Whole Body Vibration

Summary of Research

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Balance and Proprioception

High-Frequency Whole-Body Vibration Improves Balancing Ability in Elderly Women

Cheung WH, Mok HW, Qin L, Sze PC, Lee KM, Leung KS. Department of Orthopaedics and Traumatology, Chinese University of Hong Kong, Shatin, Hong Kong SAR, China.

Objective: To investigate the efficacy of high-frequency whole-body vibration (WBV) on balancing ability in elderly women.
Design: Randomized controlled trial. Subjects were randomized to either the WBV intervention or the no-treatment control group.
Setting: Community-living elderly women.
Participants: Sixty-nine elderly women aged 60 or above without habitual exercise.
Intervention: Side alternating WBV at 20Hz with 3 minutes a day and 3 days a week for 3 months in the WBV intervention group. Those in control group remained sedentary with normal daily life for the whole study period.
Main Outcome Measures: Limits of stability in terms of reaction time, movement velocity, directional control, endpoint excursion, maximum excursion, and the functional reach test were performed at baseline and endpoint.
Results: Significant enhancement of stability was detected in movement velocity (P<.01), maximum point excursion (P<.01), in directional control (P<.05).
Conclusions: WBV was effective in improving the balancing ability in elderly women. This also provides evidence to support our user-friendly WBV treatment protocol of 3 minutes a day for the elderly to maintain their balancing ability and reduce risks of fall.

Cheung W.H., Mok H.W., Qin L., Sze P.C., Lee K.M. & Leung K.S. (2007). High-frequency whole-body vibration improves balancing ability in elderly women. Archives of Physical Medicine and Rehabilitation. 88(7). 852-857.

Controlled Whole Body Vibration to Decrease Fall Risk and Improve Health-Related Quality of Life of Nursing Home Residents

Bruyere O, Wuidart MA, Di Palma E, Gourlay M, Ethgen O, Richy F, Reginster JY. WHO Collaborating Center for Public Health Aspects of Osteoarticular Disorders, Liège, Belgium.

Objective: To investigate the effects of whole body vibration in the elderly. **Design**: Randomized controlled trial. **Setting:** Nursing home. **Participants**: Forty-two elderly volunteers. **Interventions**: Six-week vibration intervention plus physical therapy (PT) (n=22) or PT alone (n=20). **Main Outcome Measures:** We assessed gait and body balance using the Tinetti test (maximum scores of 12 for gait, 16 for body balance, 28 for global score), motor capacity using the Timed Up & Go (TUG) test, and health-related quality of life (HRQOL) using the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36). **Results**: After 6 weeks, the vibration intervention group improved by a mean +/- standard deviation of 2.4+/-2.3 points on the gait score compared with no score change in the control group (P <.001). The intervention group improved by 3.5+/-2.1 points on the body balance score compared with a decrease of 0.3+/-1.2 points in the control group (P <.001). TUG test time decreased by 11.0+/-8.6 seconds in the treated group compared with an increase of 2.6+/-8.8 seconds in the control group (P <.001). The intervention group had significantly greater improvements from baseline on 8 of 9

items on the SF-36 compared with the control group. **Conclusions**: Controlled whole body vibration can improve elements of fall risk and HRQOL in elderly patients.

Bruyere O., Wuidart M.A., Di Palma E., Gourlay M., Ethgen O., Richy F. & Reginster J.Y. (2005). Controlled whole body vibration to decrease fall risk and improve health-related quality of life of nursing home residents. Archives of Physical Medicine and Rehabilitation. 86(2). 303-307.

Balance Training and Exercise in Geriatric Patients

Runge M, Rehfeld G, Resnicek E. Aerpah-Klinik Esslingen, Germany.

Objective measures of gait and balance which meet the criteria of reliability and validity are required as a basis for exercise regimens. We established reference values of clinically relevant locomotor and balance performances for geriatric patients. We are using these data for evaluating the effects of different therapeutic approaches to locomotor and balance disorders. Reference values for chair rising. We administered a battery of five tests concerning neuromuscular function, locomotion and balance to a sample of 212 participants without apparent locomotor deficits (139 women, 73 men, mean age 70,5 years, SD 6,78 , median 70 years, range 60 to 90 years, recruited by public announcements). The test battery comprised the 'chair rising test' for measuring lower extremity neuromuscular function (five repetitions of rising from a chair as quickly as possible with arms crossed over the chest). The test has been proven reliable, valid, sensible and predictive for falls and future locomotor status and ADL-status. Chair rising [sec/5x], Range: 5.4-19.4, Mean: 9.1 (women:9.2, men:9.0), SD: 1.97, Median: 8.9. Training of balance and muscle power with Galileo 2000 - preliminary results. Galileo is a device for whole body vibration/oscillatory muscle stimulation. The subject stands with bended knees and hips on a rocking platform with a sagittal axle, which thrusts alternatively the right and left leg 7-14 mm upwards with a frequency of 27 Hz, thereby lengthening the extensor muscles of the lower extremities. The reflexive reaction of the neuromuscular system is a chain of rapid muscle contractions. We conducted a randomized controlled trial, n=34 (age: mean 67y, range 61-85, 11 female), cross-over design, intervention group 2 months training program three times a week (each session 3x2 minutes), performance tests of all participants every two weeks). The first 19 subjects have finished the intervention period. They reached mean performance gains in chair rising of 18%, strikingly different to the constant values of the controls! We interpret the findings as improvements in muscle power by the oscillative muscle stimulation.

Runge M., Rehfeld G. & Resnicek E. (2000). Balance training and exercise in geriatric patients. Journal of Musculoskeletal and Neuronal Interactions. 1(1). 61-65.

The Feasibility of Whole Body Vibration in Institutionalized Elderly Persons and its Influence on Muscle Performance, Balance and Mobility: A Randomized Controlled Trial

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Background: Fatigue or lack of interest can reduce the feasibility of intensive physical exercise in nursing home residents. Low-volume exercise interventions with similar training effects might be an alternative. The aim of this

randomized controlled trial was to investigate the feasibility of Whole Body Vibration (WBV) in institutionalized elderly, and its impact on functional capacity and muscle performance. **Methods:** Twenty-four nursing home residents (15 female, 9 male; mean age 77.5 +/- 11.0 years) were randomized (stratification for age, gender and ADL-category) to 6 weeks static WBV exercise (WBV+, N = 13) or control (only static exercise; N = 11). Outcome measures were exercise compliance, timed up-and-go, Tinetti-test, back scratch, chair sit-and-reach, handgrip strength and linear isokinetic leg extension. **Results:** At baseline, WBV+ and control groups were similar for all outcome variables. Twenty-one participants completed the program and attended respectively 96% and 86% of the exercise sessions for the WBV+ and control groups. Training-induced changes in timed up-and-go and Tinetti-test were better for WBV+ compared to control ($p = 0.029$ for timed up-and-go, $p = 0.001$ and $p = 0.002$ for Tinetti body balance and total score respectively). In an alternative analysis (Worst Rank Score & Last Observation Carried Forward) the differences in change remained significant on the Tinetti body balance and total score. No other significant differences in change between both groups were observed.
Conclusion: In nursing home residents with limited functional dependency, six weeks static WBV exercise is feasible, and is beneficial for balance and mobility. The supplementary benefit of WBV on muscle performance compared to classic exercise remains to be explored further.

Bautmans I.,Van Hees E., Lemper J.C. & Mets T. (2005). The feasibility of whole body vibration in institutionalized elderly persons and its influence on muscle performance, balance and mobility: a randomized controlled trial. BMC Geriatrics. 22;5:17.

Effects of Whole Body Vibration Training on Postural Control in Older Individuals: A 1 Year Randomized Controlled Trial

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This randomized controlled trial investigated the effects of a 12 month whole body vibration training program on postural control in healthy older adults. Two hundred and twenty people were randomly assigned to a whole body vibration group (n=94), a fitness group (n=60) or a control group (n=66). The whole body vibration and fitness groups trained three times a week for 1 year. The vibration group performed exercises on a vibration platform and the fitness group performed cardiovascular, strength, balance and stretching exercises. Balance was measured using dynamic computerized posturography at baseline and after 6 and 12 months. Whole body vibration training was associated with reduced falls frequency on a moving platform when vision was disturbed and improvements in the response to toes down rotations at the ankle induced by the moving platform. The fitness group showed reduced falls frequency on the moving surface when vision was disturbed. Thus, whole body vibration training may improve some aspects of postural control in community dwelling older individuals.

Bogaerts A, Verschueren S., Delecluse C., Claessens A.L. & Boonen S. (2007). Effects of whole body vibration training on postural control in older individuals: a 1 year randomized controlled trial. Gait & Posture. 26(2). 309-316.

Effects of Whole Body Vibration on Postural Steadiness in an Older Population

Rees SS, Murphy AJ, Watsford ML. Human Performance Laboratory, School of Leisure, Sport and Tourism, University of Technology, Sydney, Australia.

The aim of this study was to investigate the effects of vibration exercise on postural steadiness performance in a healthy, older population. Forty-three healthy, older participants (23 men and 20 women, aged 73.5+/-4.5yr) were randomly assigned to either a vibration group (VIB), an exercise without vibration group (EX) or a control group (CONT). The VIB and EX groups undertook static and dynamic bodyweight exercises three times per week for eight weeks. Static balance was assessed using a one-legged postural steadiness (OLPS) test. This test was performed prior to and immediately after the training period. OLPS improved significantly for the VIB intervention after eight weeks training ($p<0.05$) compared to the EX and CONT groups. The improvements in OLPS were significantly affected by the baseline values, with the largest changes evident for VIB participants with a poorer initial score ($p<0.01$). Vibration exercise can contribute to improved static one-legged balance in a healthy, older population. As improvements in OLPS were related to baseline values, vibration exercise as an intervention would appear to serve the most benefit for those that exhibit diminished postural control.

Rees S.S., Murphy A.J. & Watsford M.L. (2008). Effects of whole body vibration on postural steadiness in an older population. Journal of Science and Medicine in Sport. [Epub ahead of print].

The Effect of Weight-Bearing Exercise with Low Frequency, Whole Body Vibration on Lumbosacral Proprioception: A Pilot Study on Normal Subjects

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Patients with low back pain (LBP) often present with impaired proprioception of the lumbopelvic region. For this reason, proprioception training usually forms part of the rehabilitation protocols. New exercise equipment that produces whole body, low frequency vibration (WBV) has been developed to improve muscle function, and reportedly improves proprioception. The aim of this pilot study was to investigate whether weight bearing exercise given in conjunction with WBV would affect lumbosacral position sense in healthy individuals. For this purpose, twenty-five young individuals with no LBP were assigned randomly to an experimental or control group. The experimental group received WBV for five minutes while holding a static, semi-squat position. The control group adopted the same weight bearing position for equal time but received no vibration. A two-dimensional motion analysis system measured the repositioning accuracy of pelvic tilting in standing. The experimental (WBV) group demonstrated a significant improvement in repositioning accuracy over time (mean 0.78 degrees) representing 39% improvement. It was concluded that WBV may induce improvements in lumbosacral repositioning accuracy when combined with a weight bearing exercise. Future studies with WBV should focus on evaluating its effects with different types of exercise, the exercise time needed for optimal outcomes, and the effects on proprioception deficits in LBP patients.

Fontana T.L., Richardson C.A. & Stanton W.R. (2005). The effect of weight-bearing exercise with low-frequency, whole body vibration on lumbosacral proprioception: a pilot study on normal subjects. The Australian Journal of Physiotherapy. 51(4). 259-2

Effect of a Vibration Exposure on Muscular Performance and Body Balance. Randomized Cross-Over Study

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Summary
This randomized cross-over study was designed to investigate the effects of a 4-min vibration bout on muscle performance and body balance in young, healthy subjects. Sixteen volunteers underwent 4-min vibration.. The vibration-loading, induced a transient (significant at the 2-min test) 2.5% net benefit in the jump height (P = 0.019), 3.2% benefit in the isometric extension strength of lower extremities (P = 0.020) and 15.7% improvement in the body balance (P = 0.049). In the other 2-min or in the 60-min tests, there were no statistically significant differences between the vibration- and sham-interventions. We have shown in this study that a single bout of whole body vibration transiently improves muscle performance of lower extremities and body balance in young healthy adults.

2002 Blackwell Science Ltd. Clinical Physiology and Functional Imaging 22,2,145-152

Knee Rehab

Strength Increase after Whole-Body Vibration Compared with Resistance Training

Christophe Delecluse, Machteld Roelants, And Sabine Verschueren

Strength Increase after Whole-Body Vibration Compared with Resistance Training. *Med. Sci. Sports Exerc.,* Vol. 35, No. 6, pp 1033-1041, 2003.
Purpose: The aim of this study was to investigate and to compare the effect of a 12-wk period of whole-body vibration training and resistance training on human knee-extensor strength**.**
Methods: Sixty-seven untrained females (21.4 ± 1.8 yr)…performed static and dynamic knee-extensor exercises on a vibration platform. The acceleration of the vibration platform was between 2.28 g and 5.09 g, whereas only 0.4 g for the PL condition. Vibration (35-40 Hz) resulted in increased EMG activity, but the EMB signal remained unchanged in the PL condition. The resistance-training group (RES, *N* = 18) trained knee extensors by dynamic leg-press and leg-extension exercises (10-20 RM). All training groups exercised 3 X wk^{-1}. The control group (CO, *N*=12) did not participate in any training. Pre- and postisometric, dynamic, and ballistic knee-extensor strength were measured by means of a motor-driven dynamometer. Explosive strength was determined by means of a counter-movement jump.
Results: Isometric and dynamic knee-extensor strength increased significantly ($P > 0.001$) in both the WBV group (16.6 ± 10.8%; 9.0 ± 3.2%) and the RES group (14.4 ± 5.3%; 7.0 ± 6.2%), respectively, whereas the PL and CO group showed no significant ($P > 0.05$) increase. Counter-movement jump height enhanced significantly ($P < 0.01$) in the WBV group (7.6 ± 4.3%) only.
Conclusions: WBV, and the reflexive muscle contraction it provokes, has the potential to induce strength gain in the knee extensors of previously untrained females to the same extent as resistance training at moderate intensity. **It was clearly shown the strength increases after WBV training are not attributable to a placebo effect.**

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A Comparative Study of Whole Body Vibration Training and Conventional Training on Knee Proprioception and Postural Stability after Anterior Cruciate Ligament Reconstruction

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Objective: To compare the effect of a whole body vibration training (WBVT) program with a conventional training (CT) program on knee proprioception and postural stability after anterior cruciate ligament (ACL) reconstruction.
Methods: Twenty athletes with unilateral ACL reconstruction were randomly assigned to the WBVT or CT group; all participants received 12 sessions of WBVT or conventional training. Absolute error in joint repositioning for two target angles (30 degrees and 60 degrees) was measured with the Biodex dynamometer; bilateral dynamic postural stability (anteroposterior, mediolateral and overall stability indices) was measured with the Biodex Stability System pre-intervention and post-intervention.
Results: The improvement in postural stability in the WBVT group was significantly greater than that in the CT group ($p< or =0.05$). The p values of the changing scores of open overall, open anteroposterior, open mediolateral, closed overall, closed anteroposterior and closed mediolateral stability indices were 0.002, 0.010, 0.0001, 0.001, 0.0001 and 0.046, respectively. In addition, there were significant differences in all averages of absolute angular error at 60 degrees and 30 degrees between the WBVT and CT groups in both knees ($p = 0.001$ in healthy knees and $p = 0.001$ and $p = 0.0001$ in reconstructed knees), apart from the healthy knees at the 30 degrees target position, which was not significant ($p = 0.131$).
Conclusions: Whole body vibration training improved proprioception and balance in athletes with reconstructed ACL.

*Moezy A., Olavaei G., Hadian M., Razi M. & Faghihzadeh S. (2008). A comparative study of whole body vibration training and conventional training on knee proprioception and postural stability after anterior cruci*ate ligament *reconstruction. British Journal of Sports Medicine. 42(5). 373-378.*

Whole-Body Vibration Induced Adaptation in Knee Extensors; Consequences of Initial Strength, Vibration Frequency, and Joint Angle

Savelberg HH, Keizer HA, Meijer K. Department of Human Movement Science, Faculty of Health Sciences, Universiteit Maastricht, Maastricht, The Netherlands.

It was hypothesized that both vibration frequency and muscle length modulate the strengthening of muscles that is assumed to result from whole-body vibration (WBV). Length of knee extensor muscles during vibration is affected by the knee joint angle; the lengths of the knee extensors increase with more flexed knee joint angles. In an intervention study 28 volunteers were randomly assigned to 1 of 4 groups. Each group received 4 weeks of WBV at 1 of 3 different frequencies (20, 27, or 34 Hz) or 1 of 2 different lengths of knee extensors. Voluntary, isometric knee extension moment-angle relationship was determined. Initially, stronger subjects reacted differently to WBV than weaker participants. In stronger subjects knee extension moment did not improve; in the weaker subjects considerable improvements were observed ranging from 10 to 50%. Neither vibration frequency nor muscle length during the intervention affected the improvements. In addition to strength, t
he knee joint angle at which the maximal joint moment was generated (optimal joint angle) was affected. When trained at short muscle lengths, optimal angle shifted to more extend joint position. WBV training at long muscle lengths tended to induce an opposite shift. The amount of this shift tended to be influenced by vibration

frequency; the lower the vibration frequency the larger the shift. Shifts of optimal lengths occurred in both weaker and stronger subjects. This study shows that muscle length during training affects the angle of knee joint at which the maximal extension moment was generated. Moreover, in weaker subjects WBV resulted in higher maximal knee joint extension moments. Vibration frequency and muscle length during vibration did not affect this joint moment gain.

Savelberg H.H., Keizer H.A. & Meijer K. (2007). Whole-body vibration induced adaptation in knee extensors; consequences of initial strength, vibration frequency, and joint angle. Journal of Strength and Conditioning Research. 21(2). 589-593.2007.

Acute Changes in Neuromuscular Excitability after Exhaustive Whole Body Vibration Exercise as Compared to Exhaustion by Squatting Exercise

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The effects of hard squatting exercise with (VbX+) and without (VbX-) vibration on neuromuscular function were tested in 19 healthy young volunteers. Before and after the exercise, three different tests were performed: maximum serial jumping for 30 s, electromyography during isometric knee extension at 70% of the maximum voluntary torque, and the quantitative analysis of the patellar tendon reflex. Between VbX+ and VbX- values, there was no difference found under baseline conditions. Time to exhaustion was significantly shorter in VbX+ than in VbX- (349 +/- 338 s versus 515 +/- 338 s), but blood lactate (5.49 +/- 2.73 mmol l-1 versus 5.00 +/- 2.26 mmol l-1) and subjectively perceived exertion (rate of perceived exertion values 18.1 +/- 1.2 versus 18.6 +/- 1.6) at the termination of exercise indicate comparable levels of fatigue. After the exercise, comparable effects were observed on jump height, ground contact time, and isometric torque. The vastus lateralis mean frequency during isometric torque, however, was higher after VbX+ than after VbX-. Likewise, the tendon reflex amplitude was significantly greater after VbX+ than after VbX- (4.34 +/- 3.63 Nm versus 1.68 +/- 1.32 Nm). It is followed that in exercise unto comparable degrees of exhaustion and muscular fatigue, superimposed 26 Hz vibration appears to elicit an alteration in neuromuscular recruitment patterns, which apparently enhance neuromuscular excitability. Possibly, this effect may be exploited for the design of future training regimes.

Rittweger J., Mutschelknauss M. & Felsenberg D. (2003). Acute changes in neuromuscular excitability after exhaustive whole body vibration exercise as compared to exhaustion by squatting exercise. Clinical Physiology and Functional Imaging. 23(2). 81-86.

Whole-Body-Vibration Training Increases Knee-Extension Strength and Speed of Movement in Older Women

Roelants M, Delecluse C, Verschueren SM. Exercise Physiology and Biomechanics Laboratory, Faculty of Physical Education and Physiotherapy, Department of Kinesiology, Katholieke Universiteit Leuven, Leuven, Belgium.

Objectives: To investigate the effects of 24 weeks of whole-body-vibration (WBV) training on knee-extension strength and speed of movement and on counter-movement jump performance in older women.

Design: A randomized, controlled trial.
Setting: Exercise Physiology and Biomechanics Laboratory, Leuven, Belgium.
Participants: Eighty-nine postmenopausal women, off hormone replacement therapy, aged 58 to 74, were randomly assigned to a WBV group (n=30), a resistance-training group (RES, n=30), or a control group (n=29).
Intervention: The WBV group and the RES group trained three times a week for 24 weeks. The WBV group performed unloaded static and dynamic knee-extensor exercises on a vibration platform, which provokes reflexive muscle activity. The RES group trained knee-extensors by performing dynamic leg-press and leg-extension exercises increasing from low (20 repetitions maximum (RM)) to high (8RM) resistance. The control group did not participate in any training.
Measurements: Pre-, mid- (12 weeks), and post- (24 weeks) isometric strength and dynamic strength of knee extensors were measured using a motor-driven dynamometer. Speed of movement of knee extension was assessed using an external resistance equivalent to 1%, 20%, 40%, and 60% of isometric maximum. Counter-movement jump performance was determined using a contact mat. RESULTS: Isometric and dynamic knee extensor strength increased significantly (P<.001) in the WBV group (mean+/-standard error 15.0+/-2.1% and 16.1+/-3.1%, respectively) and the RES group (18.4+/-2.8% and 13.9+/-2.7%, respectively) after 24 weeks of training, with the training effects not significantly different between the groups (P=.558). Speed of movement of knee extension significantly increased at low resistance (1% or 20% of isometric maximum) in the WBV group only (7.4+/-1.8% and 6.3+/-2.0%, respectively) after 24 weeks of training, with no significant differences in training effect between the WBV and the RES groups (P=.391; P=.142). Counter-movement jump height enhanced significantly (P<.001) in the WBV group (19.4+/-2.8%) and the RES group (12.9+/-2.9%) after 24 weeks of training. Most of the gain in knee-extension strength and speed of movement and in counter-movement jump performance had been realized after 12 weeks of training.
Conclusion: WBV is a suitable training method and is as efficient as conventional RES training to improve knee-extension strength and speed of movement and counter-movement jump performance in older women. As previously shown in young women, it is suggested that the strength gain in older women is mainly due to the vibration stimulus and not only to the unloaded exercises performed on the WBV platform.

Roelants M., Delecluse C. & Verschueren S.M. (2004). Whole-body-vibration training increases knee-extension strength and speed of movement in older women. Journal of the American Geriatrics Society. 52(6). 901-908.

Impact of Whole-Body Vibration Training Verses Fitness Training on Muscle Strength and Muscle Mass in Older Men: A 1-Year Randomized Controlled Trial

Bogaerts A, Delecluse C, Claessens AL, Coudyzer W, Boonen S, Verschueren SM. Division of Musculoskeletal Rehabilitation, Katholieke Universiteit Leuven, Tervuursevest 101, Leuven, Belgium.

Background: This randomized controlled study investigated the effects of 1-year whole-body vibration (WBV) training on isometric and explosive muscle strength and muscle mass in community-dwelling men older than 60 years.
Methods: Muscle characteristics of the WBV group (n = 31, 67.3 +/- 0.7 years) were compared with those of a fitness (FIT) group (n = 30, 67.4 +/- 0.8 years) and a control (CON) group (n = 36, 68.6 +/- 0.9 years). Isometric strength of the knee extensors was measured using an isokinetic dynamometer, explosive muscle strength was assessed using a counter movement jump, and muscle mass of the upper leg was determined by computed tomography.
Results: Isometric muscle strength, explosive muscle strength, and muscle mass increased significantly in the WBV group (9.8%, 10.9%, and 3.4%, respectively) and in the FIT group (13.1%, 9.8%, and 3.8%, respectively) with the training effects not significantly different between the groups. No significant changes in any parameter were found in the CON group.

Conclusion: WBV training is as efficient as a fitness program to increase isometric and explosive knee extension strength and muscle mass of the upper leg in community-dwelling older men. These findings suggest that WBV training has potential to prevent or reverse the age-related loss in skeletal muscle mass, referred to as sarcopenia.

Bogaerts A., Delecluse C., Claessens A.L., Coudyzer W., Boonen S. & Verschueren S.M. (2007). Impact of whole-body vibration training versus fitness training on muscle strength and muscle mass in older men: a 1-year randomized controlled trial. The Journals of Gerontology. 62(6). 630-650.

Low Back

Treatment of Chronic Lower Back Pain with Lumbar Extension and Whole-Body Vibration Exercise

A Randomized Controlled Trial

Jörn Rittweger, MD,* Karsten Just, MD,† Katja Kautzsch, MsPsych,‡ Peter Reeg, MD,§ and Dieter Felsenberg, PhD

Study Design. A randomized controlled trial with a 6-month follow-up period was conducted.
Objective. To compare lumbar extension exercise and whole-body vibration exercise for chronic lower back pain.
Summary of Background Data. Chronic lower back pain involves muscular as well as connective and neural systems. Different types of physiotherapy are applied for its treatment. Industrial vibration is regarded as a risk factor. Recently, vibration exercise has been developed as a new type of physiotherapy. It is thought to activate muscles *via* reflexes.
Methods. In this study, 60 patients with chronic lower back pain devoid of "specific" spine diseases, who had a mean age of 51.7 years and a pain history of 13.1 years, practiced either isodynamic lumbar extension or vibration exercise for 3 months. Outcome measures were lumbar extension torque, pain sensation (visual analog scale), and pain-related disability (pain disability index).
Results. A significant and comparable reduction in pain sensation and pain-related disability was observed in both groups. Lumbar extension torque increased significantly in the vibration exercise group (30.1 Nm/kg), but significantly more in the lumbar extension group (+59.2 Nm/kg; SEM 10.2; $P < 0.05$). No correlation was found between gain in lumbar torque and pain relief or pain related disability ($P > 0.2$).
Conclusions. The current data indicate that poor lumbar muscle force probably is not the exclusive cause of chronic lower back pain. Different types of exercise therapy tend to yield comparable results. Interestingly, well controlled vibration may be the cure rather than the cause of lower back pain. [Key words: back pain, physiotherapy, resistance training, treatment] **Spine 2002;27:1829–1834.**

Jörn Rittweger, MD, Karsten Just, MD,† Katja Kautzsch, MsPsych,‡ Peter Reeg, MD,§ and Dieter Felsenberg, PhD, SPINE Volume 27, Number 17, pp 1829–1834,©2002, Lippincott Williams & Wilkins, Inc.*

Effect of Whole-Body Vibration Exercise on Lumbar Bone Mineral Density, Bone Turnover, and Chronic Back Pain in Post-Menopausal Osteoporotic Women Treated with Alendronate.

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Background And Aims: Exercise may enhance the effect of alendronate on bone mineral density (BMD) and reduce chronic back pain in elderly women with osteoporosis. The aim of this study was to determine whether whole-body vibration exercise would enhance the effect of alendronate on lumbar BMD and bone turnover, and reduce chronic back pain in postmenopausal women with osteoporosis. **Methods**: Fifty post-menopausal women with osteoporosis, 55-88 years of age, were randomly divided into two groups of 25 patients each: one taking alendronate (5 mg daily, ALN) and one taking alendronate plus exercise (ALN+EX). Exercise consisted of whole-body vibration using a Galileo machine (Novotec, Pforzheim, Germany), at an intensity of 20 Hz, frequency once a week, and duration of exercise 4 minutes. The study lasted 12 months. Lumbar BMD was measured by dual energy X-ray absorptiometry (Hologic QDR 1500W). Urinary cross-linked N-terminal telopeptides of type I collagen (NTX) and serum alkaline phosphatase (ALP) levels were measured by enzyme-linked immunosorbent assay and standard laboratory techniques, respectively. Chronic back pain was evaluated by face scale score at baseline and every 6 months.
Results: There were no significant differences in baseline characteristics, including age, body mass index, years since menopause, lumbar BMD, urinary NTX and serum ALP levels, or face scale score between the two groups. The increase in lumbar BMD and the reduction in urinary NTX and serum ALP levels were similar in the ALN and ALN+EX groups. However, the reduction in chronic back pain was greater in the ALN+EX group than in the ALN group.
Conclusions: The results of this study suggest that whole-body vibration exercise using a Galileo machine appears to be useful in reducing chronic back pain, probably by relaxing the back muscles in post-menopausal osteoporotic women treated with alendronate.

Iwamoto J., Takeda T., Sato Y. & Uzawa M. (2005). Effect of whole-body vibration exercise on lumbar bone mineral density, bone turnover, and chronic back pain in post-menopausal osteoporotic women treated with alendronate. Aging Clinical and Experimental Research. 17(2). 157-163.

Neuromuscular

Adaptive Responses of Human Skeletal Muscle to Vibration Exposure

C. Bosco, , R. Colli, E. Introini, M. Cardinale, O. Tsarpela, A. Madella, Tihanyi, and A. Viru

The aim of this study was to investigate the effects of whole-body vibrations (WBV) on the mechanical behavior of human skeletal muscle…six female volleyball players at national level. They were tested with maximal dynamic leg press exercise on a slide machine. After the testing, one leg was randomly assigned to the control treatment (C) and the other to the experimental treatment (E) consisting of vibrations. The subjects were then retested at the end of the treatment using the leg press. Results showed remarkable and statistically significant enhancement of the experimental treatment in average velocity (AV), average force (AF) and average power (AP) ($P < 0.05$-0.005). Consequently, the velocity-force and power-force relationship shifted to the right after the treatment. In conclusion, it was affirmed that the enhancement could be caused by neural factors, as athletes were well accustomed to the leg press exercise and the learning effect was minimized.

Discussion…In the present experiment, even if the total length of the VT application period was only 10 minutes, the perturbation of the gravitational field was consistent (5.4 g). An equivalent length and intensity of training stimulus can be reached only by performing 150 leg press or half squat exercises with extra loads of three times body mass twice a week for 5 weeks (Bosco, l992).

Bosco C., Colli R., Introini E., Cardinale M., Tsarpela O., Madella A., Tihanyi J. & Viru A. (1999). Adaptive responses of human skeletal muscle to vibration exposure. Clinical Physiology. 19(2). 183-187.

Whole-Body-Vibration-Induced Increase in Leg Muscle Activity During Different Squat Exercises

Roelants M, Verschueren SM, Delecluse C, Levin O, Stijnen V. Exercise Physiology and Biomechanics Laboratory.

This study analyzed leg muscle activity during whole-body vibration (WBV) training. Subjects performed standard unloaded isometric exercises on a vibrating platform (Power Plate): high squat (HS), low squat (LS), and 1-legged squat (OL). Muscle activity of the rectus femoris, vastus lateralis, vastus medialis, and gastrocnemius was recorded in 15 men (age 21.2 +/- 0.8 years) through use of surface electromyography (EMG). The exercises were performed in 2 conditions: with WBV and without (control [CO]) a vibratory stimulus of 35 Hz. Muscle activation during WBV was compared with CO and with muscle activation during isolated maximal voluntary contractions (MVCs). Whole-body vibration resulted in a significantly higher ($p < 0.05$) EMG root-mean-square compared with CO in all muscle groups and all exercises (between +39.9 +/- 17.5% and +360.6 +/- 57.5%). The increase in muscle activity caused by WBV was significantly higher ($p < 0.05$) in OL compared with HS and LS. In conclusion, WBV resulted in an increased activation of the leg muscles. During WBV, leg muscle activity varied between 12.6 and 82.4% of MVC values.

Roelants M., Verschueren S.M., Delecluse C., Levin O. & Stijnen V. (2006). Whole-body-vibration induced increase in leg muscle activity during different squat exercises. Journal of Strength and Conditioning Research. 20(1). 124-129.

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 degrees 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.

Bakhitiary A.H., Safavi-Farokhi Z. & Aminian-Far A. (2007). Influence of vibration on delayed onset of muscle soreness following eccentric exercise. British J Sports Med 2007;41:145–148. doi: 10.1136/bjsm.2006.031278

Variation in Neuromuscular Responses During Acute Whole-Body Vibration Exercise

Abercromby AF, Amonette WE, Layne CS, McFarlin BK, Hinman MR, Paloski WH. Wyle Laboratories, Inc., Houston, TX 77058, USA.

Purpose: Leg muscle strength and power are increased after whole-body vibration (WBV) exercise. These effects may result from increased neuromuscular activation during WBV; however, previous studies of neuromuscular responses during WBV have not accounted for motion artifact.
Methods: Sixteen healthy adults performed a series of static and dynamic unloaded squats with and without two different directions of WBV (rotational vibration, RV; and vertical vibration, VV; 30 Hz; 4 mmp–p). Activation of unilateral vastus lateralis, biceps femoris, gastrocnemius, and tibialis anterior was recorded using EMG. During RV and VV, increases in EMG
relative to baseline were compared over a range of knee angles, contraction types (concentric, eccentric, sometric), and squatting types (static, dynamic).
Results: After removing large, vibration-induced artifacts from EMG data using digital band-stop filters, neuromuscular activation of all four muscles increased significantly (P e 0.05) during RV and VV. Average responses of the extensors were significantly greater during RV than VV, whereas responses of the tibialis anterior were significantly greater during VV than RV. For all four muscles, responses during static squatting were greater than or equal to responses during dynamic squatting, whereas
responses during eccentric contractions were equal to or smaller than responses during concentric and isometric contractions. Neuromuscular responses of vastus lateralis, gastrocnemius, and tibialis anterior were affected by knee angle, with greatest responses at small knee angles.
Conclusions: Motion artifacts should be removed from EMG data collected during WBV. We propose that neuromuscular responses during WBV may be modulated by leg muscle cocontraction as a postural control strategy and/or muscle tuning by the CNS intended to minimize soft-tissue vibration.

ABERCROMBY, A. F. J., W. E. AMONETTE, C. S. LAYNE, B. K. MCFARLIN, M. R. HINMAN, and W. H. PALOSKI. Variation in Neuromuscular Responses during Acute Whole-Body Vibration Exercise. Med. Sci. Sports Exerc., Vol. 39, No. 9, pp. 1642–1650, 2007.

The Use of Vibration Training to Enhance Muscle Strength and Power

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Vibration has been combined with conventional resistance training in an attempt to attain greater gains in neuromuscular performance than from conventional resistance training alone. Although there is a lack of strictly controlled studies on the vibration training effect, current findings in this area suggest that vibration may have a beneficiary acute and/or chronic training effect on strength and power enhancement. However, the effect of vibration on strength and power development appears dependent upon the vibration characteristics (method of application, amplitude and frequency) and exercise protocols (training type, intensity and volume) employed. Vibration amplitude and frequency determine the load that vibration imposes on the neuromuscular system. This vibration load should be in an optimal range to elicit strength and power enhancement. To activate the muscle most effectively, vibration frequency should be in the range of 30-50 Hz. It is less clear to what the optimal amplitude should be, but smaller amplitudes may be insufficient to elicit an enhancement. It should also be noted that the method of vibration application (i.e. vibration applied directly or indirectly to a targeted muscle) may have an influence on the magnitude of amplitude and frequency that are delivered to the muscle and, therefore, may have an influence on vibration training effect. The employment of a greater exercise intensity and volume within a vibration training program may facilitate a larger enhancement in strength and power. In addition, benefits from vibration training may be greater in elite athletes than non-elite athletes. Further studies are required to examine these inter-dependencies, especially in relation to chronic adaptation to dynamic exercises, which are the most relevant response to practitioners, but where the least amount of research has been undertaken.

Luo J., McNamara B. & Moran K. (2005). The use of vibration training to enhance muscle strength and power. Sports Medicine. 35(1). 23-41.

Effect of Whole Body Vibration Training on Lower Limb Performance in Selected High-Level Ballet Students

Annini G, Padua E, Castagna C, Salvo VD, Minichella S, Tsarpela O, Manzi V, Di Pttavio S. School of Sport and Exercise Sciences, Faculty of Medicine and Surgery, Tor Vergata University, Rome, Italy.

The aim of this study was to examine the effects of 8 weeks of whole body vibration (WBV) training on vertical jump ability (CMJ) and knee-extensor performance at selected external loads (50, 70, and 100 kg; leg-press exercise) in elite ballerinas. Twenty-two (age, 21.25 +/- 1.5 years) full-time ballerinas were assigned randomly to the experimental (E, n = 11) and control (C, n = 11) groups. The experimental group was submitted to WBV training 3 times per week before ballet practice. During the training period, the E and C groups undertook the same amount of ballet practice. Post training CMJ performance significantly increased in E group (6.3 +/- 3.8%, $p < 0.001$). Furthermore, E group showed significant ($p < 0.05$-0.001) post training average leg-press power and velocity improvements at all the external loads considered. Consequently, the force-velocity and power-velocity relationship shifted to the right after WBV training in the E group. The results of the present study show that WBV training is an effective short-term training methodology for inducing improvements in knee-extensor explosiveness in elite ballerinas.

Annini G., Padua E., Castagna C., Salvo V.D., Minichella S., Tsarpela O., Manzi V. & Dettavio S. (2007). Effect of whole body vibration training on lower limb performance in selected high-level ballet students. Journal of Strength and Conditioning Research. 21(4). 1072-1076.

Impact of Whole-Body Vibration Training Versus Fitness Training on Muscle Strength and Muscle Mass in Older Men: A 1-Year Randomized Controlled Trial

Bogaerts A, Delecluse C, Claessens AL, Coudyzer W, Boonen S, Verschueren SM. Division of Musculoskeletal Rehabilitation, Katholieke Universiteit Leuven, Tervuursevest 101, Leuven, Belgium.

Background: This randomized controlled study investigated the effects of 1-year whole-body vibration (WBV) training on isometric and explosive muscle strength and muscle mass in community-dwelling men older than 60 years.
Methods: Muscle characteristics of the WBV group (n = 31, 67.3 +/- 0.7 years) were compared with those of a fitness (FIT) group (n = 30, 67.4 +/- 0.8 years) and a control (CON) group (n = 36, 68.6 +/- 0.9 years). Isometric strength of the knee extensors was measured using an isokinetic dynamometer, explosive muscle strength was assessed using a counter movement jump, and muscle mass of the upper leg was determined by computed tomography.
Results: Isometric muscle strength, explosive muscle strength, and muscle mass increased significantly in the WBV group (9.8%, 10.9%, and 3.4%, respectively) and in the FIT group (13.1%, 9.8%, and 3.8%, respectively) with the training effects not significantly different between the groups. No significant changes in any parameter were found in the CON group.
Conclusion: WBV training is as efficient as a fitness program to increase isometric and explosive knee extension strength and muscle mass of the upper leg in community-dwelling older men. These findings suggest that WBV training has potential to prevent or reverse the age-related loss in skeletal muscle mass, referred to as sarcopenia.

Bogaerts A., Delecluse C., Claessens A.L., Coudyzer W., Boonen S. & Verschueren S.M. (2007). Impact of whole-body vibration training versus fitness training on muscle strength and muscle mass in older men: a 1-year randomized controlled trial. The Journals of Gerontology. 62(6). 630-650.

Influence of Vibration Training on Energy Expenditure in Active Men

Da Silva ME, Fernandez JM, Castillo E, Nunez VM, Vaamonde DM, Poblador MS, Lancho JL. Morphological Sciences Department, School of Medicine, University of Cordoba, Cordoba, Spain.

The aim of the present study was to analyze the effect of whole-body vibration on energy expenditure, as well as on exercise intensity, during and immediately after a typical set of exercises for muscle hypertrophy in physically active subjects. Seventeen male university students (mean age 18.3 +/- 0.24 years) volunteered to perform 2 different training exercises: half squat (HS), and half squat with vibration (HSV). Both exercises were performed by all subjects on the vibration platform (with vibration only for HSV), the sequence order being assigned randomly. Energy expenditure (EE), respiratory exchange ratio, perceived exertion (PE), and heart rate were recorded for baseline, exercise, and short-recovery conditions. Training consisted of 5 sets of 10 repetitions of HS and HSV, with a 2-minute recovery interval between sets. Analysis of variance with repeated measurements and Bonferroni correction, as well as effect size were used for statistical calculations. Results indicated that EE and PE were significantly higher in the HSV group, during both exercise and recovery. Heart rate did not differ significantly between groups. Thus, it would appear that HS strength training could be rendered more energy-efficient through the addition of vibration. Moreover, it would be feasible to introduce vibration exercises into regular training programs, particularly those whose key objective is muscle hypertrophy along with fat reduction.

Da Silva M.E., Fernandez J.M., Castillo E., Nunez V.M., Vaamonde D.M., Poblador M.S. & Lancho J.L. (2007). Influence of vibration training on energy expenditure in active men. Journal of Strength and Conditioning Research. 21(2). 470-475.

Variation in Neuromuscular Responses During Acute Whole-Body Vibration Exercise

Abercromby AF, Amonette WE, Layne CS, McFarlin BK, Hinman MR, Paloski WH. Wyle Laboratories, Inc., Houston, TX 77058, USA.

Purpose: Leg muscle strength and power are increased after whole-body vibration (WBV) exercise. These effects may result from increased neuromuscular activation during WBV; however, previous studies of neuromuscular responses during WBV have not accounted for motion artifact. **Methods**: Sixteen healthy adults performed a series of static and dynamic unloaded squats with and without two different directions of WBV (rotational vibration, RV; and vertical vibration, VV; 30 Hz; 4 mmp-p). Activation of unilateral vastus lateralis, biceps femoris, gastrocnemius, and tibialis anterior was recorded using EMG. During RV and VV, increases in EMG relative to baseline were compared over a range of knee angles, contraction types (concentric, eccentric, isometric), and squatting types (static, dynamic). **Results:** After removing large, vibration-induced artifacts from EMG data using digital band-stop filters, neuromuscular activation of all four muscles increased significantly (P< soft-tissue minimize to intended CNS the by tuning muscle or and strategy control postural a as cocontraction leg modulated be may WBV during responses neuromuscular that propose We WBV. collected data EMG from removed should artifacts Motion **Conclusions**: angles. knee small at greatest with angle, affected were anterior tibialis gastrocnemius, lateralis, vastus of Neuromuscular contractions. isometric concentric than smaller equal contractions eccentric whereas squatting, dynamic greater squatting static muscles, four all For RV. VV significantly VV, RV extensors Average VV.>

Abercromby A.F., Amonette W.E., Layne C.S., McFarlin B.K., Hinman M.R. & Paloski W.H. (2007). Variation in neuromuscular responses during acute whole-body vibration exercise. Medicine and Science in Sports and Exercise. 39(9). 1642-1650.

Neuromuscular - EMG

Influence of Vibration on Mechanical Power and Electromyogram Activity in Human Arm Flexor Muscles

Carmelo Bosco, Marco Cardinale, Olga Tsarpela

The aim of this study was to evaluate the influence of vibration on the mechanical properties of arm flexors. A group of 12 international level boxers,…one arm was given the experimental treatment (E; mechanical vibration) and the other was the control (no treatment). The E treatment consisted of five repetitions lasting 1-min each of mechanical vibration applied during arm flexion in isometric conditions with 1 min rest between them…The results showed statistically significant enhancement of the average power in the arm treated with vibrations…as an index of neural efficiency, it showed statistically significant increases. It was concluded that mechanical vibrations enhanced muscle P and decreased the related EMG/P relationship in elite athletes. Moreover, the analysis of EMGrms recorded before the treatment and during the treatment itself showed an enormous increase in neural activity during vibration up to more than twice the baseline values. This would indicate that this type of treatment is able to stimulate the neuromuscular system more than other treatments used to improve neuromuscular properties.

Carmelo Bosco, Marco Cardinale, Olga Tsarpela, Eur J Appl Physiol (1999) 79: 306-311

Electromyography Activity of Vastus Lateralis Muscle During Whole-Body Vibrations of Different Frequencies

Marco Cardinale And Jon Lim
Department of Biomedical Science, University of Aberdeen, Scotland; Northern State University,

The aim of this study was to analyze electromyography (EMG) responses of vastus lateralis muscle to different whole-body vibration frequencies. For this purpose, 16 professional women volleyball players (age, 23.9 6 3.6 years; height, 182.5 6 11.1 cm; weight, 78.4 6 5.6 kg) voluntarily participated in the study. Vibration treatment was administered while standing on a vibrating platform with knees bent at 1008 (Nemes Bosco-system, Rome, Italy). EMG root mean square (rms) and was recorded for 60 seconds while standing on the vibrating plate in the following conditions: no vibrations and 30-, 40-, and 50-Hz vibration frequencies in random order. The position was kept for 60 seconds in each treatment condition. EMGrms was collected from the vastus lateralis muscle of the dominant leg. Statistical analysis showed that, in all vibration conditions, average EMGrms activity of vastus lateralis was higher than in the no-vibration condition. The highest EMGrms was found at 30 Hz, suggesting this frequency as the one eliciting the highest reflex response in vastus lateralis muscle during whole-body vibrations in half-squat position. An extension of these studies to a larger population appears worthwhile to further elucidate the responsiveness of the neuromuscular system to whole-body vibrations administered through vibrating platforms and to be able to develop individual treatment protocols.

Cardinale, M., and J. Lim. Electromyography activity of vastus lateralis muscle during whole-body vibrations of different frequencies. Journal of Strength and Conditioning Research, 17(3):621–624. 200,. National Strength & Conditioning Association

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The Effects of Whole-Body Vibration on Upper- and Lower-Body EMG During Static and Dynamic Contractions

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Whole-body vibration (WBV) training uses a vertically oscillating platform and reports suggest that this perturbation elicits reflexive muscle contractions that augment muscle activity and contribute to increased strength. No WBV study has measured both upper- and lower-body muscle activation. The purpose of this study was to determine the optimal WBV stimulus (frequency x amplitude) to increase electromyography (EMG) in upper- and lower-body muscles for three distinctive unloaded actions: isometric semi-squat, dynamic leg squats, and static and dynamic bilateral bicep curls. Surface EMG was measured for the vastus lateralis (VL), biceps femoris (BF), biceps brachii (BB), and triceps brachii (TB) in 10 recreationally active male university students (24.4+/-2.0 years; mean+/-SD) when WBV was administered at 2 and 4 mm and at 25, 30, 35, 40, and 45 Hz. EMG changes are reported as the difference between WBV and no WBV EMG root mean square expressed as a percentage of maximum voluntary exertion (%MVE). In static semi-squat, WBV increased muscle activity 2.9%-6.7% in the VL and 0.8%-1.2% in the BF. During dynamic squatting, WBV increased muscle activity in the VL by 3.7%-8.7% and in the BF by 0.4%-2.0%. In a static biceps curl, WBV had no effect on BB EMG, but did increase TB activity 0.3%-0.7%. During dynamic biceps curls, WBV increased BB EMG activity by 0.6%-0.8% and TB activity by 0.2%-1.0%. The higher WBV amplitude (4 mm) and frequencies (35, 40, 45 Hz) resulted in the greatest increases in EMG activity.

Hazell T.J., Jakobi J.M. & Kenno K.A. (2007). The effects of whole-body vibration on upper- and lower-body emg during static and dynamic contractions. Applied Physiology, Nutrition, and Metabolism. 32(6). 1156-1163.

Range of Motion

Flexibility Enhancement with Vibration: Acute and Long-Term

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Introduction: The most popular method of stretching is static stretching. Vibration may provide a means of enhancing range of motion beyond that of static stretching alone.
Purpose: This study sought to observe the effects of vibration on static stretching to determine whether vibration-aided static stretching could enhance range of motion acquisition more than static stretching alone in the forward split position.
Methods: Ten highly trained male volunteer gymnasts were randomly assigned to experimental (N = 5) and control (N = 5) groups. The test was a forward split with the rear knee flexed to prevent pelvic misalignment. Height of the anterior iliac spine of the pelvis was measured at the lowest split position. Athletes stretched forward and rearward legs to the point of discomfort for 10 s followed by 5 s of rest, repeated four times on each leg and split position (4 min total). The experimental group stretched with the device turned on; the control group stretched with the device turned off. A pretest was followed by an acute phase posttest, then a second posttest measurement was performed following 4 wk of treatment. Difference scores were analyzed.
Results: The acute phase showed dramatic increases in forward split flexibility for both legs (P G 0.05), whereas the long-term test showed a statistically significant increase in range of motion on the right rear leg split only (P G 0.05). Effect sizes indicated large effects in all cases.
Conclusion: This study showed that vibration can be a promising means of increasing range of motion beyond that obtained with static stretching in highly trained male gymnasts. Key

Flexibility Enhancement with Vibration: Acute and Long-Term. Med. Sci. Sports Exerc., Vol. 38, No. 4, pp. 720–725, 2006.

Will Whole-Body Vibration Training Help Increase the Range of Motion of the Hamstrings?

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Muscle strain is one of the most common injuries, resulting in a decreased range of motion (ROM) in this group of muscles. Systematic stretching over a period of time is needed to increase the ROM. The purpose of this study was to determine if whole-body vibration (WBV) training would have a positive effect on flexibility training (contract-release method) and thereby on the ROM of the hamstring musculature. In this study, 19 undergraduate students in physical education (12 women and 7 men, age 21.5 +/- 2.0 years) served as subjects and were randomly assigned to either a WBV group or a control group. Both groups stretched systematically 3 times per week for 4 weeks according to the contract-release method, which consists of a 5-second isometric contraction with each leg 3 times followed by 30 seconds of static stretching. Before each stretching exercise, the WBV group completed a WBV program consisting of standing in a squat position on the vibration platform with the knees bent 90 degrees on the Nemes Bosco system vibration platform (30 seconds at 28 Hz, 10-mm amplitude, 6 times

per training session). The results show that both groups had a significant increase in hamstring flexibility. However, the WBV group showed a significantly larger increase (30%) in ROM than did the control group (14%). These results indicate that WBV training may have an extra positive effect on flexibility of the hamstrings when combined with the contract-release stretching method.

van den Tillar R. (2006). Will whole-body vibration training help increase the range of motion of the hamstrings? Journal of Strength and Conditioning Research. 20(1). 192-196.

Skeletal and Osteoporosis

Effect of 6-Month Whole Body Vibration Training on Hip Density, Muscle Strength, and Postural Control in Postmenopausal Women: A Randomized Controlled Pilot Study

Verschueren SM, Roelants M, Delecluse C, Swinnen S, Vanderschueren D, Boonen S. Laboratory of Motor Control, Department of Kinesiology, Faculteit Lichamelijke Opvoeding en Kinesitherapie, Katholieke Universiteit, Leuven, Belgium.

Vibration training significantly increased BMD of the hip. These findings suggest that WBV training might be useful in the prevention of osteoporosis.

Materials and Methods: Seventy volunteers (age, 58-74 years)
Results: No vibration-related side effects were observed. Vibration training improved isometric and dynamic muscle strength (+15% and + 16%, respectively; $p < 0.01$) and also significantly increased BMD of the hip (+0.93%, $p < 0.05$). No changes in hip BMD were observed in women participating in resistance training or age-matched controls.
Conclusion: These findings suggest that WBV training may be a feasible and effective way to modify well-recognized risk factors for falls and fractures in older women and support the need for further human studies.

Verschueren S.M., Roelants M., Delecluse C., Swinnen S., Vanderschueren D. & Boonen S. (2004). Effect of 6-month whole body vibration training on hip density, muscle strength, and postural control in postmenopausal women: a randomized controlled pilot study. Journal of Bone and Mineral Research. 19(3). 352-359.

Prevention of Postmenopausal Bone Loss by A Low-Magnitude, High-Frequency Mechanical Stimuli: A Clinical Trial Assessing Compliance, Efficacy, and Safety

Clinton Rubin, Robert Recker, Diane Cullen, John Ryaby, Joan McCabe,and Kenneth McLeod

Introduction: Here, a 1-year prospective, randomized, double-blind, and placebo-controlled clinical trial in 70 women, 3–8 years past the menopause, examined the ability of such high-frequency, low-magnitude mechanical signals to inhibit bone loss in the human.
Materials and Methods: Each day, one-half of the subjects were exposed to short-duration (two 10-minute treatments/ day), low-magnitude, 30-Hz vertical accelerations (vibration), whereas the other half stood for the

same duration on placebo devices. DXA was used to measure BMD at the spine, hip, and distal radius at baseline, and 3, 6, and 12 months. Fifty-six women completed the 1-year treatment.
Results and Conclusions: Evaluating those in the highest quartile of compliance (86% compliant), placebo subjects lost 2.13% in the femoral neck over 1 year, whereas treatment was associated with a gain of 0.04%, reflecting a 2.17% relative benefit of treatment ($p = 0.06$). In the spine, the 1.6% decrease observed over 1 year in the placebo group was reduced to a 0.10% loss in the active group, indicating a 1.5% relative benefit of treatment ($p= 0.09$). Considering the interdependence of weight, the spine of lighter women (< 65 kg), who were in the highest quartile of compliance, exhibited a relative benefit of active treatment of 3.35% greater BMD over 1 year ($p = 0.009$); for the mean compliance group, a 2.73% relative benefit in BMD was found ($p = 0.02$). These preliminary results indicate the potential for a noninvasive, mechanically mediated intervention for osteoporosis. This non-pharmacologic approach represents a physiologically based means of inhibiting the decline in BMD that follows menopause, perhaps most effectively in the spine of lighter women who are in the greatest need of intervention.

J Bone Miner Res 2004;19:343–351. Published online on December 22, 2003; doi: 10.1359/JBMR.0301251
Key words: osteoporosis, anabolic, mechanical loading, vibration, low-level, frequency, osteogenic, muscle, skeleton, aging, menopause, bone, antiresorptive JOURNAL OF BONE AND MINERAL RESEARCH Volume 19, Number 3, 2004 Published online on December 22, 2003; doi: 10.1359/JBMR.0301251 *© 2004 American Society for Bone and Mineral Research*

Effect of Whole-Body Vibration Exercise on Lumbar Bone Mineral Density, Bone Turnover, and Chronic Back Pain in Post-Menopausal Osteoporotic Women Treated with Alendronate.

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Background And Aims: Exercise may enhance the effect of alendronate on bone mineral density (BMD) and reduce chronic back pain in elderly women with osteoporosis. The aim of this study was to determine whether whole-body vibration exercise would enhance the effect of alendronate on lumbar BMD and bone turnover, and reduce chronic back pain in postmenopausal women with osteoporosis. **Methods**: Fifty post-menopausal women with osteoporosis, 55-88 years of age, were randomly divided into two groups of 25 patients each: one taking alendronate (5 mg daily, ALN) and one taking alendronate plus exercise (ALN+EX). Exercise consisted of whole-body vibration using a Galileo machine (Novotec, Pforzheim, Germany), at an intensity of 20 Hz, frequency once a week, and duration of exercise 4 minutes. The study lasted 12 months. Lumbar BMD was measured by dual energy X-ray absorptiometry (Hologic QDR 1500W). Urinary cross-linked N-terminal telopeptides of type I collagen (NTX) and serum alkaline phosphatase (ALP) levels were measured by enzyme-linked immunosorbent assay and standard laboratory techniques, respectively. Chronic back pain was evaluated by face scale score at baseline and every 6 months.
Results: There were no significant differences in baseline characteristics, including age, body mass index, years since menopause, lumbar BMD, urinary NTX and serum ALP levels, or face scale score between the two groups. The increase in lumbar BMD and the reduction in urinary NTX and serum ALP levels were similar in the ALN and ALN+EX groups. However, the reduction in chronic back pain was greater in the ALN+EX group than in the ALN group.
Conclusions: The results of this study suggest that whole-body vibration exercise using a Galileo machine appears to be useful in reducing chronic back pain, probably by relaxing the back muscles in post-menopausal osteoporotic women treated with alendronate.

Iwamoto J., Takeda T., Sato Y. & Uzawa M. (2005). Effect of whole-body vibration exercise on lumbar bone mineral density, bone turnover, and chronic back pain in post-menopausal osteoporotic women treated with alendronate. Aging Clinical and Experimental Research. 17(2). 157-163.

Low-Level, High-Frequency Mechanical Signals Enhance Musculoskeletal Development of Young Women with Low BMD

Vicente Gilsanz, Tishya AL Wren, Monique Sanchez, Frederick Dorey, Stefan Judex, and Clinton Rubin4

The potential for brief periods of low-magnitude, high-frequency mechanical signals to enhance the musculoskeletal system was evaluated in young women with low BMD. Twelve months of this noninvasive signal, induced as whole body vibration for at least 2 minutes each day, increased bone and muscle mass in the axial skeleton and lower extremities compared with controls. **Introduction:** The incidence of osteoporosis, a disease that manifests in the elderly, may be reduced by increasing peak bone mass in the young. Preliminary data indicate that extremely low-level mechanical signals are anabolic to bone tissue, and their ability to enhance bone and muscle mass in young women was investigated in this study.
Materials and Methods: A 12-month trial was conducted in 48 young women (15–20 years) with low BMD and a history of at least one skeletal fracture. One half of the subjects underwent brief (10 minutes requested), daily, low-level whole body vibration (30 Hz, 0.3*g*); the remaining women served as controls. Quantitative CT performed at baseline and at the end of study was used to establish changes in muscle and bone mass in the weight-bearing skeleton. **Results:** Using an intention-to-treat (ITT) analysis, cancellous bone in the lumbar vertebrae and cortical bone in the femoral midshaft of the experimental group increased by 2.1% ($p = 0.025$) and 3.4% ($p < 0.001$), respectively, compared with 0.1% ($p = 0.74$) and 1.1% ($p = 0.14$), in controls. Increases in cancellous and cortical bone were 2.0% ($p = 0.06$) and 2.3% ($p = 0.04$) greater, respectively, in the experimental group compared with controls. Cross-sectional area of paraspinous musculature was 4.9% greater ($p= 0.002$) in the experimental group versus controls. When a per protocol analysis was considered, gains in both muscle and bone were strongly correlated to a threshold in compliance, where the benefit of the mechanical intervention compared with controls was realized once subjects used the device for at least 2 minute/day ($n = 18$), as reflected by a 3.9% increase in cancellous bone of the spine ($p = 0.007$), 2.9% increase in cortical bone of the femur ($p = 0.009$), and 7.2% increase in musculature of the spine ($p = 0.001$) compared with controls and low compliers ($n = 30$). **Conclusions:** Short bouts of extremely low-level mechanical signals, several orders of magnitude below that associated with vigorous exercise, increased bone and muscle mass in the weight-bearing skeleton of young adult females with low BMD. Should these musculoskeletal enhancements be preserved through adulthood, this intervention may prove to be a deterrent to osteoporosis in the elderly.

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Key words: osteoporosis, treatments, mechanical, loading, novel entities, osteopenia, frequency, bone, adaptation, muscle, anabolic, osteogenic, CT diagnostics, therapeutics.

Low-Frequency Vibratory Exercise Reduces the Risk of Bone Fracture More Than Walking: A Randomized Controlled Trial

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Background: Whole-body vibration (WBV) is a new type of exercise that has been increasingly tested for the ability to prevent bone fractures and osteoporosis in frail people. There are two currently marketed vibrating plates: a) the whole plate oscillates up and down; b) reciprocating vertical displacements on the left and right side of a fulcrum, increasing the lateral accelerations. A few studies have shown recently the effectiveness of the up-and-down plate for increasing Bone Mineral Density (BMD) and balance; but the effectiveness of the reciprocating plate technique remains mainly unknown. The aim was to compare the effects of WBV using a reciprocating platform at frequencies lower than 20 Hz and a walking-based exercise program on BMD and balance in post-menopausal women. **Methods**: Twenty-eight physically untrained post-menopausal women were assigned at random to a WBV group or a Walking group. Both experimental program consisted of 3 sessions per

week for 8 months. Each vibratory session included 6 bouts of 1 min (12.6 Hz in frequency and 3 cm in amplitude with 60 degrees of knee flexion) with 1 min rest between bouts. Each walking session was 55 minutes of walking and 5 minutes of stretching. Hip and lumbar BMD (g.cm-2) were measured using dual-energy X-ray absorptiometry and balance was assessed by the blind flamingo test. ANOVA for repeated measurements was adjusted by baseline data, weight and age. **Results**: After 8 months, BMD at the femoral neck in the WBV group was increased by 4.3% (P = 0.011) compared to the Walking group. In contrast, the BMD at the lumbar spine was unaltered in both groups. Balance was improved in the WBV group (29%) but not in the Walking group. **Conclusion:** The 8-month course of vibratory exercise using a reciprocating plate is feasible and is more effective than walking to improve two major determinants of bone fractures: hip BMD and balance.

Gusi N, Raimundo A. & Leal A. (2006). Low-frequency vibratory exercise reduces the risk of bone fracture more than walking: a randomized controlled trial. BMC Musculoskeletal Disorders. 30;7-92.

Vibration Exercise for Treatment of Osteoporosis: A Theoretical Model

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Orthopaedic rehabilitation of osteoporosis by muscle vibration exercise is investigated theoretically using Wolff's theory of strain-induced bone 'remodeling'. The remodeling equation for finite amplitude vibration to be transmitted to the bone via muscle corresponds to a slowly time-varying non-linear dynamic system. This slowly time-varying system is governed by a Riccatti equation with rapidly varying coefficients that oscillate with the frequency of the applied vibration. An averaging technique is used to determine the effective force transmitted to the bone. This force is expressed in terms of the stiffness and damping parameters of the connected muscle. The analytical result predicts that, in order to obtain bone reinforcement, the frequency and amplitude of vibration should not exceed specified levels. Furthermore, low-frequency vibration does not stimulate the bone sufficiently to cause significant remodeling. The theoretical model herein confirms the clinical recommendations regarding vibration exercise and its effects on rehabilitation. In a numerical example, the model predicts that a femur with reduced bone mass as a result of bed rest will be healed completely by vibration consisting of an acceleration of 2g applied at a frequency of 30 Hz over a period of 250 days.

CVA (Stroke)

One Session of Whole Body Vibration Increases Voluntary Muscle Strength Transiently in Patients with Stroke

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Objective: To determine the effect of whole body vibration on isometric and eccentric torque and electromyography (EMG) variables of knee extensors on the affected side of stroke patients.
Design: A randomized controlled study. Setting: A rehabilitation centre. Subjects: Sixteen patients (age 58.2±9.4 years) were enrolled in an inpatient rehabilitation program 27.2±10.4 days after a stroke. Interventions: Eight patients were randomly assigned to the vibration group and received 20 Hz vibration (5mm amplitude) while standing on a vibration platform for 1 minute six times in one session. Patients in the control group also stood on

the platform but did not receive vibration. Main measures: Maximum isometric and eccentric torque, rate of torque development, root-mean-squared EMG, median frequency of vastus lateralis, and co-activation of knee flexors. Results: Isometric and eccentric knee extension torque increased 36.6% and 22.2%, respectively, after vibration ($P < 0.05$) and 8.4% and 5.3% in the control group. Vibration increased EMG amplitude 44.9% and the median frequency in the vastus lateralis by 13.1% (all $P < 0.05$) without changes in the control group (10.6% and 3.9%). Vibration improved the ability to generate mechanical work during eccentric contraction (17.5%). Vibration reduced biceps femoris co-activation during isometric (8.4%, ns) and eccentric (22.5%, $P< 0.05$) contraction. Conclusion: These results suggest that one bout of whole body vibration can transiently increase voluntary force and muscle activation of the quadriceps muscle affected by a stroke.

DOI: 10.1177/0269215507077814 Clin Rehabil 2007; 21; 782 Tekla Kornélia Tihanyi, Mónika Horváth, Gábor Fazekas, Tibor Hortobágyi and József Tihanyi patients with stroke.

Short-Term Effects of Whole-Body Vibration on Postural Control in Unilateral Chronic Stroke Patients

van Nes IJW, Geurts ACH, Hendricks HT, Duysens J:

The short-term effects of whole-body vibration as a novel method of somatosensory stimulation on postural control were investigated in 23 chronic stroke patients. While standing on a commercial platform, patients received 30-Hz oscillations at 3 mm of amplitude in the frontal plane. Balance was assessed four times at 45-min intervals with a dual-plate force platform, while quietly standing with the eyes opened and closed and while performing a voluntary weight-shifting task with visual feedback of center-of-pressure movements. Between the second and third assessments, four repetitions of 45-sec whole-body vibrations were given. The results indicated a stable baseline performance from the first to the second assessment for all tasks. After the whole-body vibration, the third assessment demonstrated a reduction in the root mean square (RMS) center-of-pressure velocity in the anteroposterior direction when standing with the eyes closed (P _ 0.01), which persisted during the fourth assessment. Furthermore, patients showed an increase in their weight-shifting speed at the third balance assessment (P _ 0.05) while their precision remained constant. No adverse effects of whole-body vibration were observed. It is concluded that whole-body vibration may be a promising candidate to improve proprioceptive control of posture in stroke patients.

Short-term effects of whole-body vibration on postural control in unilateral chronic stroke patients: Preliminary evidence. Am J Phys Med Rehabilitation 2004;83:867–873.

Circulation

Whole-Body Vibration Exercise Leads to Alterations in Muscle Blood Volume

Kerschan-Schindl K, Grampp S, Henk C, Resch H, Preisinger E, Fialka-Moser V, Imhof H. Department of Physical Medicine and Rehabilitation, University of Vienna, Vienna, Austria.

Occupationally used high-frequency vibration is supposed to have negative effects on blood flow and muscle strength. Conversely, low-frequency vibration used as a training tool appears to increase muscle strength, but

nothing is known about its effects on peripheral circulation. The aim of this investigation was to quantify alterations in muscle blood volume after whole muscle vibration--after exercising on the training device Galileo 2000. Twenty healthy adults performed a 9-min standing test. They stood with both feet on a platform, producing oscillating mechanical vibrations of 26 Hz. Alterations in muscle blood volume of the quadriceps and gastrocnemius muscles were assessed with power Doppler sonography and arterial blood flow of the popliteal artery with a Doppler ultrasound machine. Power Doppler indices indicative of muscular blood circulation in the calf and thigh significantly increased after exercise. The mean blood flow velocity in the popliteal artery increased from 6.5 to 13.0 cm x s(-1) and its resistive index was significantly reduced.

Kerschan-Schindl K., Grampp S., Henk C., Resch H., Preisinger E., Fialka-Moser V. & Imhof H. (2001). Whole-body vibration exercise leads to alterations in muscle blood volume. Clinical Physiology. 21(3). 377-382.

Arterial Stiffness Acutely Decreases after Whole-Body Vibration in Humans

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Background: Increased arterial stiffness is a well-established cardiovascular risk factor. Mechanical stimuli to artery, such as compression, elicit vasodilation and acutely decrease arterial stiffness. As whole-body vibration (WBV)-induced oscillation is propagated at least to lumbar spine, WBV mechanically stimulates abdominal and leg arteries and may decrease arterial stiffness. WBV is feasible in vulnerable and immobilized humans. Therefore, it is worthwhile to explore the possibility of WBV as a valuable adjunct to exercise training. Aim: The aim of this study was to investigate the acute effects of WBV on arterial stiffness. Methods: Ten healthy men performed WBV and control (CON) trials on separate days. The WBV session consisted of 10 sets of vibration (frequency, 26 Hz) for 60 s with an inter-set rest period of 60 s. Subjects maintained a static squat position with knees bent on a platform. In the CON trial, WBV stimulation was not imposed. Blood pressure, heart rate and brachial-ankle pulse wave velocity (baPWV), an index of arterial stiffness, were measured before and 20, 40 and 60 min after both trials. Results and conclusion: Heart rate and blood pressure did not change from baseline after both trials. Although baPWV did not change in the CON trial (baseline vs. after 20, 40 and 60 min; 1144 +/- 35 vs. 1164 +/- 41, 1142 +/- 39, and 1148 +/- 34 cm s(-1)), baPWV decreased 20 and 40 min after the WBV trial and recovered to baseline 60 min after the trial (1137 +/- 28 vs. 1107 +/- 30, 1108 +/- 28, and 1128 +/- 25 cm s(-1)). These results suggest that WBV acutely decreases arterial stiffness.

Otsuki T., Takanami Y., Aoi W., Kawai Y., Ichikawa H. & Yoshikawa T. (2008). Arterial stiffness acutely decreases after whole-body vibration in humans. Acta Physiologica. [Epub ahead of print]

Other

Hormonal Responses to Whole-Body Vibration in Men

Bosco C, Iacovelli M, Tsarpela O, Cardinale M, Bonifazi M, Tihanyi J, Viru M, De Lorenzo A, Viru A. Societa Stampa Sportiva, Rome, Italy.

The aim of this study was to evaluate the acute responses of blood hormone concentrations and neuromuscular performance following whole-body vibration (WBV) treatment. Fourteen male subjects [mean (SD) age 25 (4.6)

years] were exposed to vertical sinusoidal WBV, 10 times for 60 s, with 60 s rest between the vibration sets (a rest period lasting 6 min was allowed after 5 vibration sets). Neuromuscular performance tests consisting of counter-movement jumps and maximal dynamic leg presses on a slide machine, performed with an extra load of 160% of the subjects body mass, and with both legs were administered before and immediately after the WBV treatment. The average velocity, acceleration, average force, and power were calculated and the root mean square electromyogram (EMGrms) were recorded from the vastus lateralis and rectus femoris muscles simultaneously during the leg-press measurement. Blood samples were also collected, and plasma concentrations of testosterone (T), growth hormone (GH) and cortisol (C) were measured. The results showed a significant increase in the plasma concentration of T and GH, whereas C levels decreased. An increase in the mechanical power output of the leg extensor muscles was observed together with a reduction in EMGrms activity. Neuromuscular efficiency improved, as indicated by the decrease in the ratio between EMGrms and power. Jumping performance, which was measured using the counter-movement jump test, was also enhanced. Thus, it can be argued that the biological mechanism produced by vibration is similar to the effect produced by explosive power training (jumping and bouncing). The enhancement of explosive power could have been induced by an increase in the synchronization activity of the motor units, and/or improved co-ordination of the synergistic muscles and increased inhibition of the antagonists. These results suggest that WBV treatment leads to acute responses of hormonal profile and neuromuscular performance. It is therefore likely that the effect of WBV treatment elicited a biological adaptation that is connected to a neural potentiation effect, similar to those reported to occur following resistance and explosive power training. In conclusion, it is suggested that WBV influences proprioceptive feedback mechanisms and specific neural components, leading to an improvement of neuromuscular performance. Moreover, since the hormonal responses, characterized by an increase in T and GH concentration and a decrease in C concentration, and the increase in neuromuscular effectiveness were simultaneous but independent, it is speculated that the two phenomena might have common underlying mechanisms.

Bosco C., Iacovelli M., Tsarpela O., Cardinale M., Bonifazi M., Tihanyi J., Viru M., De Lorenzo A. & Viru A. (2000). Hormonal responses to whole-body vibration in men. European Journal of Applied Physiology. 81(6). 449-454.

Efficiency of Vibration Exercise for Glycemic Control in Type 2 Diabetes Patients

Klaus Baum[1], Tim Votteler[2], Jürgen Schiab[2]
Research Paper, Received: 2007.02.28; Accepted: 2007.05.29; Published: 2007.05.31

In the present study we compared VE with the influence of strength training and a control group (flexibility training) on glycemic control in type 2 diabetes patients. Forty adult non-insulin dependent patients participated in the intervention. Fasting glucose concentration, an oral glucose tolerance test (OGTT), hemoglobin A1c (HbA1c), the isometric maximal torque of quadriceps muscles, and endurance capacity were evaluated at baseline and after 12 weeks of training with three training sessions per week. The main findings are: Fasting glucose concentrations remained unchanged after training. The area under curve and maximal glucose concentration of OGTT were reduced in the vibration and strength training group. HbA1c values tended to decrease below baseline date in the vibration training group while it increased in the two other intervention groups. Theses findings suggest that vibration exercise may be an effective and low time consuming tool to enhance glycemic control in type 2 diabetes patients. Transmissibility of 15-Hertz to 35-Hertz Vibrations to the Human Hip and Lumbar Spine: Determining the Physiologic Feasibility of Delivering Low-Level Anabolic Mechanical Stimuli to Skeletal Regions at Greatest Risk of Fracture Because of Osteoporosis

International Journal of Medical Sciences, ISSN 1449-1907, www.medsci-org 2007 4(3): 159-163Klaus Baum1, Tim Votteler, Jürgen Schiab, Received: 2007.02.28; Accepted: 2007.05.29; Published: 2007.05.31

The Effects of Vibration on Human Performance and Hormonal Profile

Marco Cardinale , Budapest 2002

Summary: Gravity normally provides the major portion of the mechanical stimulus responsible for the development of the muscle structure during everyday life and during training. In this connection, simulation of hypergravity (wearing vests with extra loads) conditions has been utilized for enhancement of human explosive muscle power (Bosco et al., 1984; Bosco 1985). On the other hand, changes of the gravitational conditions can be produced also by mechanical vibrations applied to the whole body. In light of the above observations, it can be assumed that application of whole body vibration and/or locally applied vibrations to physical active subjects could influence the mechanical behavior of lower and upper limbs' muscles. The aim of this work was to study the effects of vibrations on human performance and hormonal profile and to provide further information for applying vibration exercise in the athletic setting. **Methods:** A total of sixty-two subjects voluntarily participated to the studies. They were all physically active and involved in regular exercise. The following were included: Vertical Jumping; Iso-inertial Dynamometry; Electromyography. EMG analyses; Hormonal measurement; Blood Lactate measurement. **Conclusions:**These findings suggest that vibration could represent an effective exercise intervention for enhancing neuromuscular performance in athletes. However, it seems appropriate to consider other applications to the general population. We are convinced that vibration could be an effective exercise intervention for reducing the effects of aging on musculoskeletal structures. The potential influence of vibration on hormonal activity also opens interesting perspectives for its application in training and rehabilitation programs for different pathologies. Due to the enormous potentials of vibration exercise treatments, it is also important to study the effects of long-term vibration exercise programs on different physiological parameters and define safe exercise protocols based upon individual responses to vibration stimuli.

Doctoral Program:Empirical and theoretical issues in sport sciences, Program Director: Prof. Dr. Frenkl Ròbert, Supervisor: Prof. Dr. Carmelo Bosco, Budapest 2002

Effects of Whole-Body Vibration in Patients with Multiple Sclerosis: A Pilot Study

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Objective: To examine whether a whole-body vibration (mechanical oscillations) in comparison to a placebo administration leads to better postural control, mobility and balance in patients with multiple sclerosis. DESIGN: Double-blind, randomized controlled trial. **Setting**: Outpatient clinic of a university department of physical medicine and rehabilitation. **Subjects:** Twelve multiple sclerosis patients with moderate disability (Kurtzke's Expanded Disability Status Scale 2.5-5) were allocated either to the intervention group or to the placebo group. **Interventions**: In the intervention group a whole-body vibration at low frequency (2.0-4.4 Hz oscillations at 3-mm amplitude) in five series of 1 min each with a 1-min break between the series was applied. In the placebo group a Burst-transcutaneous electrical nerve stimulation (TENS) application on the non-dominant forearm in five series of 1 min each with a 1-min break between the series was applied as well. **Main Outcome Measures:** Posturographic assessment using the Sensory Organization Test, the Timed Get Up and Go Test and the Functional Reach Test immediately preceding the application, 15 min, one week and two weeks after the application. The statistical analysis was applied to the change score from pre-application values to values 15 min, one week and two weeks post intervention. **Results**: Compared with the placebo group the intervention group showed advantages in terms of the Sensory Organization Test and the Timed Get Up and Go Test at each time point of measurement after the application. The effects were strongest one week after the intervention, where

significant differences for the change score (p = 0.041) were found for the Timed Get Up and Go Test with the mean score reducing from 9.2 s (pre-application) to 8.2 s one week after whole-body vibration and increasing from 9.5 s (pre-application) to 10.2 s one week after placebo application. The mean values of the posturographic assessment increased from 70.5 points (pre-application) to 77.5 points one week after whole body vibration and increased only from 67.2 points (pre-application) to 67.5 points one week after the placebo application. No differences were found for the Functional Reach Test. **Conclusion**: The results of this pilot study indicated that whole-body vibration may positively influence the postural control and mobility in multiple sclerosis patients.

Schuhfried O., Mittermaier C., Jovanovic T., Pieber K. & Paternostro-Sluga T. (2005). Effects of whole-body vibration in patients with multiple sclerosis:a pilot study. Clinical Rehabilitation. 19(8). 834-842.

Submaximal Aerobic Exercise with Mechanical Vibrations Improves the Functional Status of Patients with Chronic Fatigue Syndrome

Saggini R, Vecchiet J, Iezzi S, Racciatti D, Affaitati G, Bellomo RG, Pizzigallo E. Physical Therapy Institute, Department of Medicine and Aging, G. D'Annunzio University, Chieti, Italy.

AIM: Chronic fatigue syndrome (CFS) is an illness characterised by disabling fatigue of uncertain aetiology and other nonspecific symptoms. Typically CFS patients complain of a severe fatigue made worse by exercise, with a consistent reduction of working activity. A physical deconditioning could explain CFS features as well as a neuromuscular dysfunction, of central or peripheric origin. METHODS: Ten CFS patients were enrolled in a protocol of a rehabilitative treatment over a six-month period: they underwent a submaximal and predominantly aerobic exercise with a reduced O2 consumption using a Galileo 2000 system that provides mechanical vibrations characterised by sinusoid vertical sollecitations. Before and after such treatment, all patients underwent a pressure pain thresholds profile, an evaluation of physical and psychosocial parameters using the visual analogue scale (VAS) of Scott-Huskisson, and a muscle performance analysis by the CIBEX 6000 dynamometer. RESULTS: After the six-month period of study there was an overall improvement of the above described parameters as compared to the basal determinations. CONCLUSION: We conclude that the rehabilitative exertion provides an useful treatment for CFS patients particularly to realize an effective training of the explosive strength.

Saggini R., Vecchiet J., Iezzi S., Racciatti D., Affaitati G., Bellomo R.G. & Pizzigallo E. (2006). Submaximal aerobic exercise with mechanical vibrations improves the functional status of patients with chronic fatigue syndrome. Europa Medocophysica. 42(2). 97-102.

Effects of Random Whole-Body Vibration on Postural Control in Parkinson's Disease

Turbanski S, Haas CT, Schmidtbleicher D, Friedrich A, Duisberg P. Institute of Sport Sciences, Johann Wolfgang Goetge-University, Frankfurt/Main, Germany Parkinson’s Disease Hospital, Bad Nauheim, Germany

We investigated spontaneous effects of random whole-body vibration (rWBV) on postural control in Parkinsonian subjects. Effects were examined in biomechanical tests from a total of 52 patients divided equally into one experimental and one control group. Postural control was tested pre- and post-treatment in two standardized

conditions (narrow standing and tandem standing). The intervention was based on rWBV (y: 3 mm, f: 6 Hz 1 Hz/sec) consisting of 5 series lasting 60 seconds each. The main findings from this study were that (1) rWBV can improve postural stability in Parkinson's disease (PD) spontaneously (2) these effects depend on the test condition. Based on the results of this study, rWBV can be regarded as an additional device in physical therapy in PD.

Turbanski S., Haas C.T., Schmidtbleicher D., Friedrich A. & Duisberg P. (2005). Effects of random whole-body vibration on postural control in parkinson's disease. Research in Sports Medicine. 13(3). 243-256.
