Whole body vibration Wikipedia (last edited October 2007)

Whole Body Vibration: function and effects Whole-Body Vibration (WBV) is a term used to describe human exposure to vibration through feet, buttock and/or back. This is opposed to Hand-Arm Vibration (HAV), where the vibration is transferred through the hand and arm. The public is in general rather aware about risks associated with HAV (Raynaud´s disease, "white fingers" etc). The common awareness of risks associated with WBV is much less developed. WBV may affect perception, comfort, safety and health, as described in the International Standard ISO 2631-1 (1997). In Europe, professional exposures to WBV and/or HAV are regulated in the Health and Safety Directive 2002/44/EC, which includes Action Values and Exposure Limits for 8 h daily exposures. The Directive include a requirement of expert risk assessment of transient vibration (mechanical shock) exposure, such as of city bus drivers frequently riding over traffic calming speed bumps. Such risk assessment can be performed as per the standard ISO 2631-5 (2004).

A special form of WBV is vibration training, which becoming increasingly popular. Experts disagree upon if this self-applied form of WBV exposure brings any positive effect at all, or if it is only risky. However, Vibration training machines are NOT included nor to ISO 2631-1 or Safety Directive 2002/44/EC. Nevertheless, it is a growing business.

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 applied more and more often in the beauty and wellness branches.

Background

What is Whole Body Vibration?

The first applications of vibrations 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. The immediate predecessor of the 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 to practical uses for athletes. He observed a substantial increase in flexibility and strength in the athletes he studied after the application of vibrations (*Kunnemeyer & Smidtbleicher, 1997* [2]).

The Russians also performed experiments with WBV for the benefit of their space program. RSI, the Russian Space Institute as well as ESA, the European Space Agency 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, cosmonauts exhibited muscle atrophy (muscle impairment) and a decrease in bone mineral density, which forced them to return to earth rather quickly. In order to solve this problem the Russian scientists had their cosmonauts train on vibration machines.

Once the Iron Curtain had been dismantled, the West could finally profit from the information and experience that had been gathered in the previous years, and from the nineties the possibilities and applications of WBV were researched all over the world. There were also several countries where scientists and experts continued to develop its techniques.

How does Whole Body Vibration work?

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 exercises can be performed. The vibrations the engines underneath the platform generate are transmitted to the person standing, sitting or lying on the machine. The intensity and the direction of these vibrations are essential for their effect. Different vibration platforms have different vibration characteristics. Not all platforms perform in the same manner, and that is why the results of using them are different.

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. Remember that human bodies are made to absorb better vertical vibrations due the gravity effect. However, many machines vibrate in three different directions: sideways (x), front and back (y) and up and down (z), which could cause significant side effects after prolonged time of use. The z-axis has the largest amplitude and is the most defining component in generating and inducing muscle contractions. Concerning the z-movements two principle types of systems can be distinguished: side alternating systems, operating like a see-saw and hence mimicking the human gait where always one foot is moving upwards and the other one downwards and systems where the whole platform is mainly doing the same motion respectively both feet are moved upwards or downwards at the same time (*Abercromby et al 2007* [3]; *Burkhard 2006*[4]). Systems with side alternation offer a larger amplitude of oscillation and a frequency range of about 5 Hz to 35 Hz the other 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 lower then in non side-alternating systems (*Abercromby et al 2007*[3]).

The mechanical stimulation generates acceleration forces working 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. Due to this subconscious contraction of the muscles, many more muscle fibers are used than in a conscious, voluntary movement (*Issurin & Tenenbaum 1999* [5]). This is also obvious from the heightened EMG activity *Bosco et al. 1999* [6], *Delecluse et al 2003* [7]).

Training Effects of Vibration

Immediate and short term effects of WBV

Because more muscle fibers (also known as motor units) are activated under the influence of vibration than in normal, conscious muscle contractions the muscles are incited more efficiently (*Paradisis & Zacharogiannis 2007* [8]; *Lamont et al. 2006* [9]; *Cormie et al 2006* [10]; ; *Bosco et al. 1999* [6], *2000* [11]; *Rittweger 2001* [12], *2002* [13]; *Abercromby et al. 2005* [14]; *Amonette et al. 2005* [15]). 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* [16]; *Lohman et al. 2007* [17]). Subjects often experience this as a tingling, prickling, warm sensation in the skin. Both Stewart (2005 [18]) and Oliveri (1989 [19]) describe the appearance of vasodilatation (widening of the blood vessels) as a result of vibration

Long term effects of WBV

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 will occur. 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* [20], *Delecluse et al 2003* [7], *Verschueren et al 2004* [21], *Paradisis et al 2007* [22]). In the only placebo-controlled study to date (*Delecluse et al 2003* [7]) a significant increase in strength was found in the WBV group, when there was no improvement measured in the placebo group. This is a 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 deducted 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* [7]).

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 the passive structures such as bones, ligaments and joints. That is why WBV is extremely suited to people that are difficult to train due to old age, disease, disorders, weight or injury. On the other hand, it is also very 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* [23]; *Mahieu et al 2006* [24]).

Other than its influence on the muscles, WBV can also have a positive effect on bone mineral density. The vibrations cause compression and remodeling of the bone tissue Mechanostat[25][26][27][28], 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 the 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* [21], *Jordan 2005* [29], *Olof Johnell & John Eisman, 2004* [30], *Rubin et al. 2004* [31]).

Further more 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* [32], *Felsenberg et al 2004* [33], *Bleeker et al 2005* [34], *Blottner et al 2006* [35]).

In **preventing falls and the bone fractures** that they often result in, enhancing bone mineral density is not the only important issue. Increased muscle power, postural control and balance are also considerable factors. Studies involving elderly subjects have shown that all of these issues can be improved using whole body vibration (*Roelants et al 2004* [20], *Bautmans et al 2005* [36], *Bogaerts et al 2007* [37], *Kawanabe et al 2007* [38]).

References

External links

- Criticism of WBV
- 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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