscle strength significantly differed ($P < 0.05$). However, balance and muscle strength did not show any difference between the two groups ($P > 0.05$).
Conclusion: WBB may help improve balance, while WBB and WBB+MI may enhance the strength of the thigh muscles in football players.

Keywords: Balance, motor imagery, muscle strength, Wii Balance Board.

Football is a popular sport with a significant numbers of players, resulting in higher injury rates than other sports. The most common injuries include bruises and muscle strain, which usually occur because the players are not physically ready for their training and matches. Kanoknan S, *et al*.[1] studied football injuries during football training and seven matches and found that the thigh is the most injured position (83.95% of all injuries). Thigh injuries affect football training and matches because thighs have key structures

that promote the balance necessary for consistent movement and directional changes.[2] Football players also inevitably hit each other when playing, resulting in injury risks. If football players have injuries that affect their thigh muscle strength and balance,[3] their training and match efficiency may be affected. Football players' injuries have initiated studies of several guidelines for the prevention and rehabilitation of balance-related injuries.

The sports industry has applied scientific and technological knowledge as an alternative to training as it can be used to enhance athletes' skills and prevent and rehabilitate injuries. Popular electronic exercise devices are used by teenagers and health-conscious people. For example, electronic equipment called Wii Balance Board, (WBB) is used to enhance balance ability and is similar to traditional balance training.[4]

WBB is also used by patients with nervous system diseases,[5] to increase muscle strength,[6] and as a valid and reliable balance training device.[7] Motor imagery (MI) also enhances balance ability by enabling the translation of imagination to motion without the actual performance of the motion.[8] MI may enhance learning, movement ability, and sport skills.[9]

WBB has been used for the rehabilitation and maintenance of balance skill and muscle strength,[4] but it has not been used for balance training in football players. In addition, muscle contraction during MI also helped enhance the skills necessary for other sports.[9, 10] Therefore, this study compared the effects of WBB and WBB+MI on balance, muscle strength, and the rehabilitation and prevention of injuries in football players who were unable to join training or place their weight on the lower parts of their bodies.

Methods
Populations

The participants included 16 football players from Kasetsart University, Kamphaeng Saen Campus, aged 18 - 23 years old. The inclusion criteria included the following: having no current illnesses that affected their balance ability and daily movement, having no WBB experience or mental disorders, having the ability to understand instructions or explanations, and having not mini-mental state examination (MMSE)[11] score < 22 or an movement imagery questionnaire-revised (MIQ-R)[12] score < 20.

The participation procedures were explained to the volunteers, and they received the introduction documents to review. Then, the volunteers signed and returned their permit forms. The participation procedures were explained to the volunteers, and they received the introduction documents to review. Then, the volunteers signed and returned their informed consent forms.

Data collection
Balance evaluation

The participants' balance evaluations were conducted using a Posturomed device (Haider-Bioswing GmbH, Pullenreuth, Germany). The intratester reliability was tested and was at a high level (ICC = 0.892).

To evaluate their balance (mm), the volunteers were instructed to stretch both thigh muscles for five minutes. Then, they stood up straight on the Posturomed plate with their toes separated slightly, hands down by their sides, and eyes looking forward. The test was conducted once to make familiarity. When the real test was conducted, the volunteers were instructed to try balancing while remaining as still as they could.[13] The participants' balance was remeasured twice. The mean of the two measurements was used for analysis.

Muscle strength evaluation

The isometric muscle strength of the knee extensor was measured using a wireless muscle strength tester (Tracker™ version 5, JTECH Medical Industries, Inc., USA). The intratester reliability was tested and was at a high level (ICC = 0.750).

To evaluate their muscle strength (kg), the volunteers were instructed to stretch both of their thigh muscles for five minutes. Then, they sat on the beds and arranged their posture for the isometric muscle strength evaluation of their knee extensors. The participants stretched and bent their knees to make familiarity. When they were ready for the real test, they pushed the resistance of the researcher as hard as possible for five seconds. Then, the participants relaxed for 30 seconds.[14] The participants' muscle strength was remeasured twice. The mean of the two measurements was used for analysis. The volunteers rested for one minute before their other legs were measured.

Later, the volunteers were divided into groups by ordering their Posturomed device balance test results. The results were run from maximum to minimum. Then, the 16 volunteers were drawn the lots for both groups. Each group had eight volunteers (i.e., eight in the WBB group and 8 in the WBB+MI group).

Electroencephalography (EEGs)

The patients' EEGs were recorded using NeXus 10 Mark II device during MI. The volunteers' heads were measured to identify where to place the electrodes. The electrodes were placed on the middle of the head and on both earlobes.[15] EEGs were then recorded using a laptop with Biotech+. The alpha frequency was the focus because this brainwave indicates that the brain is alert and ready for activities.[16] This wave also indicates MI as it suggests the translation of imagination to motion without the actual performance of the motion.[8] Therefore, the EEGs were used to measure MI.

Training programs

The WBB group completed balance training on the WBB for 40 minutes per day, 3 days a week (Monday, Wednesday, and Friday), for 4 weeks. The training difficulty was adjusted every week. Week 1 included lateral weight shifting using the ski slalom, penguin slide, tight rope walking, and soccer heading games. Week 2 focused on multidirectional balance using the table tilt and balance bubble games. Week 3 focused on multidirectional balance with a cognitive component using the perfect 10 games (basic level-advance level). Week 4 focused on multidirectional balance and multidirectional balance with a cognitive component using the table tilt, balance bubble, and perfect 10 games. The training was divided into steps: a 5-minute warm up of basic walking in the training room, 20 minutes of balance training using the Nintendo Wii Fit Plus, a 5-minute cool down of basic walking,[17] and a 10-minute rest in the quiet training room.

The WBB+MI group received the same balance training as the WBB group, but they also received 10 minutes of MI training in the quiet training room. During their MI training, the volunteers laid down on adjustable beds with the top set at 60 degrees. They breathed in and out for 2 minutes.[18] Then, they completed MI of the WBB motions they completed while they were playing the games.[19] The volunteers' EEGs were recorded during their MI training.

Statistical analysis

The subjects' physical characteristics, including age, height, weight, MMSE score, and MIQ-R score, are displayed as mean ± standard deviation (SD). The differences between the two groups were compared using unpaired t - test, and the statistical significance was set at 0.05 (P <0.05).

Balance and muscle strength are also displayed as mean ± SD. The subjects' results before and after they completed their training were compared using paired t - test, and the results of the two groups were compared using unpaired t - tests with the statistical significance set at 0.05 (P < 0.05).

Results

Physical characteristics

During the study, 16 male subjects were divided into 2 groups of 8. The subjects' ages were 18 - 23 years old; their heights were 162 - 185 cm, weighed 53 - 93 kg; they had MMSE scores of 28 - 30 points, and MIQ-R (KI) scores of 21.5 - 22.75 points, and had MIQ-R (VI) scores of 21.5 - 22.75 points (Table 1).

Balance comparison

The balance results before and after the WBB group's training were significantly different (P = 0.04). The balance results before and after the WBB+MI group's training were not different (P > 0.05) (Table 2). The balance results after the WBB and WBB+MI groups' training were not significantly different (P > 0.05).

The WBB group's balance results before and after their training showed significant decreases (P < 0.05).

Muscle strength comparison

The WBB groups' knee extensor muscle strength results in both legs before and after their training were significantly different (P = 0.009). The WBB+MI group's knee extensor muscle strength results for both legs before and after their training were also significantly different (P = 0.049, 0.035, respectively) (Table 3). The WBB and WBB+MI groups' knee extensor muscle strength results after their training were not significantly different (P > 0.05).

Table 1. Physical characteristics.

Physical characteristics	WBB (Mean ± SD)	WBB+MI (Mean ± SD)	P - value
Age (yr)	20.87 ± 1.24	20.17 ± 1.16	0.850
Height (cm)	171.00 ± 6.59	173.25 ± 6.77	0.472
Weight (kg)	67.25 ± 10.43	69.75 ± 10.18	0.617
MMSE score	29.37 ± 0.74	29.37 ± 0.91	1.000
MIQ-R score: Kinesthetic Imagery; KI	21.84 ± 0.49	21.78 ± 0.31	0.802
MIQ-R score: Visual Imagery; VI	22.25 ± 0.56	22.21 ± 0.47	0.879

MMSE = mini mental state examination; MIQ-R = movement imagery questionnaire-revised

Table 2. Balance comparison before and after in the WBB group and in the WBB+MI group and between the WBB group and the WBB+MI group.

Group	Before (mm) (Mean ± SD)	After (mm) (Mean ± SD)	P - value
WBB (N = 8)	175.95 ± 56.67	147.85 ± 35.99	0.040*
WBB+MI (N = 8)	176.03 ± 40.77	153.09 ± 37.11	0.170
P - value	0.997	0.739	

* = P < 0.05

Table 3. Muscle strength comparison before and after in the WBB group and in the WBB+MI group and between the WBB group and the WBB+MI group.

Muscle strength (kg)	Group	Before (Mean ± SD)	After (Mean ± SD)	P - value
Rt	WBB	32.62 ± 6.72	40.37 ± 3.36	0.009*
	WBB+MI	33.20 ± 7.63	39.05 ± 5.22	0.049*
P-value		0.992	0.586	
Lt	WBB	31.47 ± 6.13	39.05 ± 3.54	0.009*
	WBB+MI	32.52 ± 7.10	39.95 ± 6.17	0.035*
P - value		0.779	0.965	

* = P < 0.05

The muscle strength results for the WBB and WBB+MI groups before and after their training showed significant increases ($P < 0.05$).

Electroencephalogram

The WBB+MI group's EEG measurement results revealed theta waves (4 - 8 Hz) at 7.14%, low-frequency alpha waves (7.5 - 9 Hz) at 9.37%, high-frequency alpha waves (9.5 - 12.5 Hz) at 48.81%, and beta waves (14 - 30 Hz) at 28.64%.

Discussion

This study compared the effects of WBB and WBB+MI training on balance and muscle strength in 16 football player volunteers aged 18 - 23 years. The ages, weights, heights, MMSE scores, and MIQ-R scores in both groups were not significantly different.

The WBB group's balance after the training was significantly better ($P < 0.05$). The WBB+MI group tended to have better balance likewise. Balance represents the body's ability to hold its center mass within the base of support while the body moves in different directions.[20] In this study, balance was measured using the Posturomed device. Balance may be improved through balance training due to increased muscle strength, range of motion, and neural movement control. The participants psychological factors involved information/data transfer through the perception mechanism within the central nervous system (i.e., visual, vestibular, and proprioception).[21] The results of the study supported previous WBB studies that sought to enhance balance ability in healthy individuals,[5] the elderly with balance issues, and patients with nervous system diseases (e.g., cerebrovascular disease and Parkinson's disease). WBB enhanced the subjects' balance ability. In addition, WBB may correct posture or promote the best balance position during WBB training.

This study also found that knee extensor (thigh muscle) muscle strength ($P < 0.05$) was significantly enhanced in both the WBB and WBB+MI groups. Strengthened thigh muscles facilitate the adjustment of the center of gravity, improving balance.[20] This result conformed the research of Rozzi SL, et al.[22] who found that the four-week training program motivated the reflex musculature necessary for posture and balance support.

Furthermore, this study identified the effect of MI on balance and muscle strength. MI enhanced balance, which supports Gaggioli A, et al.[9] who applied MI to enhance sports skills and muscle strength. A previous study suggested that 50% muscle contraction for

movement/motion preparation occurred during MI[10] as MI motivated the brain to begin the muscles' motor unit function. Motor neuron contraction prepared muscles for motion[23] without the actual performance of the motion. MI also affected the adjustment of the nervous system, which was necessary for muscle strength enhancement and the mental control structure.[24] During MI, the participants' EEGs were measured. Then, the participants' high-frequency alpha waves were found (9.5 - 12.5 Hz). These waves indicated that the brain was alert and ready for activities.[16] The results supported a previous study that found alpha waves during MI before actual motion.[25] Alpha waves may reveal the brain's functioning process. The MI process resembled that of the actual motion. The only difference was no actual motion occurred during MI.[26] Therefore, MI resulted in better balance and improved muscle strength in the WBB+MI group.

Electromyography should be conducted to explore muscle performance during MI, and muscle strength improvements after MI should be confirmed.

Conclusions

WBB training may enhance balance ability and WBB and WBB+MI training may enhance thigh muscle strength in football players.

Acknowledgments

Conflict of interest

The authors, hereby, declare no conflict of interest.

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