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EFFECTS OF WHOLE BODY VIBRATION TRAINING ON KNEE EXTENSOR MUSCLE STRENGTH AND RATE OF FORCE DEVELOPMENT

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This study compared the effects of 8-week whole-body vibration (WBV) training programs on knee extensor muscle strength and rate of force development. Twenty physically active male subjects were randomly assigned to a whole-body vibration training group (WBV; n = 10) or a sham training group (SHAM; n = 10). Maximal voluntary isometric joint moment, rate of force development (RFD) and contractile impulse of the knee extensors were assessed before and after the training period. There were significant differences between WBV and sham groups on improvement percentage of maximum joint moment, RFD and contractile impulse in knee extensor. We concluded that not only knee extensor muscle strength could be enhanced but also muscle contractile abilty could be faster after a 8-week WBV training program.

KEY WORDS: MVC, Rate of force development, Whole body vibration

INTRODUCTION: Whole-body vibration exercise is used widely among healthy and physically active people, mainly to increase strength and power in the lower limb muscles. Recently, it has been proved that whole body vibration (WBV) training could increase muscle strength and improve jumping performance (Cochrane, Legg, & Hooker, 2004; de Ruiter et al., 2003; Fagnani et al., 2006). Whole-body vibration constitutes a mechanical stimulus that enters the human body via the feet when standing on an oscillating platform. Some authors have proposed that WBV training could improve body balance, motor capacity, explosive power and muscle strength. Many sport skills are characterized by fast and powerful movements, including running and jumping (Rehn et al., 2007). However, the short contraction time may not allow maximal muscle force to be reached. Recently, rate of force development (RFD) has become an inherently of major measurement for athletes engaged in sports that involve an explosive type of muscle action. RFD could determine the force that can be generated in the early phase of muscle contraction by 0-200ms (Aagaard et al., 2002). Therefore, RFD is an important parameter to assess explosive strength qualities of the neuromuscular system (Gruber & Gollhofer, 2004; Aagaard et al., 2002). As a result, the purpose of this study was to investigate the effects of 8-week whole body vibration training (WBV) on the improvement of knee muscle strength, RFD and contractile impulse between WBV and sham groups.

METHODS: Twenty trained male physical education students agreed to participate in this study. All were informed of the procedures that would be performed and gave informed written consent prior to enrolment in the investigation. They were randomly allocated to a whole-body vibration (WBV) trining group (WBV; n = 10; age: 20.2 ± 1.7 years; height: 178 ± 9.8 cm; body mass: 77.2 ± 13.3 kg, means ± SD) or a sham training group (SHAM; n = 10; age: 20.2 ± 1.8 years; height: 177.9 ± 7.0 cm; body mass: 69.1 ± 6.9 kg, means ± SD). All subjects had trained and competed regularly in various physical activities for at least 4 years. None of the subjects had been engaged in systematic strength training or WBV programs in the 3 months preceding the beginning of the experiments. The training program consisted of 18×20-min sessions of static unloaded exercises over a 8-week period, with three sessions per week (Monday, Wednesday, and Friday). WBV group performed the exercises on a vertical vibration platform (i.e., a platform that vibrate in a vertical direction; AV-001A, B. Green

Technology Co.Ltd., Taiwan). The vibration frequency and peak-to-peak displacement were set at 30 Hz and 1-1.8 mm for WBV group. Prior to each training session, a standardized warm-up was performed over 3min. The subjects then maintained ten isometric squatting positions, each for 30s or 60s and immediately followed by 60s rest periods (Table 1.). During the vibration, the subjects thus stood on the vibration platform in a squatting position with feet and knees rotated externally. Knee angle was changed every 2 weeks over the 8-week period in order to increase training intensity (60° for the first 2 weeks, 70° for the 3rd and 4th weeks and 80° for the 5th and 6th weeks and 90° for the 7th and 8th weeks, where 0° corresponds to full extension of the knee). During vibration exposure, the participants' hands were positioned on their waist, thus providing no postural support, and the trunk was leaning slightly forward. During the 60-s rest periods, the participants adopted a relaxed standing position. SHAM group followed exactly the same training protocol as for WBV group but the platform did not vibrate. The subjects did not change their level of physical activity during the training period.

Table 1
The 8-week whole body vibration training program

week	frequency (Hz)	amplitude (mm)	duration (sec/set)	rest (sec)	set	times / week
1-2	30	1	30	60	10	3
3-4	30	1	60	60	10	3
5-6	30	1.8	30	60	10	3
7-8	30	1.8	60	60	10	3

Measurements of knee extensor and flexor contractile moments were used maximal voluntary isometric contraction (MVIC) via the Biodex System 4 dynamometer (Biodex Medical Systems, New York, USA). During the MVIC test, all subjects were asked to seat on a chair with the hip and trunk fixed in neutral position, then, the maximal voluntary isometric contractions were performed knee extension and flexion at a knee angle of 60 degrees (0 degree = full extension). All measurements were performed in the dominate leg. After 5 minutes of practice and warm-up, each subject needed to perform three times of knee extensions and flexions as quickly as possible at maximum effort. In this current study, we selected the trial with maximum moment from the three MVICs and analyzed the maximum moment, rate of force development (RFD) and contractile impulse. The contractile RFD was derived as the average slope of the moment-time curve (Δmoment/Δtime) over time intervals of 0–30 and 0–50 (ms) relative to the onset of contraction. The onset point was defined as the time point exceed 5 N·m of baseline moment. Similarly, contractile impulse was determined as the area under the moment-time curve in time intervals of 0–30 and 0–50 (ms) relative to onset of contraction. The improvement percentanges on maximum moment, RFD and impulse were calculated by the formula: [(post - pre) / pre]*100. An independent-samples T test was used to compare the improvement of knee muscle strength between WBV and control groups. Significant level was set at 0.05.

RESULTS: There were significant differences between WBV and sham groups on improvement percentage of maximum moment, RFD and contractile impulse in knee extensor (Figure 1). WBV group demonstrated a significant greater improvement percentage (28.96%±0.02%) than sham group (3.39%±2.2%) on maximum extensor moment. When compared knee extensor RFD at 30 and 50 ms, WBV group demonstrated significant greater improvement percentage at both 30ms and 50ms RFD (99%, 98%) than sham group (14%, 8%), respectively. In addition, compared the contractile impulse of knee extensor at 30 and 50 ms, WBV group demonstrated significant greater improvement percentage at both 30ms and 50ms impulse (55%, 69%) than sham group (11%, 16%), respectively. None of the knee flexor parameters between WBV and sham were found significant different.

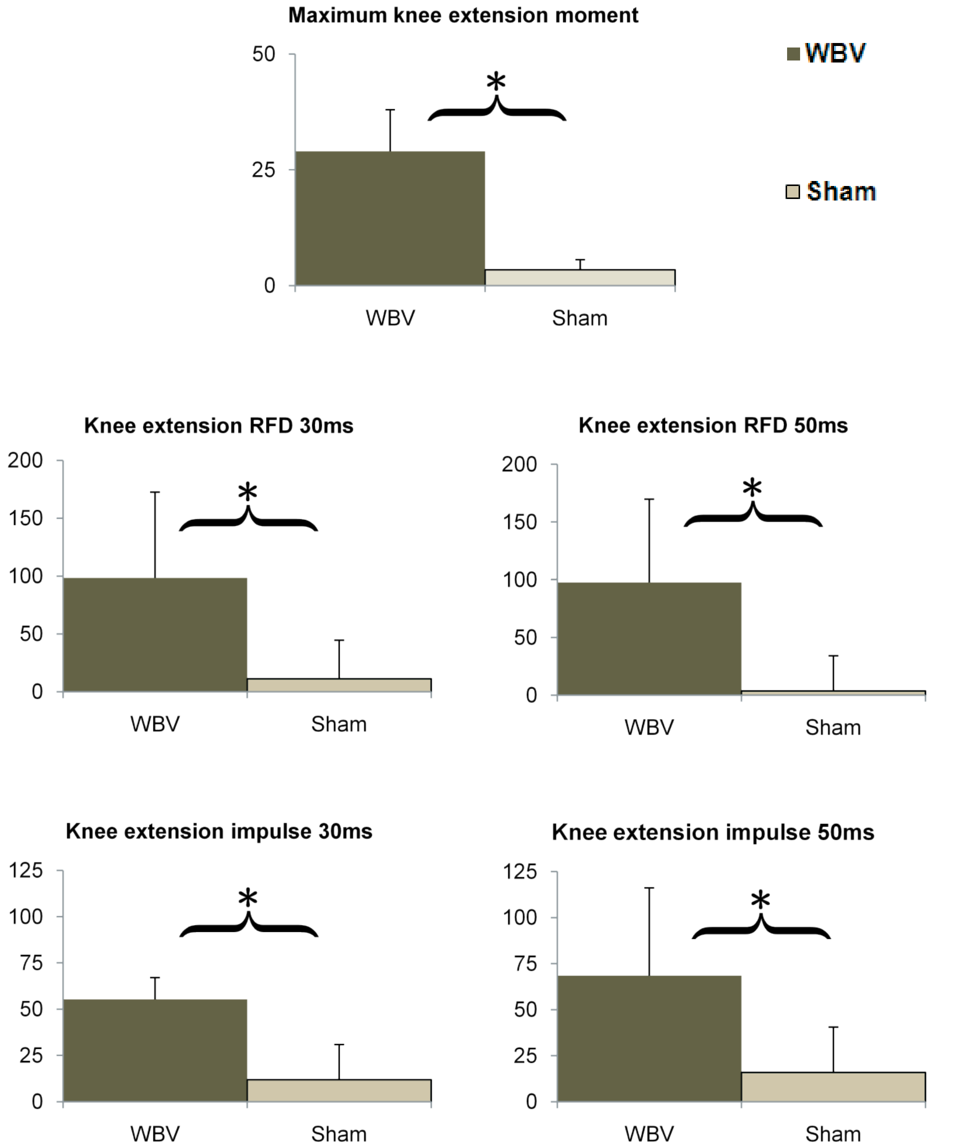

Figure 1: The improvement percentage of maximum moment, RFD and contractile impulse in knee extensor between WBV and Sham groups.

DISCUSSION: In the current study, results revealed that there were significant differences between WBV and sham groups on improvement percentage of maximum moment, RFD and contractile impulse in knee extensor. WBV group demonstrated significant greater improvement percentages in all knee extensor parameters. In the past, several studies have confirmed the RFD would increase after resistance and jump training (Aagaard, et al., 2002). It was also suggested that RFD properties after training might potentially involve alterations in motoneuron recruitment and firing frequency, and changes in type II myosin heavy chain

(MHC) isoforms and sarcoplasmic reticulum calcium kinetics (Aagaard, et al., 2002). WBV group demonstarted a steeper slope of the knee extensor RFD at 30 and 50 ms than sham group. The steeper slope indicates a faster rate to reach maximum joint moment. In addition, contractile impulse has been used to access the muscle strength because it incorporates the aspect of contraction time and it also reflects the specific time history of contraction which includes the overall influence of RFD. Results of the current study also demonstrated higher contractile impulses in WBV group than in sham group. The increase in contractile RFD and impulse is probably the most important strength adaptation elicited by whole body vibration training. As a result, we suggested that whole vibration training not only could increase knee extensor muscle strength but also could help knee extensor to contract as faster as forcefully. Therefore, we presumed these changes for knee extensor muscle after 8-week whole body vibration training might have positive effects on sports involved with explosive power, such as sprint running or rapid jumps.

CONCLUSION: After 8-week training, WBV group had better training effects than sham group in knee extensor parameters during open kinetic chain exercises. Although WBV training was a close kinetic chain exercise, the results of the current study suggested that the positive effects of the close kinetic chain WBV training could also pass onto open kinetic chain exercises.

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