

The acute effect of different frequencies of whole-body vibration on range of motion and jump performance in preadolescent karate athletes.

Esra ATIŞ¹ Ertugrul GELEN¹ , Suat YILDIZ²

¹Sakarya University, Faculty of Sport Sciences, Sakarya, Turkey

²Manisa Celal Bayar University Faculty of Sport Sciences Manisa / Turkey

Corresponding Address S. YILDIZ e-mail: drsuatyildiz@gmail.com

Abstract

Whole-body vibration (WBV) treatments have acute effects on strength, power, and range of motion (ROM) by affecting the nerve-muscle function. However, there is little evidence about what could be the optimal practice for acute WBV. The purpose of this study is to reveal the acute effects of vibrations applied at different frequencies to preadolescent karate athletes on jump and ROM performance. Forty-six competing preadolescent karate athletes, who trained regularly (12.7 ± 1.7 years, 155.2 ± 3.1 cm, 50.9 ± 4.7 kg) and were blue belt and above, were included in the study. Each athlete followed a vibration protocol with four different frequencies (0, 25, 30, and 35 Hz) in random order on nonconsecutive days. After a 5 min light-paced warm-up jog before each protocol, three repetitions of 20 sec (20 sec rest between repetitions) vibration treatments were applied. Jump and ROM tests were carried out after each vibration treatment. Vibration protocols were compared in repeated measurements using the ANOVA and post-hoc methods. Based on the test results, a vibration frequency range of 30 to 35 Hz positively affected the countermovement jump, while the 30 Hz frequency range positively affected squat jumps. Furthermore, frequency ranges of 25, 30, and 35 Hz positively affected the ROM. This effect was most intensely revealed in the 35 Hz frequency range. Applying vibrations between the ranges of 30-35 Hz on preadolescent karate practitioners is believed to acutely improve both jump and ROM performance.

Key words: Vibration, Range of motion, Jump, Power, Karate

INTRODUCTION

The common goal of athletes and trainers is to bring the current performance to the desired level. For this reason, researchers continue their work to develop motor skills such as strength, power, flexibility, balance, and coordination. Work being done on this topic is leading researchers into new pursuits. Researchers have recently begun using vibrations as a new method to increase the acute and chronic performance of athletes(1-6). Training sessions incorporating the application of vibration treatments are referred to as vibration training in the literature(4, 7).

Although vibration treatment may seem like a new practice in the field of sports, it has quite a long history in the field of health. According to ancient Greco-Roman sources dating back nearly two centuries, vibration treatment was not only used in medical techniques, but it is also known to be a

technique frequently used by physicians in the 19th century in the form of vibration massage(7). The studies investigating in what manner vibration training may affect athletes' performance date back to the 1980s. Particularly following the discovery that it created a positive impact on strength development, studies have been further deepened and work has increased by applying vibration treatments at different frequencies(4, 7). The measurement of a person's acute performance has been attempted in many studies by administering vibration training prior to maximal performance, especially in branches requiring maximum strength, such as jumps, in order to increase the individual's performance in both competition and training(2, 8-12). These studies have shown that vibration treatments increase acute performance.

Researchers investigating the effects of vibration on sports performance consider three possible factors. The first of these is increased blood flow due to muscle activation and a temperature rise in connection with this(10). This condition is thought to increase flexibility due to the effect of heat on expansion. Secondly, although the effects of vibration on the muscle are yet to be clearly explained, researchers are focusing on the tonic vibration reflex (TVR)(4, 8, 13, 14). During vibration treatments, the primary endings in the muscle fibers are stimulated by vibration of the muscle (Ia efferent), and this prompts the a-motor neuron activation that causes reflex muscle contractions. This reflex is defined as the TVR(15-17). When vibration is applied to the whole body, all receptors within the skin, subdermal surface, joint capsule, and muscle (Ia efferent) are stimulated and thus the stretch reflex is activated. In some studies, the inhibition and activation (excitation) of the stretch reflex have been reported together (8, 18). The third mechanism has been defined as the ability of the person being loaded to continue being loaded, due to the inhibition of pain and a rise in the pain threshold as feedback from the vibration (13).

While the effects of vibration treatments on acute performance have been investigated in several sports branches, its effects on preadolescent karate athletes are not yet known. The purpose of this research is to display the acute effects of vibration applied at different frequencies on jump and flexibility performance in Karate athletes.

METHODS

Participants

Forty-six competitive blue belt and above karate athletes (age: 12.7 ± 1.7 years, height: 155.2 ± 3.1 cm., weight: 50.9 ± 4.7 kg.) voluntarily participated in the study. There was no history of musculoskeletal injury in any of the athletes. All athletes were asked not to engage in high intensity exercise within the 24 hours prior to treatment and testing and to consume their last meal at least two hours prior to the study. All athletes and their parents were informed about the risks and benefits involved in their participation in the study, and signed the form of informed consent prior to participation in any test. Furthermore, at all stages of the study, the "Helsinki Declaration" was complied with, and the study was carried out with the permission from University Ethics Committee.

Procedures

Before beginning data collection, a presentation and trial session regarding vibration treatments and flexibility, and countermovement jump (CMJ) and squat jump (SJ) tests were arranged for each athlete included in the survey two days before the first test. Each protocol was initiated with the athletes taking a low intensity warm-up jog in the gym for five minutes. After this warm-up jog, they took a two-minute walk to rest. Then, each athlete separately applied one of the four vibration protocols (0, 25, 30, and 35 Hz) on non-consecutive days that were determined according to the random method. Vibration treatments were applied using a platform (PowerMaxx, SA) capable of producing vibrations at different frequency ranges. Vibration treatments were applied three times at 20 sec durations followed by 20 sec rest intervals. Vibration was applied with an amplitude of 4.5 mm. Two movements, in the form of normal straight posture and squat posture (knee and hip angle at 110 degrees), were used on the vibration platform. After completion of the related protocol, flexibility, CMJ, and SJ tests were carried out in order. All applications were carried out by the same trainer, in groups of four, at approximately the same time (14:00).

Flexibility Tests

The flexibility of the athletes was evaluated with a sit-and-reach test and hip and hamstring flexion test on their dominant and non-dominant sides. Flexibility testing measurements were taken with a standard goniometer (Baseline, CE, Plastic 360o) and a sit and reach measuring device (Takeda brand Sci. Inst. Co., Ltd., DGTK-5403, JP). All flexibility tests were repeated three times, and the highest value recorded for analysis (19).

Jump Performance Tests

The countermovement (CMJ) and squat jump (SJ) techniques were used in this study to determine jump performance. A force platform (Kistler, 9290 AD model, Switzerland) capable of taking measurements at 500 Hz frequency was used to measure the jump performances of the athletes. The hands of the athletes were on their waists during both jump techniques. The knee-hip angle of the athletes during the squat jump was kept at 110 degrees through measurement with a standard goniometer. For both jump styles

(first CMJ, then SJ), three repetitions were made, and the highest value used in the analysis of jump performance (19).

Statistical Analyses

Descriptive statistics (mean \pm SD) for the age, height, body weight, flexibility, and jump variables were calculated. Values obtained after three experimental (25, 30, and 35 Hz vibration) and one control (0 Hz vibration) application protocol were calculated using the analysis of variance in repeated measurements (ANOVA). When a difference was detected between vibration frequencies after the variance analysis, a least significant difference (LSD) calculation was used to determine from which frequencies the difference was arising. All statistical operations were calculated based on a significance level of $p > 0.05$ (SPSS, Inc., Chicago, IL).

Table 1. The acute effect of different frequencies of whole-body vibration on range of motion and jump performance.

	0 Hz Vibration	25 Hz Vibration	30 Hz Vibration	35 Hz Vibration
Countermovement Jump	34.3 \pm 6.0	35.0 \pm 6.1	35.6 \pm 6.5*	35.4 \pm 6.4*
Squat Jump	33.3 \pm 6.2	34.2 \pm 5.5	34.8 \pm 6.6*	34.0 \pm 6.3
Sit and Reach Flexibility	24.7 \pm 6.4	26.8 \pm 5.9*	27.8 \pm 6.0*	27.4 \pm 6.8*
D-Hip Flexion	117.9 \pm 8.8	121.1 \pm 9.3	124.4 \pm 7.5*	125.8 \pm 5.4*
ND-Hip Flexion	112.8 \pm 11.1	120.8 \pm 7.1*	123.7 \pm 8.1*	124.3 \pm 7.6*
D-Hamstring Flexion	102.5 \pm 9.5	107.1 \pm 11.0	111.6 \pm 7.8*	117.9 \pm 6.4*
ND- Hamstring Flexion	102.5 \pm 11.1	109.4 \pm 10.4*	112.9 \pm 9.7*	115.5 \pm 9.3*

D, Dominant; ND, Non-Dominant

* $p < 0.05$

DISCUSSION

Vibration treatments have come to be used as quite a popular exercise and training method in recent years. In this study, which was conducted in order to investigate the acute effects of vibration treatments on jump and flexibility performance in karate athletes, and which to determine between which frequency ranges this effect best reveals itself, vibration treatments were seen to improve the acute performances of athletes. In the current study, the highest increase in performance was seen at the 30 and 35 Hz frequency levels. While a statistically significant difference was found between the 30 Hz and 35 Hz vibration treatments when examining the CMJ performance of participants, only the 30 Hz frequency showed a significant difference for the SJ. As for flexibility performance, significant increases were seen at the 25, 30, and 35 Hz frequency levels. The best values were observed after the 35 Hz vibration treatment.

RESULTS

The acute effects of vibration applied at different frequencies on the range of motion and jump performance are shown in Table 1. When the data were analyzed, a statistical difference was found ($p > 0.05$) between 0 Hz vibration and 25 and 35 Hz vibrations with respect to the countermovement jump; between 0 Hz vibration and 30 Hz vibration with respect to the squat jump; between 0 Hz vibration and 25, 30, and 35 Hz vibrations with respect to sit-and-reach flexibility; between 0 Hz vibration and 30 and 35 Hz vibrations with respect to D-hip flexion; between 0 Hz vibration and 25, 30, and 35 Hz vibrations with respect to ND-hip flexion; between 0 Hz vibration and 30 and 35 Hz vibrations with respect to D-hamstring flexion; and between 0 Hz vibration and 25, 30, and 35 Hz vibrations with respect to ND-hamstring flexion.

While the applied frequencies and their results vary in previous studies made in this field, the general observation is that vibration treatments improve jump and flexibility performance (2, 12, 20, 21).

While a significant difference was found in CMJ performance before and after vibration treatment in the study conducted by Soyulu et al. (2012), to demonstrate the acute effects of vibration at a 35 Hz frequency and of 4.5 mm amplitude on CMJ and SJ performance, no significant difference was found in SJ performance (21).

Cochrane and Stannard (2005) demonstrated in their study that vibration treatment (26 Hz, 6 mm) improved jump and flexibility performance after applying randomly alternating treatments lasting no longer than five minutes on 18 female field hockey players whose mean age was 21.8 years (2).

The study of Ronestad (2009b) examined the effect of vibration treatments at different frequency ranges

on lower body strength, and used 20, 35, and 50 Hz frequency vibration treatments on trained and untrained persons. In SJs, the 50 Hz vibration treatment showed a significant difference in trained and untrained persons when compared with other protocols. In the active vertical jump, a significant difference occurred only in untrained persons between the 50 Hz vibration treatment and 20 and 35 Hz vibration treatments (20).

In other studies investigating the effects on maximum performance of the acute effects of vibration treatments, Ronestad's (2009a) study measured 1 RM squat performance during 0 Hz, 20 Hz, 35 Hz, and 50 Hz vibration treatments, and found that while a significant difference occurred between the 50 Hz group and the no vibration group, there was no significant difference between the 20 and 35 Hz vibration group and the no vibration group (12). Gelen et al. (2008) investigated the acute effect of vibrations on penalty performance in football at three different frequency ranges (25 Hz, 30 Hz, 35 Hz). They concluded that vibration treatment improves penalty performance in football and that the best effect revealed itself between the 30 and 35 frequency ranges (11).

While studies conducted in this field generally reveal findings similar to the current study regarding the acute effects of vibration treatments, there are also dissimilar results. Gerodimos et al. (2009) in their study carried out with the participation of 18 healthy sedentary women who engaged in physical activity two to three times per week, observed that vibration treatments applied for six minutes (15, 20, and 30 Hz; 6mm) did not improve jump performance (22). Although one waits in a pose very close to a normal posture (knees bent 170 degrees) on the vibration device, static contractions occur for the duration of the six-minute wait. It is known that static contractions have a negative influence on the explosive force. For this reason, it is believed that the resulting different conclusion might be due to the duration of the vibration treatments.

In vibration treatments, the effect of training is achieved and muscle contraction occurred without even any conscious effort. Thanks to vibration and the speed of these vibrations, muscles begin to work immediately (5, 15, 18). As the muscles exposed to vibration come into contact with the platform, they are

forced into activation at the same speed. This situation forces the muscle to work harder and ensures that it naturalizes the training stimulus.(7, 23) The main advantage of this type of muscle activation is the possibility for it to work 100% of the muscle fibers. In the traditional way of training, muscle fibers can be worked between 40 and 60% (23). The activation of nearly the entirety of all muscle fibers is thought to be quite important prior to activities requiring maximum effort, such as jumps. Based on this, we believe that this situation may have a positive influence on activities that require maximum performance, such as jumps.

Looking at research examining the effects of vibration treatments on flexibility performance, we can claim that the results we obtained from our study are similar to other studies (12). While jump and flexibility performance are evaluated together, as in previous studies, there are also studies wherein flexibility attributes alone are investigated. Sands et al. (2006) demonstrated in his study that static stretch exercises done with the help of vibration improved flexibility performance more than static stretch exercises practiced on their own (24). Researchers have demonstrated in a study conducted with ten male athletes, whose mean age was 10.1 years, that vibration treatment (30 Hz, 2 mm) improved flexibility performance.

In conclusion, in evaluating this study, acute vibration treatments at different frequencies are seen to yield different results. While in all measurements, the 30 Hz vibration treatment was seen to improve acute performance, the same results could not be obtained from the application of other frequencies. The study demonstrated that the use of a 30-35 Hz frequency during vibration training showed a greater effect with relation to explosive force performances, such as the vertical jump, and to range of motion. It can be stated that vibration treatments improve flexibility performance due to reasons such as increasing blood flow, creating the TVR effect, and pushing the pain threshold.

REFERENCES

1. Ebrem, Ş., et al. *The acute effects of vibration on handball throw performance*. in *10. International sport Sciences Congress*. 2008. Bolu, Turkey.
2. Cochrane, D.J. and S.R. Stannard, *Acute whole body vibration training increases vertical jump and flexibility performance in elite*

- female field hockey players. *British Journal of Sports Medicine*, 2005. 39(11): p. 860-865.
3. Cochrane, D.J., S.J. Legg, and M.J. Hooker, *The short-term effect of whole-body vibration training on vertical jump, sprint, and agility performance*. *Journal of Strength and Conditioning Research*, 2004. 18(4): p. 828-832.
 4. Cardinale, M. and C. Bosco, *The use of vibration as an exercise intervention*. *Exercise and Sport Sciences Reviews*, 2003. 31(1): p. 3-7.
 5. Cardinale, M. and J.A. Erskine, *Vibration Training in Elite Sport: Effective Training Solution or Just Another Fad?* *International Journal of Sports Physiology and Performance*, 2008. 3(2): p. 232-239.
 6. Colson, S.S., et al., *Whole-Body Vibration Training Effects on the Physical Performance of Basketball Players*. *Journal of Strength and Conditioning Research*, 2010. 24(4): p. 999-1006.
 7. Issurin, V.B., *Vibrations and their applications in sport - A review*. *Journal of Sports Medicine and Physical Fitness*, 2005. 45(3): p. 324-336.
 8. Bagheri, J., et al., *Acute Effects of Whole-Body Vibration on Jump Force and Jump Rate of Force Development: A Comparative Study of Different Devices*. *Journal of Strength and Conditioning Research*, 2012. 26(3): p. 691-696.
 9. Cormie, P., et al., *Acute effects of whole-body vibration on muscle activity, strength, and power*. *Journal of Strength and Conditioning Research*, 2006. 20(2): p. 257-261.
 10. Egan, C.E., et al., *Acute effects of vibration on peripheral blood flow in healthy subjects*. *Occupational and Environmental Medicine*, 1996. 53(10): p. 663-669.
 11. Gelen, E., Saygın, Ö., Karacabey, K., Süel, E., Kılınç, F., Harmandar, D. *The acute effects of vibrasyon on soccer penalty kick performance*. in *10. International sport Sciences Congress*. 2008. Bolu, Turkey.
 12. Ronnestad, B.R., *Acute Effects of Various Whole Body Vibration Frequencies on 1rm in Trained and Untrained Subjects*. *Journal of Strength and Conditioning Research*, 2009. 23(7): p. 2068-2072.
 13. Albasini, A., M. Krause, and I.V. Rembitzki, *Using whole body vibration in physical therapy and sport : clinical practice and treatment exercises*. 2010, Edinburgh ; New York: Churchill Livingstone/Elsevier. x, 202 p.
 14. Martin, B.J., J.P. Roll, and G.M. Gauthier, *Inhibitory effects of combined agonist and antagonist muscle vibration on H-reflex in man*. *Aviat Space Environ Med*, 1986. 57(7): p. 681-7.
 15. Bishop, B., *Vibratory stimulation. Part 1. Neurophysiology of motor responses worked by vibratory stimulation*. *Physical Therapy* 1974. 55(1): p. 7.
 16. Hagbarth, K.E. and G. Eklund, *Tonic vibration reflexes (TVR) in spasticity*. *Brain Res*, 1966. 2(2): p. 201-3.
 17. Lance, J.W., *The reflex effects of muscle vibration*. *Proc Aust Assoc Neurol*, 1966. 4: p. 49-56.
 18. Desmedt, J.E. and E. Godaux, *Mechanism of the vibration paradox: excitatory and inhibitory effects of tendon vibration on single soleus muscle motor units in man*. *J Physiol*, 1978. 285: p. 197-207.
 19. Ellis L., G.P., Lawrance S., Savage B., Buckeridge A., Stapff A., Tumilty D., Quinn A., Woolford S., Young W. , *Protocols for the physiological assessment of team sport players*, in *Physiological Tests for Elite Athletes*
 20. C.J. Gore, Editor. 2000, Human Kinetics Publ.: Champaign, IL. p. 128-144.
 21. Ronnestad, B.R., *Acute Effects of Various Whole-Body Vibration Frequencies on Lower-Body Power in Trained and Untrained Subjects*. *Journal of Strength and Conditioning Research*, 2009. 23(4): p. 1309-1315.
 22. Soyly, Ş., E. Gelen, and S. Yıldız, *The acute affect of vibration applications on jumping performance*. *International Journal of Human Sciences (Online)*, 2012. 9(2): p. 1684-1690.
 23. Gerodimos, V., et al., *The acute effects of different whole-body vibration amplitudes and frequencies on flexibility and vertical jumping performance*. *Journal of Science and Medicine in Sport*, 2010. 13(4): p. 438-443.
 24. Martinez, F., et al., *Effects of 6-week whole body vibration training on the reflex response of the ankle muscles: a randomized controlled trial*. *Int J Sports Phys Ther*, 2013. 8(1): p. 15-24.
 25. Sands, W.A., et al., *Flexibility enhancement with vibration: Acute and long-term*. *Medicine and Science in Sports and Exercise*, 2006. 38(4): p. 720-725.