The effect of whole body vibration therapy on bone density in patients with thalassemia: A pilot study

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Patients with thalassemia (Thal) have low bone mass which can lead to fracture and decreased quality of life. There are no noninvasive anabolic therapies available to improve bone health in Thal.

A longitudinal cross-over pilot trial was conducted to evaluate the effectiveness of low magnitude whole body vibration (WBV) therapy on bone in 18 patients with Thal (9 adults, 10 male, 22.1 ± 10.7 years). Subjects were asked to stand on a vibrating platform (30 Hz, 0.3 g) for 20 min/day for 6 months. Areal bone mineral density (aBMD) by DXA and volumetric BMD by peripheral quantitative computed tomography (pQCT) was assessed at baseline, 6 and 12 months. Adherence in the first 3 months was greater when compared with the second 3 months (14 ± 6 vs. 10 ± 7 min/day, P50.007). Intention to treat analysis revealed a significant increase in whole body BMC (2.6%; P 5 0.021), BMC/Ht (2.6%, P 5 0.02) and aBMD (1.3%; P 5 0.036), as well as a net increase in serum markers of bone formation (Osteocalcin/CTx, P 5 0.027) in the adult subjects.

These preliminary findings suggest that vibration therapy may be an effective non-pharmacologic intervention in Thal. Future research is needed to confirm these findings in a larger sample for longer duration.

Effect of whole body vibration (WBV) therapy on bone density and bone quality in osteopenic girls with adolescent idiopathic scoliosis: a randomized, controlled trial

Osteoporos Int DOI 10.1007/s00198-012-2144-1

Abstract
Summary - The aim of this randomized controlled trial was to determine whether whole body vibration (WBV) therapy was effective for treating osteopenia in adolescent idiopathic scoliosis (AIS) patients. Results showed that WBV was effective for improving areal bone mineral density (aBMD) at the femoral neck of the dominant side and lumbar spine BMC in AIS subjects.

Effect of High Frequency, Low Magnitude Vibration on Bone and Muscle in Children with Cerebral Palsy

J Pediatr Orthop. 2010 ; 30(7): 732–738. doi:10.1097/BPO.0b013e3181efbabc.

BACKGROUND—Children with cerebral palsy (CP) have decreased strength, low bone mass, and an increased propensity to fracture. High frequency, low magnitude vibration might provide a non-invasive, non-pharmacological, home-based treatment for these musculoskeletal deficits. The purpose of this study was to examine the effects of this intervention on bone and muscle in children with CP.

METHODS—Thirty-one children with CP ages 6-12 years (mean 9.4, SD 1.4) stood on a vibrating platform (30 Hz, 0.3 g peak acceleration) at home for 10 min/day for 6 months and on the floor without the platform for another 6 months. The order of vibration and standing was randomized, and outcomes were measured at 0, 6, and 12 months. The outcome measures included computed tomography measurements of vertebral cancellous bone density (CBD) and cross-sectional area, CBD of the proximal tibia, geometric properties of the tibial diaphysis, and dynamometer measurements of plantar flexor strength. Outcomes were assessed using mixed model linear regression and Pearson's correlation.

RESULTS—The main difference between vibration and standing was greater increases in the cortical bone properties (cortical bone area and moments of inertia) during the vibration period (all p's ≤ 0.03). There was no difference in cancellous bone or muscle between vibration and standing (all p's > 0.10) and no correlation between compliance and outcome (all r's < 0.27; all p's > 0.15). The results did not depend on the order of treatment (p > 0.43) and was similar for children in GMFCS 1-2 and GMFCS 3-4.

CONCLUSIONS—The primary benefit of the vibration intervention in children with CP was to cortical bone in the appendicular skeleton. Increased cortical bone area and structural (strength) properties could translate into a

decreased risk of long bone fractures for some patients. More research is needed to corroborate these findings, to elucidate the mechanisms of the intervention, and to determine the most effective age and duration for the treatment.

Reversal of Lower-limb Edema by Calf Muscle Pump Stimulation.

J. Cardiopulmonary Rehab. & Prevention. 28:174-179. (2008)

Shows Juvent stimulation reverses fluid pooling in the lower limbs. It offers a simple counter-measure to address a problem affecting 40% of adult women.

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

J Bone Miner Res 2006; 21:1464–1474. Published online on June 26, 2006; doi: 10.1359/JBMR.060612

ABSTRACT: 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.

Plantar vibration improves leg fluid flow in peri-menopausal women.

Am.J. Physiol. Regul. Intergr. Comp. Physiol. 288:R623-R629 (2005)

Shows Juvent increases in peripheral, systemic blood flow, peripheral lymphatic flow and venous drainage from the lower limb, thereby providing an efficient, potential counter-measure for patients with inefficient calf muscle pump (most elderly or immobile people).

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

(Journal of Bone and Mineral Research, Vol.19, Number 3, 2004)

Abstract: A 1-year, prospective, randomized, double-blind, and placebo-controlled trial of 70 postmenopausal women demonstrated that brief periods (<20 minutes) of low-level (0.2g, 30 Hz) vibration applied during quiet standing can effectively inhibit bone loss in the spine and femur, with efficacy increasing significantly with greater compliance, particularly in those subjects with lover body mass.

Low level, high frequency vibrational loading can be safely and efficiently applied to the human skeleton, with approximately 80% of the loads reaching the hip and spine in the standing or sitting human.

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. Spine, Vol. 28, No. 23, pp 2621-2627, 2003.

The mechanical vibration from the Juvent DMT device is transmitted non-invasively through the plantar surface of the foot to the lower appendicular and axial skeleton of a standing individual (Figure 1). At 30 Hz, The International Organization for Standardization (ISO), in standard ISO-2631, and in ISO-7962 sets an exposure limit of 21.2 m/sÇ DMT, corresponding to sinusoidal 4.24g peak-to peak accelerations of the standing human for 20 minutes. (ISO, 1985).

In clinical use, the Juvent device applies accelerations of 0.3 g at 30 Hz to the standing human for a daily time duration of less than 30 minutes, and is, therefore, well below the ISO exposure limit of 4.24.g., a transmissibility study was performed. To establish the transmissibility of high frequency vibration to the lower appendicular and axial skeleton and to ensure this vibration would not couple into any untoward resonances in the musculo-skeletal system, experiments were conducted on six human volunteers (age 23-33 years). Under sterile conditions and local anesthesia, transcutaneous Steinman pins were placed in the spinous process of L4 and the greater trochanter of the femur of the volunteers. Each subject stood on a vibrating platform and data were collected from accelerometers fixed to the pins while the platform provided sinusoidal loading at discrete frequencies from 15 to 35

Hz, with accelerations ranging up to 1 g peak-peak. Acceleration transmissibility was determined for frequencies of 15 Hz to 40 Hz and at accelerations of 0.1 g to 0.5 g.

At frequencies above 25 Hz, transmissibility of the applied foot reaction forces to the hip and spine reached approximately 80% when the subjects stood erect (Figure 2). Standing with knees bent at 20º reduced the transmissibility to 30% in the hip, and 50% in the spine. Transmissibility decreased with increasing frequency beyond 30Hz. Subjects were tested sitting on the DMT device with similar results.
For frequencies below approximately 20 Hz, distinct resonances in the hip could be identified. At frequencies above 20 Hz, an apparent resonance could be identified near 25Hz, though the mean transmissibility never exceeded 0.7 in this frequency range. Some subjects noted a slight effect on visual processes in the frequency regime between 25 and 28 Hz. These data indicated that the safest point of operation for whole body vibration would be at frequencies from 30Hz. and above, while remaining within the frequency range of Type IIa muscle fibers, i.e. below approximately 50 Hz.

These data indicate that extremely low-level, high-frequency mechanical accelerations are readily transmitted into the lower appendicular and axial skeleton of the standing individual

Significant improvements in muscle dynamics resulted from treatment with the Juvent DMT device. Postural stability was significantly improved in an eight week study; Type IIa muscle fiber activity was significantly increased in older (> 65 years) women; and neuro-muscular activity was significantly improved as reflected in the response of peri- and post-menopausal women to orthostatic stress.

The role of postural sway in the maintenance of bone mass. Trans. Am. Soc. Bone & Min. Res. 2002, Frequency dependent response of the cardio-vascular system to foot based vibration while in the seated position. Trans. Biomed. Eng. Soc., 2002

The Juvent DMT device does effectively mimic the activity of Type IIa skeletal muscle fibers as determined by several recent investigations. In a study involving 15 adult women age 22-58 years, ten minutes per day of treatment for eight weeks with a 30 Hz, 0.2 g vibration was observed to produce a significant improvement in the postural stability. Vibromyography was used to measure the specific Type IIa muscle fiber activity in the 20 to 50 Hz range in a group of twelve elderly women (65-85 years) who self-treated for 30 minutes per day with a 30 Hz, 0.3g vibration during quiet standing. After two months, Type IIa fiber activity had increased significantly ($p=0.05$) by the Wilcoxon signed rank test (Fig. 1).

Type IIa muscle fibers play a critical role in maintaining adequate venous and lymphatic return from the lower limbs, and therefore in the maintenance and growth of tissues in the lower extremities, including bone formation. The Juvent DMT device's role in replacing Type IIa muscle fiber activity in skeletal muscle pumping, and thereby modifying the cardio-vascular response to orthostatic stress, was evaluated in a group of 32 women age 30-80 years. During upright posture, blood pressure falls in response to inadequate skeletal muscle pump activity, and a significant drop of approximately 15 mm Hg in mean arterial pressure was observed in this subject group. However, during treatment with the Juvent device, this blood pressure drop could be significantly inhibited, with the maximum benefit observed in the 30-60 Hz range. Additional testing at the NY Medical Center investigated the influence of Juvent vibration on lymphatic return using strain gage plethysmographic measurements. The Juvent DMT device was found to significantly improve lymphatic return (Figure 2).

A clinical trial on children with cerebral palsy demonstrated an 11% increase in trabecular bone density in the tibia following six months of treatment, in contrast to the 6% loss of bone mineral density in children standing on placebo devices.

Low Magnitude Mechanical Loading is Osteogenic in Children with Disabling Conditions. J Bone Min Res, accepted for publication, March, 2004.

In summary, this pilot RCT in children with disabling conditions provides evidence that short durations of extremely low magnitude high frequency mechanical loading can significantly increase vTBMD of the proximal tibia, with a positive trend observed in the spine. These data are indicative of the potential of this unique, biomechanically based intervention to offer a non-pharmacological, non-invasive method to increase low trabecular bone mineral density in humans.

A clinical trial on adolescent females (10-13yr) with osteoporosis showed a significant increase in BMD of both cortical and trabecular bone of the tibia, as well as an increase in muscle mass of the thigh, following two months of treatment.

Short Term Low Level Mechanical Stimulation Increases Cancellous and Cortical Bone Density and Muscles of Females with Osteoporosis: A Pilot Study. Endocrine Society Transactions in press. 2002.

This data indicates that the Juvent low amplitude, high frequency device is an effective, non-pharmacologic means of significantly increasing bone density in the cancellous bone of the lower appendicular spine (CaBD) and in the cortical bone of the femurs (CoBD) of children with osteopenia or osteoporosis as well as increasing muscle mass over the femurs in the short term period.

This clinical study assessed compliance with standing for 10 minutes/day on a Juvent DMT device. The compliance with the required daily use period and the satisfaction with the daily use of the device was assessed in the target population for osteoporosis therapy, elderly women.

Establishing the Compliance in Elderly Women for Use of a Low Level Mechanical Stress Device in a Clinical Osteoporosis Study

Conclusions: Elderly women showed high compliance, high satisfaction and few adverse experiences with a daily non-pharmacologic treatment designed to inhibit bone loss. Larger randomized controlled trials should evaluate the long-term efficacy of vibrating platform devices for treatment of low bone mass and osteoporosis in elderly individuals.