Original

The Effect of Wii Training on Neurocognitive Function in Athletes with Functional Ankle Instability: Matched Randomized Clinical Trial

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ABSTRACT

Background: Many studies have investigated ankle sprain injury and It has been reported that in 80% of cases, ankle sprains lead to functional ankle instability (FAI). The conventional exercises for FAI rehabilitation neglect the associated neurocognitive dysfunction.

Objective: This study aims to evaluate the effect of Wii Fit Plus as a virtual reality training on neurocognitive function in athletes with FAI compared to athletes without FAI.

Material and Methods: In this matched randomized clinical trial study, 25 athletes with unilateral FAI and 25 athletes without FAI were assigned to two groups randomly: 1) the intervention group, subjects performed the Wii training including balance and strengthening games three times a week for 12 sessions and 2) subjects in the control group received no intervention. Before and after the training, the neurocognitive function was assessed through the computerized-reaction time test based on the detection or identification of 'X' mark on a computer monitor. Between-groups and within-group comparisons were done by the independent T-test and paired T-test, respectively.

Results: A significant difference was observed in mean differences of neurocognitive function between athletes with and without FAI. Comprising before and after training was significant in the intervention group.

Conclusion: Based on the results, the information-processing speed of athletes with FAI increased after the training, utilized for rehabilitation protocols.

Keywords

Ankle Injuries; Neurocognitive Function; Wii Fit Plus; Reaction Time; Virtual Reality

Introduction

However, many studies were focused on decreasing the risk of an ankle sprain, albeit, this problem is still a common injury [1] for 60% of all sports injuries [2] and leads to recurrence and functional ankle instability (FAI) affecting the daily life of subjects in 80% of cases [3, 4]. The characteristic feature of FAI is a tendency to frequent sprain or giving way, resulting in an inability to maintain ankle joint stability during dynamic activities [4].

Some studies reported evidence of a possible link between informa-

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Received: 20 December 2020
Accepted: 4 March 2021

tion processing and musculoskeletal injuries [5-10]. Neurocognitive reaction time appears as an indicator of the high risk of lower extremity injuries [10]. Information processing impairment was reported in athletes with FAI [11]. Thus, it is necessary to pay attention to neurocognitive function in the training kit for subjects with FAI.

Wii Fit Plus, a video game console, is an interactive game called "Gameaction" or "exergaming". An important innovation is the remote control of the Wii, a wireless controller that responds to the movements of players [12]. In addition, the feedback of movements improves the athlete's performance and leads to subject progression. Thus, Wii Fit Plus training may positively affect the movements and timing of the subject in sports.

Training with video games in sport is beneficial to minimize errors [13]. According to some evidence during several simultaneous activities in trained subjects with video games, a better focus is provided due to the nature of the game in which the player encounters several items [14]. Better results in video games might cause good eye-hand coordination during the game [15], emphasized by a study by the University of Iowa in which surgeons with regularly played video games had fewer errors during laparoscopic surgery [15]. Therefore, a direct relationship is between the movement ability in playing a game and physical performance.

In a virtual game, the subject is interacting in a virtual environment that observes, evaluates, and controls his/her movements in the game. Accordingly, the virtual game could be considered as a new intervention for neural rehabilitation [16]. In interactive games, the patient's attention is drawn from the repetitive nature of conventional exercises to the competitive aspects of interactive games [17-19]. Exergames are interactive with physical and mental activities. Regarding some research, these games could increase the motivation for exercise more pleasantly and have cognitive benefits compared to physical activity alone [20-22]. In doing exergames during rehabilitation protocols, two aspects of cognitive and physical functions are focused more (i.e. interaction of mind and body) [23].

Conventional therapeutic exercises and the following assessments in previous studies only focused on the physical aspects of the subject's performance with musculoskeletal injuries [24-28]. In other words, previous studies suggested that neurocognitive dysfunction played an important role in incoordination, during sports information processing. Impairment may lead to errors in predicting external environment changes and loss of coordination when the players are faced with the changes during competition [10]. The relationship between the physical and neurocognitive function was investigated in case-control and physical-intervention studies [29-35].

To the best of our knowledge, no study is conducted about the effects of Wii training on neurocognitive performance in athletes with FAI. In this study, the reaction time (i.e. simple and choice) and errors were compared to athletes with and without FAI. Affected individuals in the intervention group received Wii training and unaffected individuals in the control group did not receive any treatment. Further, some hypotheses were suggested in the present study as follows: 1) reducing reaction time and the number of errors after training in athletes with FAI and 2) no difference in neurocognitive function between athletes with and without FAI after training.

Material and Methods

This is the single-blinded matched randomized clinical trial study.

Subjects

Based on the pilot study (which recruited 10 athletes), with a power of 80% and a confidence interval of 95%, twenty-five male basketball players with unilateral FAI and 25 without FAI voluntarily participated during this study with the sampling method "the non-probability convenient technique". Participants were basketball players of 20-30 age. Subjects with the following criteria were included in the FAI group as follows: 1) with at least one significant unilateral inversion sprain of either ankle and more than one repetition of "giving-way", 2) with a Cumberland Ankle Instability Tool score less than 24, and no mechanical instability (assessed by anterior drawer and talar tilt tests), 3) no history of ankle injury within the three months prior to participation, and 4) no cognitive deficit [36-38]. Persian version of Cumberland Ankle Instability Tool was used as a reliable and valid tool to detect FAI [38]. Subjects in the control group had no history of ankle sprain or "giving-way". In both groups, subjects were excluded from the study if they didn't want to continue the tests or use any medicine that could affect their cognitive function [36].

Ethical Consideration

The Ethics Committee of Tehran University of Medical Sciences approved the protocol of the study (Ethic cod: IR.TUMS.FNM.REC.1396.3235) and all subjects signed an informed consent form. This study was registered in the Iranian Registry for Clinical Trial (registration number: IRCT20090301001722N19) and was supported by Tehran University of Medical Sciences [grant number: 260/48]. The study took place at the physical therapy clinic School of Rehabilitation TUMS from May 2018 to July 2019.

Procedure

The first trained therapist collected the information such as self-report questionnaire and clinical examination and was blind to assignment and training protocol applied to athletes by the second physiotherapist. In the matched pairs design, 25 pairs were studied in two groups that each pair was randomly assigned (block randomization) in intervention and control groups using the Random Allocation Software (version 1.0). In the intervention group, each subject performed five minutes warm-up on a stationary bike [4] and Wii training, including balance training (e.g. soccer heading, ski slalom, tight rope walk, table tilt) and strengthening games with coordinated movements of the upper and lower extremity (e.g. single leg extension, sideways leg lift, single leg twist, rowing squat) (Figure 1) [39]. Furthermore, athletes completed 12 training sessions in the intervention group (three days per week) and received no intervention in the control group. Before and after training periods, the neurocognitive function was assessed by the Deary-Liewald reaction time task (DLRT) which is a valid computerized neurocognitive test to assess information processing introduced by the Centre for Cognitive Ageing at the University of Edinburgh in Scotland [40]. High reliability of DLRT application was shown for athletes with FAI [41].

Neurocognitive Test

All athletes completed a DLRT and had some practice trial to familiarize themselves with the test and eliminate the learning effect [40]. Everyone used a headphone during the test to minimize outside distractions. The computerized neurocognitive assessment is based on the presentation of the 'X' mark on a computer monitor and includes detection (i.e. simple reaction time) or identification (i.e. choice reaction time) (Figure 2). In simple reaction time (SRT), 20 trials were completed; each time the 'X' mark appeared, the athlete pressed the space key as fast as possible and reaction times were recorded. In choice reaction time (CRT), 40 trials were completed and reaction times and errors were recorded such as the other study [41].

The tests were performed randomly with 1-minute intervals and every subject performed each test three times and therefore the mean of these three times was recorded as the final score for each subject.

The mean and standard deviation of all data

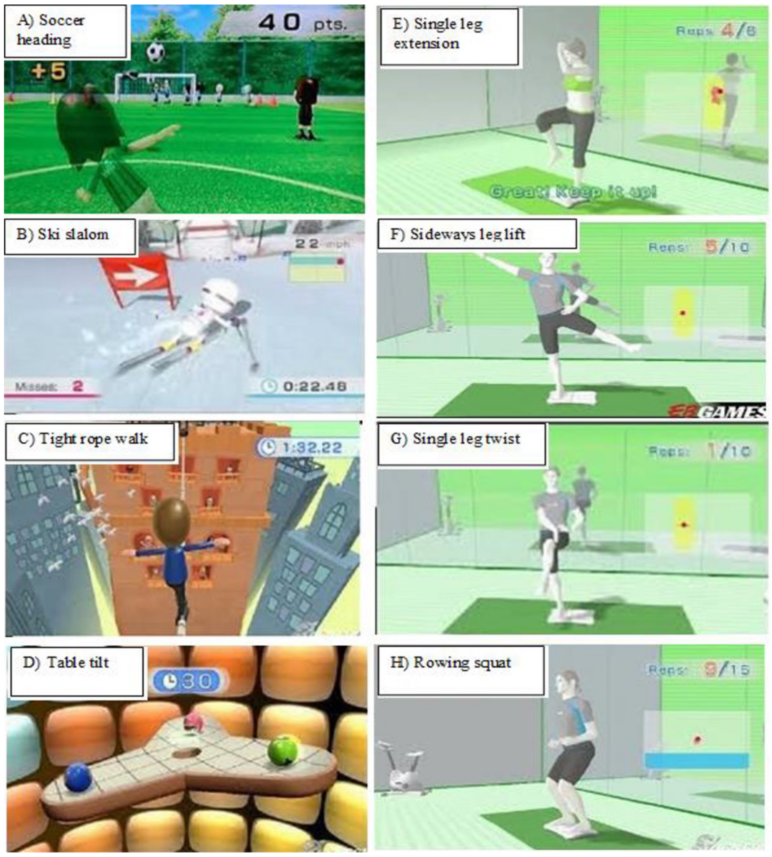

Figure 1: Wii Fit Plus games including balance training games and strengthening exercises.

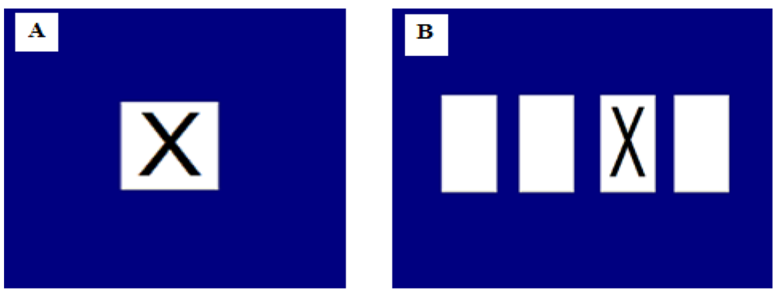

Figure 2: Reaction time task; A) simple reaction time B) choice reaction time

as descriptive statistics were calculated using SPSS (version 16). The normal distribution of each variable was verified by the K-S test. Independent and paired T-test were used to find any difference between groups or before and after training, respectively. The significance level of α was 0.05 for all analyses.

Results

Finally, 50 athletes were assessed and analyzed, and demographic characteristics for each group (N=27), as seen in Table 1. The level of reliability changed from high to very high, ranging from ICC (SEM) for SRT, CRT, and error was 0.84-0.98 (8.44-15.49), 0.80-0.98 (13.17-16.96), and 0.70-0.88 (0.31-0.76), respectively.

The mean and standard deviation of variables in each group were reported in Table 2. Furthermore, Table 3 shows "Mean difference" and "percentage change" in both groups and effect size. The comparison of "mean difference" between the two groups was significant, i.e. P <0.001 and P = 0.009 for the simple as well as choice reaction times and the Error, respectively. The intervention group had neurocognitive impairment before training, and then neurocognitive function improved after training; thus, the range of changes compared to the control group was significant (Table 3). However, simple and choice reaction times showed medium effect size (Cohen's d >0.5), error had a small effect size (0.2< Cohen's d <0.5) [42]. In the intervention group, comparison before and after training showed a significant difference in SRT, CRT, and Error (p <0.001), while this comparison was not significant in the control group (Table 4).

Discussion

Wii Fit Plus training as a neurocognitive exercise was studied in previous research [17, 20, 43-44] with little evidence of the positive effects of Wii training on FAI [36]. A lack of data was about the possible effects on neurocognitive function in athletes with FAI.

Considering the effect size, the results of this study showed that Wii Fit Plus training had a

Table 1: The mean and Standard Deviations (SD) of demographic characteristics for each group.

Variables	Intervention	Control	t-value	p-value
	Mean (Standard Deviations)	Mean (Standard Deviations)		
Age (year)	21.56 (2.31)	22.16 (1.95)	-0.433	0.667
Weight (kg)	66.92 (12.56)	66.72 (12.78)	0.243	0.809
Height (m)	1.74 (0.11)	1.75 (0.14)	-0.198	0.844

Table 2: The mean and standard deviation of variables before and after training.

Variables	Intervention				Control			
	Before		After		Before		After	
	Mean	Standard Deviations	Mean	Standard Deviations	Mean	Standard Deviations	Mean	Standard Deviations
Simple Reaction Time	323.89	39.17	235.68	36.95	231.07	36.03	234.92	34.26
Choice Reaction Time	531.06	59.11	423.37	58.87	418.20	21.70	403.29	51.49
Error	1.01	1.09	0.33	0.51	0.36	0.51	0.37	0.46

Table 3: Between-group comparison had significant differences in simple and choice reaction time, and Error (p <0.001).

Variables	Intervention		Control		t- value	p- value	Effect size
	Mean difference	Percentage change	Mean difference	Percentage change			
Simple Reaction Time	-88.21	-27.24	3.85	1.67	-7.234	0.000	0.63
Choice Reaction Time	-107.69	-20.28	-14.91	3.57	-10.057	0.000	0.78
Error	-0.68	-67.33	0.01	2.78	-4.134	0.000	0.28

Table 4: Paired-t test; the intervention group showed significant differences in the simple and choice reaction time, and Error (p <0.001).

Variables	Intervention		Control	
	t- value	p- value	t- value	p- value
Simple Reaction Time	15.603	0.000	-0.338	0.739
Choice Reaction Time	70.468	0.000	1.639	0.114
Error	4.925	0.000	-0.140	0.890

significant effect on reaction time (i.e. SRT, and CRT) compared to before and after the training in the intervention group. Based on the results, after Wii Fit Plus training, athletes with FAI performed faster in the processing of information. Maillot et al. [21], Hughes et al. [43], and Zimmermann et al. [44] reported cognitive improvement after Wii training, that the results of the current study were consistent with those of them [21,43-44]. Also, some studies assessed the effects of physical training on neurocognitive function and also reported significantly positive impacts [29-35]. Thus, the results of this study, i.e. exergame include neurocognitive and physical exercises were in line with the positive results of physical training on neurocognitive functions.

Many studies focused on the association of neurocognitive impairment in musculoskeletal injuries during the last two decades. Wilkerson in a cohort study showed that neurocognitive impairment increased the risk of lower limb injuries [10]. On the other hand, in case-control studies, neurocognitive impairment was reported in subjects with musculoskeletal injuries such as FAI [5-9,11]; therefore, they concluded that neurocognitive improvement can be considered as an important factor for improving physical function and preventing injury [5-10]. Despite improvements in pain, swelling, muscle strength, proprioception, and increase range of motion (ROM) in subjects with FAI after conventional exercises, frequent recurrences of ankle sprain were reported and the neurocognitive aspect of the exercise was neglected in these subjects. Wii Fit Plus training as an exergame, comprised of two aspects of physical and neurocognitive components, can enhance interactions between the mind along the body and affect positively information processing in basketball players with FAI.

Therefore, Wii Fit Plus training is vital for the rehabilitation protocol of FAI and is considered as neuromuscular training with feedback that is very important for subject motivation and positive reinforcement. Furthermore, significant improvements were reported in balance ability and lower limb muscle activity using biofeedback training in football players with FAI [39].

This study included a short-term intervention period (i.e. 4 weeks, 12 sessions). Increasing the number of training sessions resulted in increasing the effect size for the error and the Wii training would affect the processing accuracy with an acceptable effect size. Furthermore, we had no follow-up observations to track any possible changes over time and assessed only neurocognitive function. Future studies should use physical function assessment and compare athletes with and without FAI or check the correlation between physical and neurocognitive function. The participants in this study were young male basketball players and our results could not be extended to females and also other injuries. Therefore, the training protocol of the current study can be effective in the rehabilitation of ankle sprains in young male basketball players.

Conclusion

Wii Fit Plus training can improve the information processing speed in basketball players with FAI and be used safely and effectively as a part of rehabilitation protocols by physiotherapists.

Acknowledgment

We appreciate all staff of the School of Rehabilitation who kindly help us during the term of research.

Authors' Contribution

Mohammadi N. conceived the idea. The paper was written by Mohammadi N. and Hadian M. The study was designed by Mohammadi N. and Hadian M. and Olyaei Gh. The experiment was carried out by Mohammadi N. Results and Analysis was carried out by Mohammadi N. The research work was proofread and supervised by Hadian M. and Olyaei Gh. All the authors read, modified, and approved the final version of the manuscript.

Ethical Approval

The Ethics Committee of Tehran University of Medical Sciences approved the protocol of the study (Ethic cod: IR.TUMS.FNM.REC.1396.3235).

Funding

This study was supported by Tehran University of Medical Sciences [grant number: 260/48].

Conflict of Interest

None

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