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EFFECTS OF VIBRATION TRAINING ON MUSCLE RECOVERY AND EXERCISE INDUCED SORENESS: A SYSTEMATIC REVIEW

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Abstract

Objective: The positive effects of vibration training (VT) on improving strength and muscle performance have been widely documented. However, its ability to diminish the effects of Delayed Onset Muscle Soreness (DOMS) and initiate muscle recovery has not been thoroughly correlated. **Data Sources:** Systematic literature searches for randomized controlled trials between 2009-2014 were performed in the databases of: SOLAR (CSS Library), CINAHL and PubMed between July15 to July 26, 2014. **Study Selection and Data Extraction:** Five randomized controlled trials conducted with a total of 163 subjects supported moderate evidence with the use of VT to diminish DOMS. **Data Synthesis and Conclusions:** The studies presented moderate evidence for the use of VT in muscle recovery parameters of: power, explosive muscle ability, return of strength, and maximal voluntary isometric contraction as well as ROM. This review found no evidence for the effects of VT on limb circumference. Vibration Training (VT), when compared to other exercises such as a standard sport cool down or treadmill walking, had no significant difference on the return of muscle function as measured in terms of strength and power. The same studies, however, showed that VT led to significantly faster recovery time compared to the control (no intervention) group.

Keywords: Delayed onset muscle soreness, muscle recovery, vibration training

Introduction

When the German National Football Team won the 2014 World Cup for football in dominating fashion, photos of the athletes utilizing vibration platform technology during their training surfaced, causing a stir in the sports and rehabilitation community. Their preparation and recovery techniques have even brought media attention to German sports science programs (Duff, 2014). The technology of vibration training (VT) has been in existence for a few years, finding its way into the training rooms of elite basketball, American football, and baseball teams as well as top tennis and mixed martial arts athletes. In spite of this, fewer than a dozen articles on its performance effects have been written, and even less research on the technology's ability to enhance muscle recovery and diminish the effects of delayed onset muscle soreness (DOMS) has come under scrutiny.

The predominant reason for the use of vibration for training and performance has been based on the theory that increased strength can be achieved in a short time frame (Cardinale & Bosco, 2003). This muscle performance benefit may also be extended to people with functional disabilities. Double blind randomized trials have shown VT rehabilitation benefits for patients with multiple sclerosis (Schuhfried, Mittermaier, Jovanovic, Pieber, & Paternostro-Sluga, 2005), cerebral palsy (Ahlborg, Andersson, & Julin, 2006), and osteogenesis imperfecta (Semler, et al., 2008) among others.

A phenomenon that causes reduced muscle strength especially after eccentric exercise is delayed onset muscle soreness (DOMS) (Allen, 2001). DOMS has also been found to decrease performance and functional abilities in athletics (Smith, 1992). Recovery strategies for DOMS and muscle recovery have captured the attention of scientists, coaches, and athletes in recent years. Given that muscle pain or impaired muscle function negatively affect the quality of training sessions and therefore subsequent adaptations, enhancing recovery from soreness is vital to long term training and performance (Marin et al., 2012). Different methods have been investigated and recommended to prevent these symptoms. This study was designed to find the possible effects of Vibration Training (VT) on muscle recovery and to control and prevent DOMS after exercise. With the emerging acceptance of vibration training as a therapeutic modality, its ability to enhance or hasten the recovery process from traditional therapeutic exercise regimens must be evaluated for both applicability and efficacy.

The objective of this study is to perform a systematic review of existing studies reporting the effects of vibration training on muscle recovery, as well as the phenomenon of Delayed Onset Muscle Soreness usually attributed to the eccentric component of exercise. Literature and evidence search was performed on the databases of SOLAR (CSS library), CINAHL and PubMed between July 15 to 26, 2014. Cochrane Collaboration Reviews yielded no results, while the PEDro Database showed similar results in an initial search. Cross-referencing applicable articles were performed to locate additional articles. Language was limited to articles originally written in English. Keywords utilized in the search included “Delayed Onset Muscle Soreness”, “muscle recovery”, and “vibration training”.

Methods

During the database search, all article titles were reviewed and nine relevant titles were printed. Abstracts for relevant titles were read. Five studies were randomized controlled trials that were determined eligible for this review. Three articles had full online versions and PDF files were downloaded. Two articles were requested through an interlibrary loan and upon receipt, PDF files were downloaded as well. Methodological quality of the studies was rated using the Physiotherapy Evidence Database (PEDro) Scale (see Table 1). The PEDro scale is a valid measure of the methodological quality of clinical trials (de Morton, 2009). Original PEDro ordinal scores were highly correlated with transformed PEDro interval scores ($r = 0.99$) (de Morton, 2009). The PEDro scale breaks down the levels of blinding and accounts for concealed allocation, intention-to-treat, and attrition providing a more comprehensive measure of methodological quality in the analysis of interventions where double-blinding studies are often not possible due to the nature of the interventions (Bhogal, Teasel, Foley, & Speechley, 2005). **Inclusion and Exclusion Criteria**: Of all nine studies from the database search, only randomized controlled trials were reviewed. All researches graded ‘good’ (6-8 points on the PEDro scale) to ‘excellent’ (9-11 points on the PEDro scale) were included in the study. RCT’s graded ‘fair’ (4-5 points) and below were excluded due to the lower methodological quality. Only studies conducted between 2009 and 2014 were included, in order to incorporate the prevalent and more recent technological models of whole body vibration equipment.

Table 1: PEDro Scale (http://www.pedro.org.au/english/downloads/pedro-scale/)

PEDro scale

1. eligibility criteria were specified	no ❑ yes ❑ where:
2. subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	no ❑ yes ❑ where:
3. allocation was concealed	no ❑ yes ❑ where:
4. the groups were similar at baseline regarding the most important prognostic indicators	no ❑ yes ❑ where:
5. there was blinding of all subjects	no ❑ yes ❑ where:
6. there was blinding of all therapists who administered the therapy	no ❑ yes ❑ where:
7. there was blinding of all assessors who measured at least one key outcome	no ❑ yes ❑ where:
8. measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	no ❑ yes ❑ where:
9. all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat"	no ❑ yes ❑ where:
10. the results of between-group statistical comparisons are reported for at least one key outcome	no ❑ yes ❑ where:
11. the study provides both point measures and measures of variability for at least one key outcome	no ❑ yes ❑ where:

The PEDro scale is based on the Delphi list developed by Verhagen and colleagues at the Department of Epidemiology, University of Maastricht (*Verhagen AP et al (1998). The Delphi list: a criteria list for quality assessment of randomised clinical trials for conducting systematic reviews developed by Delphi consensus. Journal of Clinical Epidemiology, 51(12):1235-41*). The list is based on "expert consensus" not, for the most part, on empirical data. Two additional items not on the Delphi list (PEDro scale items 8 and 10) have been included in the PEDro scale. As more empirical data comes to hand it may become possible to "weight" scale items so that the PEDro score reflects the importance of individual scale items.

The purpose of the PEDro scale is to help the users of the PEDro database rapidly identify which of the known or suspected randomised clinical trials (ie RCTs or CCTs) archived on the PEDro database are likely to be internally valid (criteria 2-9), and could have sufficient statistical information to make their results interpretable (criteria 10-11). An additional criterion (criterion 1) that relates to the external validity (or "generalisability" or "applicability" of the trial) has been retained so that the Delphi list is complete, but this criterion will not be used to calculate the PEDro score reported on the PEDro web site.

The PEDro scale should not be used as a measure of the "validity" of a study's conclusions. In particular, we caution users of the PEDro scale that studies which show significant treatment effects and which score highly on the PEDro scale do not necessarily provide evidence that the treatment is clinically useful. Additional considerations include whether the treatment effect was big enough to be clinically worthwhile, whether the positive effects of the treatment outweigh its negative effects, and the cost-effectiveness of the treatment. The scale should not be used to compare the "quality" of trials performed in different areas of therapy, primarily because it is not possible to satisfy all scale items in some areas of physiotherapy practice.

Last amended June 21st, 1999

Results

Nine studies were found and only randomized controlled trials were assessed. After application of the inclusion and exclusion criteria and the administration of the PEDro scale, five studies met the standards for higher methodological quality (see Table 2).

Table 2: Overview of the results from PEDro Scale Rating

Authors	PEDro Scale 1 2 3 4 5 6 7 8 9 10	Raw Score	Quality Rating
Whole Body vibration			
Aminian-Far et al. (2011)	Y Y N Y N N X Y Y Y N	6	Good
Marin et al. (2012)	Y Y N Y N N X Y Y Y Y	7	Good
Wheeler & Jacobson (2013)	Y Y N Y N N X Y Y Y Y	7	Good
Isolated Vibration			
Imtiyaz et al. (2014)	Y Y N Y N N X Y Y Y Y	7	Good
Koh et al. (2013)	N Y N Y N N X Y Y Y Y	6	Good

Y= yes, N= no, X= no information

Effects of Vibration Training on DOMS

Five of five studies showed statistically significant advantages with the effects of Vibration Training on DOMS and muscle recovery (see Table 3).

DOMS and Perceived Pain

Vibration Training had statistically less perceived pain and DOMS in three of three studies. 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 (Shinohara, Moritz, & Pascoe, 2005). This increased background tension and motor unit activity synchronization in the vibrated muscle may prevent sarcoma disruption or damage to excitation–contraction coupling, which may happen due to tension development during eccentric exercise (McHugh, Connolly, & Eston, 1999). Such optimized muscle performance may control and prevent muscle damage and so reduce DOMS (Bakhtiary, Safavi-Farokhi, & Aminian-Far, 2007), as evidenced by these results.

Serum CK and LDH levels

Tests of blood markers for DOMS revealed that Serum CK and Lactate Dehydrogenase levels were lower when VT was utilized as opposed to the control group in two out of two studies, while lower LDH levels were found in one out of one study. The Creatine Kinase enzyme has been defined as an index for muscle damage and its level will be increased within 24 to 48 hours after eccentric activities (Nosaka & Clarkson, 1996) which is a sign of eccentric muscle damage. However, this increase was seen only in the control group, and not in the Vibration Training 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 therefore higher muscle damage, which was also accompanied by higher muscle soreness (Bakhtiary et al., 2007). Vibration therapy also leads to an increase in skin temperature and blood flow (Friden, 1994), leading to decreased accumulation of lactate in the blood.

Effects of Vibration Training on Muscle Recovery

Vibration Cool Down vs Exercise Cool Down

In studies in which Vibration Training (VT) is compared with an exercise such as a standard cool down or treadmill walking with the goal of muscle recovery, VT showed no significant difference with the exercise group for muscle recovery but showed statistically significant faster recovery compared to the control (no intervention) group.

Explosive Ability and Power Recovery

In tests of explosive ability and power recovery, two out of four tests for power revealed that VT demonstrated statistically significantly faster recovery time than the control group.

Maximal Isometric Contraction Recovery

Vibration Training had significantly significant faster recovery time in two of three studies for return of maximal isometric contraction ability. One test compared with exercise cool down had no significant difference from Vibration Training. The positive effects of whole-body vibration on perceived muscle pain and countermovement jump shown by these data could be dependent on vascular and neurophysiological mechanisms. Enhanced local blood flow immediately after a vibration stimulus (Kerschan-Schindl, et al., 2001) is one of the factors expected to result in a decrease in perceived muscle pain and an increase in countermovement jump ability. This increase in local blood flow generates additional heat and thereby initiates a healing response within the tissues. Another prediction may be the proprioceptive feedback potentiation of inhibition of pain. This mechanism increases the pain threshold (Hansson & Ekblom, 1986). The reason why whole-body vibration aided countermovement jump performance but not MVIC is speculative at best, however, it may be related to different test procedures and mechanics. Further research is needed to identify the physiological mechanism(s) by which whole-body vibration may result in decreased perceived muscle pain (Marin et al., 2012).

Range of Motion

In the recovery of muscle range of motion after exercise, one out of two tests reports that VT had a statistically significantly faster return of ROM. Research has shown that vibration therapy increases range of motion (Jacobs & Burns, 2009) as well as decreasing tendon and aponeurosis stiffness (Furlong & Harrison, 2010). This flexibility and range of motion effect, however, may be diminished by the presence of soreness due to eccentric exercise (Wheeler & Jacobson, 2013).

Thigh Circumference

Aminian-Far, Hadian, Olyaei, Talebian, and Bakhtiary (2011) found that Vibration Training had no effect on thigh circumference during muscle recovery.

Table 3: Overview of Randomized Controlled Trials on Vibration Effects on Muscle Recovery and Exercise Induced Soreness

Authors	Subject Demographic	Control Group	Experimental Group	Outcome Measures	Results (all studies set p at <0.05)
Whole Body Vibration					
Aminian-Far et al. (2011)	22 healthy females 10 healthy males 21.46±2.66 yrs. (WBV) 21.88±1.93 yrs. (Control)	No Intervention (CG)	Whole Body Vibration (VG) 60 seconds	Perceived Pain/Soreness Isokinetic Muscle Strength Pressure Pain Threshold Serum Creatine Kinase Thigh Circumference	VG<CG all intervals VG>CG* VG>CG 24, 48,72,96, no diff 336h VG<CG 24, 48h, no diff by 168h No sig diff across all timeframes
Marin et al. (2012)	16 healthy males Age 17.1±0.9 yrs.	Exercise Traditional Cool Down (EG)	Whole Body Vibration (VG) 2 min. 15 sec.	Perceived Pain Repeated Sprint Ability Countermovement Jump Leg Extension Maximal Voluntary Isometric Contraction (MVIC)	VG<EG,VG no sig diff from pretest VG no sig diff from EG VG faster recovery vs EG, full 24h VG no sig diff from EG
Wheeler & Jacobson (2013)	10 healthy college age females 10 healthy college age males 20.85±1.81 yrs.	Walking on Treadmill (EG) for 10 mins	Whole Body Vibration (VG) 10 minutes	Perceived Pain Hamstring and low back flexibility Explosive Power (Vertical Jump)	VG less DOMS than EG over 5d** No sig diff bet VG and EG No sig diff bet VG and EG
Isolated Vibration					
Imtiyaz et al. (2014)	45 healthy non athletic females (no age mentioned)	No Therapy (CG)	Massage Group (MG) 15 mins Vibration Group (VG) 5mins	Perceived Pain Range of Motion 1 RM Serum Creatine Kinase Lactate Dehydrogenase Maximal Isometric Force (MIF)	VG < MG <CG VG and MG =CG 24h,> CG 48-72h VG > MG > CG VG and MG < CG VG < CG VG and MG>CG 48-72h, = CG 24h
Koh, et al., (2013)	30 healthy males 30 healthy females 21.72 ± 2.16 yrs.	No Therapy (CG)	Ultrasound (UG) 10 mins Vibration (VG) 10 mins	Maximal Voluntary Isometric Contraction (MVIC)	VG > CG 72h VG had no significant difference with UG 72h

* Maximal isometric torque was larger at the 15° knee angle (27.3 ± 2.3 Nm) than at other angles before exercise and throughout the measurements; however, the magnitude of decrease in torque post exercise was similar among the 4 angles. A decrease was seen in maximal isometric torque for the control group at all angles in all sessions. In the control group, the torque decreased immediately post exercise by 42.70% below baseline, compared with a 7.50% decrease in the WBVT group. This trend was shown in the control group at 24 hours (by 51.75%) and 48 hours (by 55.44%), whereas decreases of 12.21% and 13.45% were demonstrated at 24 and 48 hours, respectively, in the WBVT group. By day 14, a mean percentage decrease of 22.22% was still evident in the control group, compared with a 2.28% decrease in the WBVT group ($P < .0001$). No time effect was found in maximal isokinetic torque at 60°/s between baseline and any other sessions (immediately after or 1, 2, 7, or 14 days post exercise) in the WBVT group over time ($P = .999$, $P = .167$, $P = .211$, $P = .183$, and $P = .999$, respectively). Maximal isokinetic torque at 60°/s changed over time within the control group ($P < .001$), decreasing by 42.53% below baseline immediately post exercise and by 49.02% and 52.88% at 24 and 48 hours, respectively. Between-groups comparisons of maximal isokinetic torque showed a decrease in the control group compared with the WBVT group.

**Both groups responded similarly to the DOMS induction and that DOMS dissipated at approximately the same rate for both groups. No significant ($p>0.05$) within-group DOMS differences were found for either the WBV or walking group and no significant between-group difference were found when comparing pretest and post test groups.

Discussion

For the purpose of discussion, evidence correlating purported effects for an outcome measure will be evaluated through qualitative and quantitative descriptors of: strong evidence (agreement of between 75-100% of the studies), moderate evidence (agreement between 50-74% of the studies), weak evidence (agreement between 25-49% of the studies), minimal evidence (agreement between 1%-24% of the studies), and no evidence (0% of studies). The results from this systematic review show that there is strong evidence (100%) that long-term whole-body vibration exercise reduces the effects of Delayed Onset Muscle Soreness (DOMS) in terms of pain perception, pain threshold and tenderness. There is also strong evidence for reduced serum Creatine Kinase reduction (100%) and Lactate Dehydrogenase production (100%), both of which are blood markers for the phenomenon of DOMS (Imtiyaz, Veqar, & Shareef, 2014).

In the return of power and explosive muscle ability as a means of measuring muscle recovery, there is moderate evidence (50%) that vibration training can aid in the return of performance. Evidence also showed moderate evidence (66%) in the ability of vibration training to facilitate early return of maximal voluntary isometric contraction. Moderate evidence (50%) exists for the faster return of ROM with the use of vibration training. The study by Aminian-Far et al. (2011) showed VT had no effect on limb circumference.

Vibration Training (VT), when compared to traditional exercises such as a standard sport cool down or treadmill walking, had no significant difference when measuring return of muscle function in terms of strength and power. The same studies however, showed VT had statistically significant faster recovery compared to the control (no intervention) group.

Recommendations

The findings of this systematic review support the use of vibration training (VT) as a tool to help diminish and decrease the effects of Delayed Onset Muscle Soreness (DOMS) from exercise. Evidence averaging 6.6 points as appraised on the PEDro scale show that Vibration Training might be beneficial for the muscle recovery components of power, explosive ability and maximal voluntary contraction.

Neuromusculoskeletal patients already undergoing therapeutic exercise, stroke and cancer patients engaged in therapeutic activities, athletes looking to improve recovery times, and clients looking for increased compliance with exercise programs but experience muscle pain and soreness may all benefit with the introduction of vibration training as a cool down tool or as a platform on which the whole protocol/program can be performed. The results of this systematic review of higher methodological quality studies revealed that muscle recovery with the use of VT is superior to no cool down. Further studies exploring DOMS and muscle recovery effects with the use of VT for the entire exercise protocol is recommended as this will further reduce treatment time spent for the cool down and recovery phase while yielding the same benefits. Also, additional research on determining shorter duration VT (less than or equal to 5 minutes) against 10-15 minute traditional cool downs will also offer valuable data not just for elite athletes looking to accelerate performance, but also for patients with overtraining and overuse injuries.

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