Whole –body Vibration

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As a therapy, **whole body vibration** (sometimes abbreviated as **WBV**) was explored by Russian scientist Vladimir Nazarov, who tested vibration on cosmonauts in an effort to decrease the loss of muscle and bone mass in space. As there is minimal gravitational force in space, muscles and bones are not loaded as they normally are on earth. Cosmonauts (and astronauts) in space lose their muscular strength very quickly, which is why they are not able to easily walk when they come back to earth. The decrease of bone density increases the risk of bone fractures, so it's not safe to stay in space for extended periods. The aerospace industry in the former Soviet Union worked with vibration training. Before their departure, cosmonauts were subjected to special training sessions so that the density of their bones would increase and their muscular strength would rise.

A particular form of WBV is vibration training, which is becoming increasingly popular. Initially, vibration training was mainly used in the fitness industry, but the use of vibration equipment is expanding quickly. It is now widely used in physical therapy, rehabilitation and professional sports, but it is also increasingly used for beauty and wellness applications

What it is

The first applications of vibration for the improvement of human performance were developed in ancient Greece; a saw covered in cotton was used as a tool to transmit mechanical vibrations to the part of the body that was not functioning properly.[*citation needed*] In the 1880s and 1890s, Dr. John Harvey Kellogg was utilizing vibrating chairs, platforms and bars at his Battle Creek, Michigan sanitarium. These methods were part of his "wellness" strategies for inpatient and outpatient populations.

The immediate predecessor of modern vibration training is Rhythmic Neuromuscular Stimulation (RNS). In former East Germany Dr. Biermann was experimenting with the use of cyclic oscillations and their effects on the human body back in the sixties (*Biermann, 1960* [1]).

In that same era the Russian scientist Nazarov translated these findings into practical uses for athletes. He observed a substantial increase in flexibility and strength after the application of vibrations in the athletes he studied (*Kunnemeyer & Smidtbleicher, 1997* [2]). The Russians also carried out experiments with "Biomechanical Stimulation" for the benefit of their athletes as well as in their space program. Unlike WBV devices on which the user stands, Biomechanical Stimulation uses vibration stimulation directly on muscles or tendons.

The Russian Space Institute (RSI)[*citation needed*], the European Space Agency[3][4][5] and NASA are experimenting with various types of vibration training systems in order to get the ultimate benefits from the vibration stimulus. Due to the lack of gravity in space, astronauts and cosmonauts exhibited muscle atrophy (muscle impairment) and bone loss, which forced them to return to earth rather quickly. For rehabilitation after prolonged space flights, Russian scientists experimented with biomechanical stimulation. Once the Iron Curtain had been dismantled, the West could finally profit from the information and experience that had been gained in the previous years.

Whole-body vibration platforms enable the user to train various skeletal muscles, and trigger other body reactions. The effects are used in sports, fitness, aesthetics, rehabilitation and medical therapies. Several hundred peer-reviewed papers have been published on the effects of WBV, and the number of research studies conducted every year is accelerating. Effects described in the studies include: muscle strength and toning, cellulite reduction, improved bone density, heightened secretion of hormones associated with exercise, and depressed response of hormones associated with stress. Several inventions regarding whole body vibration devices have also been patented.

There are currently many whole body vibration machine brands and types of machine available. These vary in quality, design specifications and manufacturing materials. Some machines are able to provide the benefits that are described in the studies, others do not. In fitness centers or when buying for home use intended results need to be matched with the machine type and quality chosen. There are machines designed specifically for physical fitness training or muscle build while others are efficacious in physical therapy.

[edit] How it works

As apparent from its name, in WBV, the entire body is exposed to vibration, as opposed to local vibration (Biomechanical Stimulation, BMS), where an isolated muscle or muscle group is stimulated by the use of a vibration device. Whole body vibration is implemented through the use of a vibrating platform on which static poses are held or dynamic exercises can be performed depending on the type and force of the machine. The vibrations generated by motors underneath the platform are transmitted to the person on the machine. The intensity, defined by the parameters frequency, amplitude, magnitude (light vibration versus heavy vibration) and the direction of these vibrations are essential for their effect.

[edit] Vibration Platform Types

Vibration platforms fall into different, distinct categories. The type of platform used is a moderator of the effect and result of the training or therapy performed (*Marin PJ, Rhea MR, 2010* [6]). Main categories of machine types are: 1. High Energy Lineal, found mostly in commercial vibration training studios and gyms. The vibration direction is lineal/upward eliciting a strong stretch-reflex contraction in muscle fibres targeted by the positions of

training program. 2. Premium Speed Pivotal, (teeter-totter movement) used for physiotherapy work at lower speeds and exercise workouts at “premium” speed, up to 27 Hz. Both commercial and home units are available. 3. Medium Energy Lineal, the majority of lineal platforms produced. These are usually made of plastic; some have 3-D vibration which is low quality. They give slower and less consistent results. 4. Low Speed Pivotal units. These can give “therapy” benefits. Other machine types are low Energy/Low amplitude lineal and Low energy/High amplitude lineal with varying uses from osteoporosis prevention, therapy for improved blood circulation and flexibility and limited fitness training.

In order to elicit a stretch reflex in the muscles, the major contributing factor to the training results that can be achieved with vibration platforms, the up-down movement is the most important. The platform is vibrated upwards to work directly against gravity and therefore is called "hyper-gravity". High Energy Lineal Machines can overload the muscles up to 6 times(6G)in the upward phase; meaning the person on the platform is weight training using their own body mass.

The training frequency (Hz) is another of the important factors involved. The human body is designed to absorb vertical vibrations better due to the effects of gravity; however, many machines vibrate in more than one direction: sideways (x), front and back (y) and up and down (z). The z-axis has the largest amplitude and is the most defining component in generating and inducing muscle contractions.

Concerning the z-movements, two main types of system can be distinguished (*Marin PJ et al. 2010* [6], *Rittweger 2010*[7], *Rauch 2010*[8]) :

- Side alternating (pivotal) systems, operating like a see-saw and hence mimicking the human gait where one foot is always moving upwards and the other one downwards, and
- Linear systems where the whole platform is mainly doing the same motion, respectively: both feet are moved upwards or downwards at the same time.

Systems with side alternation usually offer a larger amplitude of oscillation and a frequency range of about 5 Hz to 35 Hz. Linear/upright systems offer lower amplitudes but higher frequencies in the range of 20 Hz to 50 Hz. Despite the larger amplitudes of side-alternating systems, the vibration (acceleration) transmitted to the head is significantly smaller than in non side-alternating systems (*Abercromby et al. 2007*[9]). This difference can be a determining factor when choosing a platform for therapy versus training effects.

Mechanical stimulation generates acceleration forces acting on the body. These forces cause the muscles to lengthen, and this signal is received by the muscle spindle, a small organ in the muscle. This spindle transmits the signal through the central nervous system to the muscles involved (*Abercromby et al. 2007* [9], *Burkhardt 2006*[10]).

Due to this subconscious contraction of the muscles, many more muscle fibers are used than in a conscious, voluntary movement (*Issurin & Tenenbaum 1999* [11]). This is also obvious from the heightened EMG activity (*Bosco et al. 1999* [12], *Delecluse et al. 2003* [13]).

[edit] Training effects

[edit] Immediate and short term

More motor units (and the correlating muscle fibers) are activated under the influence of vibration than in normal, conscious muscle contractions. Due to this, muscles are incited more efficiently (*Paradisis & Zacharogiannis 2007* [14]; *Lamont et al. 2006* [15]; *Cormie et al. 2006* [16]; ; *Bosco et al. 1999* [12], *2000* [17]; *Rittweger 2001* [18], *2002* [19]; *Abercromby et al. 2005* [20]; *Amonette et al. 2005* [21]). The immediate effect of WBV is therefore that the muscles can be used quickly and efficiently, rendering them capable of producing more force. However, this process will only be effective if the stimulus is not too intense and does not last too long, because otherwise performance will diminish due to fatigue.

Another immediate effect of WBV is an improvement of circulation. The rapid contraction and relaxation of the muscles at 20 to 50 times per second basically works as a pump on the blood vessels and lymphatic vessels, increasing the speed of the blood flow through the body (*Kerschan-Schindl et al. 2001* [22]; *Lohman et al. 2007* [23]). Subjects often experience this as a tingling, prickling, warm sensation in the skin. Both Stewart (2005 [24]) and Oliveri (1989 [25]) describe the appearance of vasodilatation (widening of the blood vessels) as a result of vibration

[edit] Long term

In order to have any effect on the body in the long term it is vital that the body systems experience fatigue or some sort of light stress. As in other kinds of training, when the body is overloaded repeatedly and regularly, the principle of supercompensation applies. This principle is the cause of the body adapting to loading. In other words: performance will increase.

This effect has been proven several times in scientific research for both young and elderly subjects (*Roelants et al. 2004* [26], *Delecluse et al. 2003* [13], *Verschueren et al. 2004* [27], *Paradisis et al. 2007* [14]). The only placebo-controlled study to date (*Delecluse et al. 2003* [13]) concluded "specific Whole Body Vibration protocol of 5 weeks had no surplus value upon the conventional training program to improve speed-strength performance in sprint-trained athletes". Therefore there is no clear indication that the vibrations actually do have added value when performing static exercises.

From research into the structural effects of vibration training it can be deduced that the increased strength resulting from WBV training can definitely be compared to the results that can be attained with conventional methods of training. But there are indications that better results may be achieved with WBV in the area of **explosive power** (*Delecluse et al. 2003* [13]).

Another important difference between conventional training methods and WBV is that there is only a minimum of loading. No additional weights are necessary, which ensures that there is very little loading to passive structures such as bones, ligaments and joints. That is why WBV is highly suited to people that are difficult to train due to old age, illness, disorders, weight or injury. On the other hand, it is also highly suitable for professional athletes who want to stimulate and strengthen their muscles without overloading joints and the rest of the physical system (*Cochrane et al. 2005* [28]; *Mahieu et al. 2006* [29]).

Other than its influence on the muscles, WBV can also have a positive effect on bone mineral density. Vibrations cause compression and remodeling of the bone tissue Mechanostat[30][31][32][33], activating the osteoblasts (bone building cells), while reducing the

activity of the osteoclasts (cells that break bone down). Repeated stimulation of this system, combined with the increased pull on the bones by the muscles, will increase bone mineral density over time. It is also likely that improved circulation and the related bone perfusion due to a better supply of nutrients, which are also more able to penetrate the bone tissue, are contributing factors (*Verschueren 2004* [27], *Jordan 2005* [34], *Olof Johnell & John Eisman, 2004* [35], *Rubin et al. 2004* [36]).

Furthermore the Berlin Bedrest Study (*BBR*) proved that 10 minutes of vibration training 6 times a week prevented muscle and bone loss in total bedrest over 55 days (*Rittweger et al. 2004* [3], *Felsenberg et al. 2004* [4], *Bleeker et al. 2005* [5], *Blottner et al. 2006* [37]).

In preventing falls and the bone fractures that often result from them, enhancing bone mineral density is not the only important issue. Increased muscle power, postural control and balance are also factors worthy of consideration. Studies involving elderly subjects have shown that all of these issues can be improved using whole body vibration (*Roelants et al. 2004* [26], *Bautmans et al. 2005* [38], *Bogaerts et al. 2007* [39], *Kawanabe et al. 2007* [40]).

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[edit] Recommendations for reporting whole-body vibration intervention studies

- Rauch F, Sievanen H, Boonen S, Cardinale M, Degens H, Felsenberg D, Roth J, Schoenau E, Verschueren S, Rittweger J: *Reporting whole-body vibration intervention studies: Recommendations of the International Society of Musculoskeletal and Neuronal Interactions*, J Musculoskelet Neuronal Interact., 10(3):193-8, 2010; PMID 20811143

[edit] Literature

- Albasini, Krause, Rembitzki: *Using Whole Body Vibration in Physical Therapy and Sport: Clinical Practice and Treatment Exercises*, Elsevier Health, 2010, ISBN 978-0702031731

[edit] External links

- Berlin BedRest-Study 1 - Zentrum für Muskel und Knochen (ZMK) Charité, Berlin, sponsored by the European Space Agency (ESA)
- Berlin BedRest-Study 2 - Zentrum für Muskel und Knochen (ZMK) Charité, Berlin, sponsored by the European Space Agency (ESA) and the Deutsches Zentrum für Luft- und Raumfahrt (DLR)

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