ORIGINAL ARTICLE

Influence of vibration on delayed onset of muscle soreness following eccentric exercise

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Delayed onset muscle soreness (DOMS), which may occur after eccentric exercise, may cause some reduction in ability in sport activities. For this reason, several studies have been designed on preventing and controlling DOMS. As vibration training (VT) may improve muscle performance, we designed this study to investigate the effect of VT on controlling and preventing DOMS after eccentric exercise.

Methods: Fifty healthy non-athletic volunteers were assigned randomly into two experimental, VT (n = 25) and non-VT (n = 25) groups. A vibrator was used to apply 50 Hz vibration on the left and right quadriceps, hamstring and calf muscles for 1 min in the VT group, while no vibration was applied in the non-VT group. Then, both groups walked downhill on a 10° declined treadmill at a speed of 4 km/hour. The measurements included the isometric maximum voluntary contraction force (IMVC) of left and right quadriceps muscles, pressure pain threshold (PPT) 5, 10 and 15 cm above the patella and mid-line of the calf muscles of both lower limbs before and the day after treadmill walking. After 24 hours, the serum levels of creatine-kinase (CK), and DOMS level by visual analogue scale were measured.

Results: The results showed decreased IMVC force (P = 0.006), reduced PPT (P = 0.0001) and significantly increased mean of DOMS and CK levels in the non-VT group, compared to the VT group (P = 0.001).

Conclusion: A comparison by experimental groups indicates that VT before eccentric exercise may prevent and control DOMS. Further studies should be undertaken to ascertain the stability and effectiveness of VT in athletics.

The first detailed description of delayed onset muscle soreness (DOMS) was given by Hough in 1902.[1] DOMS is often precipitated predominantly by eccentric exercise, such as downhill running, plyometrics and resistance training. It has been explained[2 3] that the injury itself is a result of eccentric exercise causing damage to the muscle cell membrane, which sets off an inflammatory response. In other words, shocking the muscles during the eccentric range of motion is probably the leading factor in producing DOMS. It has been claimed that the type of force development during eccentric exercise may cause sarcoma disruption and consequently an inflammatory response within the muscle.[4–6] DOMS is typically experienced by all individuals regardless of fitness level, and is a normal physiological response to increased exertion and the introduction of unfamiliar physical activities.[7] The pain and discomfort associated with DOMS typically peaks 24–48 hours after an exercise bout, and resolves within 96 hours.[8] Generally, an increased perception of soreness occurs with greater intensity and a higher degree of unfamiliar activities.[9] Other factors that play a role in DOMS are muscle stiffness, contraction velocity, fatigue, and angle of contraction.[2] Due to the sensation of pain and discomfort, which can impair physical training and performance, prevention and treatment of DOMS is of great concern to coaches, trainers and therapists.[10] Although DOMS is experienced widely, science has not established a sound and consistent treatment for it.

Recent research has shown that vibration training (VT) may improve muscle performance.[11 12] By considering this mechanism, we designed this study to find out if VT before eccentric exercise may prevent DOMS by improving muscular strength and power development strategy,[13–17] improving kinesthetic awareness,[18] and providing insights into the effects of fatigue,[19 20] within the vibrated muscles.

MATERIALS AND METHODS

The study was approved by the ethical committee of Semnan University of Medical Sciences. Fifty healthy non-athletic volunteers (25 females, mean (SD) age 21.1 (0.2) years and 25 males mean (SD) age 20.1 (0.5) years) were assigned randomly into two experimental, VT and non-VT groups. Exclusion criteria included a history of cardiac and neuromuscular diseases, undertaking severe sport activity or having received an intramuscular injection during the last week.

A computer generated randomisation list was drawn up by the statistician for each group. It was given to the physiotherapy department in sealed numbered envelopes. When the subjects qualified to enter the study and had signed their informed consent forms, the appropriate numbered envelope was opened at the reception; the card inside indicated the subject's allocation to one of the VT or non-VT groups. This information was then given to the physiotherapist to administer the appropriate intervention.

Intervention

Both experimental groups walked downhill on a 10° declined treadmill at a speed of 4 km per hour for 30 min. In the VT group, a 50 Hz vibrator apparatus (model VR-7N, ITO, Tokyo, Japan) was used to apply vibration on the middle line of each of the left and right quadriceps, hamstring and calf muscles for 1 min before downhill treadmill walking, while the subjects in the non-VT group did not receive any vibration before downhill treadmill walking.

Measurements

Measurements were performed before and 24 h after treadmill walking and included isometric maximum voluntary contraction. The IMVC force of the left and right quadriceps muscles in 100° of knee flexion was measured in the sitting position. The subject was asked to sit on a back-supported quadriceps table and a load cell was connected to the distal end of her/his leg by means of a tight sling. The output of the load cell was connected to a digital monitor so it was possible to record and save the maximum tension on the load cell. After bringing to

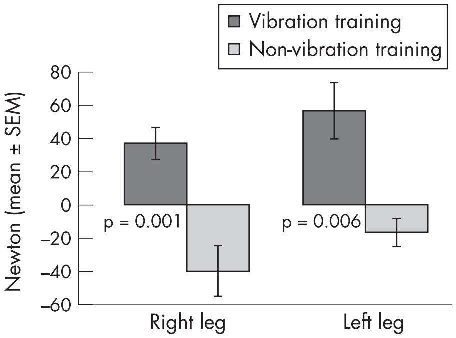

Figure 1 Mean change of maximum isometric voluntary contraction force of quadriceps.

zero the output of the load cell, the subject was encouraged to perform IMVC by pulling the sling tight as hard as she/he could, three times, with 30-second intervals between each pull. The best attempt was recorded and considered as the quadriceps IMVC force in newtons.

Pressure pain threshold (PPT) on the 5, 10 and 15 cm above the left and right patellae and also on the middle line of calf muscles was measured by a 20 ml syringe with a spring inside which was scaled from 0 to 10. The rounded tip of syringe was placed at the above points in a vertical position and the piston was pressed down. The subject was asked to announce any unpleasant sensation (pain), and then the indicating number on the syringe was recorded as the PPT.

The level of muscle soreness was evaluated by mean of a Visual Analogue Scale (VAS). The day after treadmill walking, the subject was asked to indicate her/his feel of the level of muscle soreness in each lower limb along a 10 cm line ranging from 0 (''no muscle soreness at all'') to 10 (''the most severe muscle soreness that I can imagine).

The serum level of creatine kinase (CK) was measured 24 hours after treadmill walking by taking 3 cc blood samples from the brachial artery in the front of the elbow and then the level of CK enzyme was measured in the laboratory.

Statistics
To compare the possible effect of VT on DOMS, an intention to treat analysis was used which involved all subjects who were randomly assigned to their group. Student's *t* tests were used to compare the mean changes in the IMVC force, PPT values and the mean of CK level and muscle soreness between the experimental groups.

RESULTS
Fifty healthy subjects were randomly assigned into two experimental VT (n = 25, 12 male and 13 female) and non-VT (n = 25, 13 male and 12 female,) groups and the study was then completed. The mean age was 20.6 (1.9) years (mean (SD)) for the VT group, and 20.6 (2.1) years (mean (SD)) for non-VT group, without any significant differences between the two groups.

Isometric maximum voluntary contraction force
A comparison of the mean change in the IMVC force in the right quadriceps showed a significantly higher decrease (P = 0.001) in the non-VT group (−39.6 (46.6) years, mean (SD)) compared with the VT group (37.2 (100.1) years, mean (SD)). This reduction was also seen in the left quadriceps (non-VT group −16.5 (77.6) years vs VT group 56.8 (100.9) years, P = 0.006), fig 1.

Pain pressure threshold
Table 1 shows the mean changes in PPT at 5, 10 and 15 cm above the right and left patella. Comparison of these values from non-VT and VT groups showed significant reduction of PPT in the non-VT group (P = 0.0001). The same significant reduction (P = 0.0001) of PPT was seen in the calf muscles of the non-VT group (right −1.1 (1.3) and left −1.3 (1.4)) compared with the VT group (right 0.4 (0.8) and left 0.4 (1.2)).

Level of muscle soreness
The comparison of mean level of muscle soreness recorded the day after treadmill walking showed higher soreness in the non-VT group (right 2.3 (1.9) and left 2.3 (2.1)) vs VT group (right 0.4 (1.1) and left 0.5 (1.1)). These differences were significant in both lower limbs (P = 0.0001), fig 2.

Level of CK enzyme
The higher mean of the CK enzyme was found in the non-VT group (195.2 (109.2)) compared with the VT group (116.1 (27.8)) which was statistically significant (P = 0.001), fig 3.

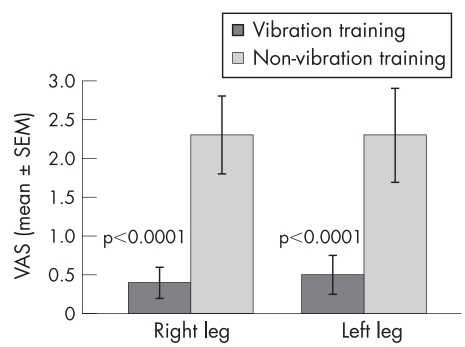

Figure 2 Mean change of delayed onset muscle soreness at 24 h after eccentric exercises.

Table 1 Mean changes in the pain pressure threshold of the right and left quadriceps at 5, 10 and 15 cm above the patella

	5 cm above patella		10 cm above patella		15 cm above patella	
	Right mean (SD)	Left mean (SD)	Right mean (SD)	Left mean (SD)	Right mean(SD)	Left mean (SD)
VT group	0.3 (1.5)	0.4 (1.1)	0.5 (1.3)	0.1 (1.1)	0.5 (0.8)	0.3 (0.7)
Non-VT group	−1.8 (1.3)	−1.6 (1.4)	−1.3 (1.0)	−1.2 (1.1)	−1.3 (0.9)	−1.1 (1.1)
p Value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

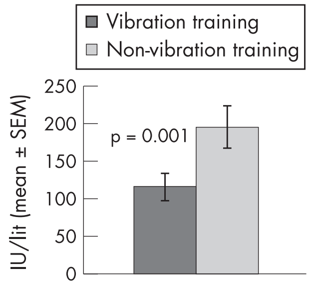

Figure 3 Mean serum level of creatine kinase enzyme at 24 h after eccentric exercise.

DISCUSSION

Delayed onset muscle soreness and reduced muscle strength after eccentric exercise[5 21] may decrease functional activities in athletics.[7 22] Because of this, different methods have been investigated and recommended to prevent these symptoms.[2] This study was designed to find the possible effects of VT to control and prevent DOMS after eccentric exercise.

A previous study showed muscle strength reduction after eccentric activities,[9] while our findings showed no muscle strength reduction in the IMVC force of quadriceps in the VT group, which may be due to the establishment of optimum neuromuscular function in the quadriceps muscles by applying VT. This has been reported by other researchers,[12 15] who showed better muscle performance after vibratory stimulation. Thompson and Belanger (2002) also showed that VT may increase muscle spindle activities and establish motor unit activity synchronisation that may optimise neuromuscular function.[23] By contrast, it has been shown that muscle spindle stimulation by vibration may increase the afferent activities of muscle spindles which may increase background tension in the vibrated muscles.[24 25] This increased background tension and motor unit activity synchronisation in the vibrated muscle may prevent sarcoma disruption or damage to excitation–contraction coupling, which may happen due to tension development during eccentric exercise.[4] Therefore, this optimised muscle performance may control and prevent muscle damage and so reduce DOMS. This reduction in DOMS was seen in our study, as we found increased PPT in the right and left quadriceps and calf muscles, lower muscle soreness, and lower levels of CK enzyme in the VT group compared with the non-VT group.

The CK enzyme has been defined as an index for muscle damage and its level will be increased within 24 to 48 hours after eccentric activities,[5 22] which is a sign of eccentric muscle damage. However this increase was seen only in the non-VT group, and not in the VT group. In fact, the lower CK level in the VT group may indicate lower muscle damage in this group, while the non-VT group showed a higher CK level and so higher muscle damage, which was accompanied by higher muscle soreness.

These findings may indicate that vibration training before eccentric exercise may help the muscles to build up a background tension and optimal neuromuscular activity to overcome the increased passive tension within the exercised muscles during eccentric activities. Thus, vibration training could be used before eccentric activities to control and prevent delayed onset muscle soreness and it might be a useful method for athletes to prevent any DOMS in their sports activities.

CONCLUSION

DOMS is a major complication faced by athletes after eccentric activities, which may compel them to postpone their sports activities, thus prevention and treatment of DOMS is of great concern to coaches, trainers, and therapists. In this study, we investigated the effect of vibration on muscle before downhill treadmill walking and our results showed that applying vibration before eccentric activities may prevent DOMS and so it may help non-athletic people to follow and complete their sport activities without any delay. Further studies are needed to investigate these results to find the possible application in athletics.

What is already known on this topic?

Delayed Onset Muscle Soreness (DOMS) is one of the complications that has been most reported by athletes after severe exercise. Several methods have been applied to prevent DOMS but it is still a matter of recent study. By contrast, vibration training (VT) has been used recently as a useful method to increase muscle performance. By considering these findings, we propose that applying VT before eccentric exercise may improve muscle performance and thus prevent DOMS.

What this study adds?

Our findings show that VT may improve muscle performance and thus prevent DOMS by prevention of sarcoma disruption, which is caused by high tension development during eccentric exercises.

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Competing interests: None declared

REFERENCES

1 **Hough T**. Ergographic studies in muscular soreness. *Am J Physiol* 1902;**7**:76–92.
2 **Connolly DAJ**, Sayers SP, McHugh MP. Treatment and prevention of delayed onset muscle soreness. *J Strength Cond Res* 2003;**17**:197–8.
3 **Dierking, Jenny K, Bemben, et al**. Delayed Onset Muscle Soreness. *Strength and Conditioning* 1998;**20**:44–50.
4 **McHugh MP**, Connolly J, Eston RG, *et al.* Exercise induced muscle damage and potential mechanisms for the repeated bout effect. *Sports Med* 1999;**27**:158–70.
5 **Nosaka K**, Clarkson PM. Changes in indicators of inflammation after eccentric Exercise of the elbow flexors. *Med Sci Sports Exs* 1996;**28**:953–61.
6 **Nosaka K**, Newton M. Repeated eccentric exercise bouts do not exacerbate muscle damage and repair. *J Strength Cond Res* 2002;**16**:117–22.
7 **Smith LL**, Fulmer MG, Holbert MR, *et al.* The impact of a repeated bout of eccentric exercise on muscular strength, muscle soreness and creatine kinase. *Br J Sports Med* 1994;**28**:267–71.
8 **Smith LL**. Acute inflammation: The underlying mechanism in delayed onset muscle soreness. *Med Sci Sports Exerc* 1991;**23**:542–51.
9 **Cleak MJ**, Eston RG. Muscle soreness, swelling, stiffness and strength loss after intense eccentric exercise. *Br J Sports Med* 1992;**26**:267–72.
10 **Szymanski DJ**. Recommendations for the avoidance of delayed-onset muscle soreness. *J Strength Cond Res* 2001;**23**:7–13.
11 **Ivanenko YP**, Grasso R, Iacquaniti F. Influence of leg muscle vibrationon human walking. *J Neurophysiol* 2000;**84**:1737–47.
12 **Bosco C**, Cardinal M, Tsarpela O. Influence of vibration on mechanical power and electromyogram activity in human arm flexor muscles. *Eur J Appl Physiol* 1999;**79**:306–11.

13 **Johnston RM**, Bishop B, Coffey GH. Mechanical vibration of skeletal muscles. *Physical Therapy* 1970;**50**:499–505.
14 **Samuelson B**, Jorfeldt L, Ahlborg B. Influence of vibration on endurance of maximal isometric contraction. *Clinical Physiology* 1989;**9**:21–5.
15 **Issurin VB**, Liebermann DG, Tenenbaum G. Effect of vibratory stimulation training on maximal force and flexibility. *J Sports Sci* 1994;**12**:561–6.
16 **Issurin VB**, Tenenbaum G. Acute and residual effects of vibratory stimulation on explosive strength in elite and amateur athletes. *J Sports Sci* 1999;**17**:177–82.
17 **Warman G**, Humphries B, Purton J. The effects of timing and application of vibration on muscular contractions. *Aviat Space Environ Med* 2002;**73**:119–27.
18 **Burke JR**, Schutten MC, Koceja DM, *et al.* Age-dependent effects of muscle vibration and the Jendrassik maneuver on the patellar tendon reflex response. *Arch Phys Med Rehabil* 1966;**77**:600–4.
19 **Herzog W**, Zhang Y, Vaz M, *et al.* Assessment of muscular fatigue using vibromyography. *Muscle and Nerve* 1994;**17**:1156–61.
20 **Gabriel DA**, Basford JR, Kai-Nan A. Vibratory facilitation of strength in fatigued muscle. *Arch Phys Med Rehabil* 2002;**83**:1202–5.
21 **Allen DG**. Eccentric muscle damage: Mechanisms of early reduction of force. *Acta Physiol Scand* 2001;**71**:311–9.
22 **Smith LL**. Causes of delayed onset muscle soreness and the impact on athletic performance: a review. *J Appl Sport Sci Res* 1992;**6**:135–41.
23 **Thompson C**, Belanger M. Effects of vibration in inline skating on the Hoffmann reflex, force, and proprioception. *Med Sci Sports Exerc* 2002;**34**:2037–44.
24 **Ren JC**, Fan XL, Song XA, *et al.* Influence of 100 Hz sinusoidal vibration on muscle spindle afferents of soleus muscles in suspended situation rat. *Space Med Eng* 2004;**17**:340–4.
25 **Shinohara M**, Moritz CT, Pascoe MA, *et al.* Prolonged muscle vibration increases stretch reflex amplitude, motor unit discharge rate, and force fluctuations in a hand muscle. *J Appl Physiol* 2005;**99**:1835–42.

COMMENTARY

This study investigated the effect of vibration training on preventing and controlling delayed onset of muscle soreness. The author has measured the isometric force of knee extensor muscles, pain threshold pressure, delayed onset of muscle soreness (DOMS) level and creatine kinase enzyme to compare two experimental and control groups. The results showed lower values of isometric force and pain pressure threshold and higher values of DOMS level and creatine kinase enzyme in a non-vibration training group (control group). The authors suggest that the use of vibration training before eccentric exercise can prevent and control DOMS. The authors base their study on the observation that in previous studies, the use of vibration training would establish an optimum neuromuscular function in the quadriceps muscle via muscle spindle stimulation. They stated that this function of vibration may prevent sarcoma disruptions of the muscle. In fact, this is the major point of this study, by which one can prevent a major complication of athletes after eccentric muscle contraction.

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ECHO

Cognition is best yardstick of fitness after concussion

Please visit the *British Journal of Sports Medicine* website [www.bjsportmed.com] for a link to the full text of this article.

Concussed athletes must wait until cognitive function returns to normal before resuming their sport, researchers are urging, after prospectively comparing performance of Australian rules footballers with and without symptoms days after their initial injury. Waiting until symptoms resolve, as currently recommended, is not enough, they say.

Footballers showed significantly reduced performance in motor function and divided attention on computerised tests if they still had even minimal symptoms at the time of testing. Performance dipped only for divided attention if the footballers had no symptoms; their cognitive function equalled that at baseline and that of uninjured control players. On pencil and paper neuropsychological tests footballers with symptoms performed as well as at baseline but did not show the significant improvements evident in those without symptoms and the controls. Footballers with symptoms took longer to return to sport, and it seemed that symptoms at injury, symptom resolution, cognitive performance, and time before resuming training and competition may turn out to be interrelated.

The prospective study was performed on 615 footballers, all of whom completed cognitive and neuropsychological tests at the start to the season. Those footballers concussed during the season, 25 with symptoms and 36 without, were retested up to 11 days after their injury, and the controls were tested at the end of the season.

This study is one of the few to test the assumption that lack of symptoms after concussion indicates a return to full mental fitness and cognitive functioning.

▲ Collie A, *et al. Journal of Neurology Neurosurgery, and Psychiatry* 2006;**77**:241–245.