Original Article

PTRS Physical Therapy Rehabilitation Science

http://dx.doi.org/10.14474/ptrs.2013.2.2.115
pISSN 2287-7576
eISSN 2287-7584

Phys Ther Rehabil Sci
2013, 2 (2), 115-118
www.jptrs.org

Effects of immediate unilateral whole body vibration on muscle performance and balance in young adults

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Objective: Whole body vibration training is a relatively new approach for enhancement of muscle strength, physical performance, and balance. The aim of this study was to assess the effect of unilateral whole body vibration training.
Design: One group pretest-posttest design.
Methods: Sixteen healthy, physically active volunteers participated in this study. Whole body vibration was applied with a frequency of 20 Hz and an amplitude of 3 mm for 3 minutes. Muscle performance and static balance were assessed before and after unilateral whole body vibration training. One leg standing broad jump test was measured to determine muscle performance which is closely linked to lower extremity muscle function. The good balance system was used in evaluation static balance. All test were measured 3 times and the average value was analyzed.
Results: Jumping length was significantly improved by 0.11m in all participants after intervention ($p<0.05$). Among static parameters, significant results were observed where in the eyes opened condition, X-speed (medial-lateral sway) changed from 4.20 mm/s to 4.95 mm/s, Y-speed (anterior-posterior sway) changed from 5.77 mm/s to 6.54 mm/s and velocity moment changed from 12.77 mm^2/s to 13.57 mm^2/s ($p<0.05$). In the eyes closed condition, X-speed changed from 4.34 mm/s to 4.85 mm/s, Y-speed changed from 7.84 mm/s to 8.16 mm/s and velocity moment changed from 16.03 mm^2/s to 16.11 mm^2/s ($p<0.05$).
Conclusions: Immediate unilateral whole body vibration improved muscle performance but impaired static balance in young adults.

Key Words: Balance, Muscle performance, Unilateral, Whole body vibration

Introduction

The ability to control balance of the body is an important prerequisite to performance of functional activities [1] and its failure can seriously limit performance and quality of life [2]. The most current measures for assessment of the postural sway are related to the excursion of the center of pressure [3], which has been widely used in studies reported in the literature [4]. Several postural parameters in the time and/or frequency domains have been reported according to the center of pressure excursion [5]. Postural parameters in the time domain have been used extensively in quantification of postural stability [6].

Whole body vibration is a type of exercise that uses high-frequency mechanical irritation, which are generated by a vibrating platform and transmitted through the body. This technology may be attractive particularly for subjects who are otherwise unable or unwilling to perform conventional exercise and will therefore be a promising option for increasing subjects' physical activity of subject [7]. Whole body vibration training can have advantageous effects on the proprioceptive mechanisms of the ankle joint because with this intervention, it is possible to impact the muscle performance, electromyography responses, as well as muscular

Received: 5 October, 2013 **Revised:** 14 December, 2013 **Accepted:** 16 December, 2013

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strength [8]. This type of training was applied in sport performance through the research of Ramas *et al*. [9]. In recent years, whole body vibration training has been utilized more as a neuromuscular training technique [10] and as a method for injury rehabilitation and prevention method [11]. Some authors have suggested that whole body vibration training can be used for improvement of balance and proprioception [12]. There is some evidence indicating that whole-body vibration training can improve neuromuscular function [13].

Therefore, this study investigated the immediate effect of unilateral whole body vibration training on muscle performance and static balance. We hypothesized that unilateral whole body vibration would result in significant improvement of muscle performance and static balance.

Methods

Subjects

The study was designed as a pilot trial for young adults who had been in attending at Sahmyook University. Sixteen healthy, physically active volunteers participated in this study. The inclusion criteria were age between 20 and 35 years. Exclusion criteria included any type of injury within six months prior to conduct of the study.

Muscle performance was evaluated using the one leg standing broad jump test. We modified the existing research procedure by having the subject jump vertically [14]. At that time, all subjects jumped on the dominant leg as much as possible and then the jumping length was measured.

Static balance was measured using the good balance system (Good Balance System; Metitur Ltd., Jyväskylä, Finland, 2008). The Good Balance system consists of an equilateral triangular force platform connected to a computer. The following measurements were carried out with the subject standing on the force platform: (1) normal standing for 30 s with eyes opened, hands hanging down loosely, feet comfortably apart, and gaze fixed on forward at eye level; (2) normal standing as above for 30 s but with eyes closed. The tests were performed three times in the same order for every subject (Figure 1).

Intervention

This study used whole body vibration (Galilieo advanced plus; Novotec, Pforzheim, Germany, 2011). Frequency and amplitude parameters were 20 Hz and 3 mm for 3 minutes. Type of vibration of this machine was vertical. Participants were instructed as follows. First, the subject remained with one leg to the dominant side. Second, the subject bent his or her knee approximately 120^{o} (Figure 2). Third, the subject remained in a squatting position, maintaining weight bearing on the toes [15].

Data analysis

SPSS version 15.0 for Windows (SPSS Inc., Chicago, IL,

Figure 1. Standing on one leg to the dominant side.

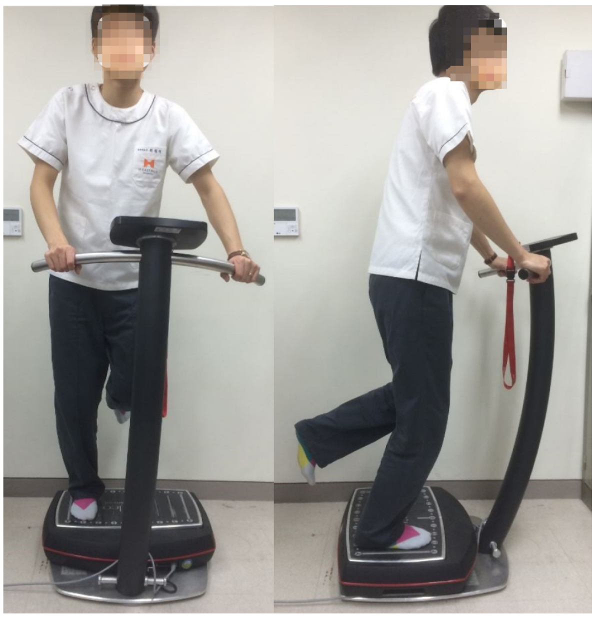

Figure 2. Standing on one leg with knee flexed approximately 120 degrees.

Table 1. General characteristics of the subjects (N=16)

Characteristic	Value
Age (yr)	28.40 (6.34)
Height (cm)	166.92 (8.13)
Weight (kg)	61.29 (14.86)
Dominant foot (right/left)	13/3

Values are presented as n or mean (SD).

USA) was applied for statistical analysis of the results. Descriptive statistics was used for general history of subjects. Paired t-test was performed for comparison of jumping performance and static balance. The alpha level was set at 0.05 for all analyses.

Results

This study was conducted on 16 subjects, whose general characteristics are listed in Table 1. Muscle performance, which was evaluated based on jumping length, showed a significant change, from 0.93 m to 1.04 m ($p < 0.05$), and static balance was evaluated based on postural sway. In the eyes opened condition, X-speed (mediolateral sway) changed from 4.20 mm/s to 4.95 mm/s ($p < 0.05$), Y-speed (anterioposterior sway) changed from 5.77 mm/s to 6.54 mm/s and velocity moment changed from 12.77 mm^2/s to 13.57 mm^2/s ($p < 0.05$). In the eyes closed condition, X-speed changed from 4.34 mm/s to 4.85 mm/s ($p < 0.05$), Y-speed changed from 7.84 mm/s to 8.16 mm/s and velocity moment changed from 16.03 mm^2/s to 16.11 mm^2/s ($p < 0.05$; Table 2).

Discussion

The current study was conducted in order to identify the effects of immediate unilateral whole body vibration on muscle performance and balance of young adults. The findings of this study showed that vibration induced an increase in muscle performance and a decrease in static balance.

Some of the long-term effects of this type of training involved increases in muscular strength [16], power [17] and jump length [14]. There are different theories that may explain the reason for these improvements. Some authors have stated that they may be due to muscle adaptations produced by the gravitational load. Acute physiological adaptations to whole body vibration training are related to an increase in the sensitivity of muscle spindles, of gamma motor neurons, and their effects on the stretch-shortening reflex [18].

Table 2. Comparison of the static balance with eye opened, eye closed and jumping length (N=16)

Parameter	Pre-test	Post-test	*p*
Jumping (m)	0.93 (0.30)	1.04 (0.28)	0.045
EO			
X-speed (mm/s)	4.20 (2.17)	4.95 (2.12)	0.000
Y-speed (mm/s)	5.77 (1.90)	6.54 (1.87)	0.006
Velocity moment (mm^2/s)	12.77 (9.91)	13.57 (9.13)	0.398
EC			
X-speed (mm/s)	4.34 (2.87)	4.85 (2.82)	0.045
Y-speed (mm/s)	7.84 (4.95)	8.16 (4.29)	0.483
Velocity moment (mm^2/s)	16.03 (27.84)	16.11 (22.02)	0.970

Values presented as mean (SD).
EO: eyes opened, EC: eyes closed.

Therefore, according to the results of our study, jumping length increased by approximately 11.8%. This finding reflected results similar to those of previous studies [14]. However, static balance showed a significant decrease in the eyes opened condition. In general previous studies had applied whole body vibration for long term and both feet [15]. However, this study applied whole body vibration one time, and static balance was then measured immediately. Results showed that whole body vibration induced an increase in bone density. This is because, with continuing vibration, a larger proportion of the incident vibration energy is directed to bones, instead of being absorbed by muscle tissue [19].

It is suggested that stress on the lower extremity muscle produced fatigue, which may have produced a negative effect on static balance.

There were two limitations to this study. First, due to a small sample size, it is difficult to make any generalization. Second, since this study was a one-group pretest-posttest study, further studies are needed to investigate for the long term intervention effects to unilateral whole body vibration.

The findings described above suggest that vibration is a potentially efficient training stimulus and future studies should focus on evaluation of the long-term effects of whole body vibration on body muscle performance and balance.

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