Contraindications and Potential Dangers of the Use of Vibration as a Treatment for Osteoporosis and other Musculoskeletal Diseases

There is mounting scientific evidence, through both animal and clinical studies, that low-level, mechanical signals, delivered using vibration, can stimulate bone formation and perhaps curb osteoporosis. Just because some vibration may be beneficial, however, does not mean that a lot is better. Before considering vibration as an avenue of intervention for osteoporosis, it is important to consider the benefits of vibration *versus* the potential risks and complications of use. In short, vibration can be exceedingly dangerous, and is an etiologic factor in several pathologic conditions. Exposure to whole body vibration has been determined to be a central etiologic factor in low back pain [(1)], neurovestibular disorders [(2)] and Raynaud's syndrome [(3)], and thus industries such as transportation and construction [(4)], as well as the military [(5)], are working towards minimizing occupational exposure to these potentially noxious mechanical stimuli, rather than introducing them as an intervention for musculoskeletal disease.

Before considering vibration as an avenue of intervention for osteoporosis, it is important to consider the benefits of vibration *versus* the potential risks and complications of use. Noxious levels of vibration are typically considered as a function of magnitude (g-force, where 1g = earth's gravitational field, or an acceleration of 9.8 meters per second per second), frequency (Hz, or cycles per second), and duration (time of exposure). A large body of research has demonstrated a broad range of pathological responses to high frequency (5 to 100 Hz), high magnitude vibration (greater than 1g) [(6)], including irrefutable evidence of

such vibration magnitudes contributing to low back pain following extended exposure [7], and serving as a key etiologic factor in circulatory disorders such as Raynaud's syndrome [3]. Ignoring such dangers, g-forces that greatly exceed 1.0 are the very basis of devices referred to as PowerPlate, Galileo, SoloFlex, Galaxy, Nemes, and others, and should be approached with extreme caution. Conditioned athletes, should they knowingly understand these dangers and still wish to put their body at risk is one thing, but to use such interventions on the elderly, osteoporotic, or functionally impaired individuals is dubious, at best.

Considering the potential dangers of vibration, and the potential of an intervention that may well cause the very fracture it is prescribed to prevent, it is reasonable to ask if any forms of vibration are safe. Towards that end, there is no evidence of any noxious effects of 15-50 Hz vibration exposure that falls below 0.2 $g_{rms,}$ corresponding to sinusoidal accelerations of 0.56 g-force, peak to peak. In fact, for short duration exposures (up to one-half hour), the International Safety Organization threshold for human tolerance of vibration, ISO 2631, establishes a level of $0.3g_{rms}$ ($0.8\ g_{p-p}$) as the pathogenic level for vibration in the 20-50 Hz range [8]. With g-forces that exceed this level, acute discomfort arises not only from focal pain in muscle and joints, but from induced alterations in visual perception and tracking. As early as 1938, Coermann [9] reported discontinuities in visual activity between 25 and 40 Hz for whole body vibration (WBV). In addition, he noted that at some acceleration levels, vibrations above 20 Hz temporarily diminished patellar reflexes, a finding which has since been confirmed by Goldman [10], Seidel [2] and Roll et al [11]. Dupuis and Hartung [12] reported a physical resonance of the eyeball

at 20-21 Hz, and correspondingly, that visual perception time is affected during vibration exposure at 5-8 Hz, and again near 25 Hz. In contrast to concerns for the use of vibration that exceeds 1g, it should also be pointed out that no adverse effects were observed in any of the preliminary trial with humans which kept vibration below 0.3g [13-15]. Certainly, considering the demonstrated risk to so many physiologic systems, if functional disorders compromise an individual's ability to protect themselves, it is clear that vibration that approaches 1g should be studiously avoided.

The great majority of research has focused on *attenuating* the transmissibility of whole body vibration to the skeleton, with the widely held presumption that high frequency vibrations are pathogenic to the musculoskeletal system [16-18]. In cases where vibration is inevitable [7], exposure limits have been recommended by agencies focused on occupational hazards, such as the National Institute of Occupational Safety and Health, (NIOSH), Centers for Disease Control (CDC), and the International Organization for Standardization (ISO)[17]. Please note that our research has no relationship whatsoever with the technology or claims made by vibration plates used for exercise and physical training and manufactured by companies such as Galaxy, SoloFlex, Galileo, Power-Plate, NEMES, etc. The magnitudes used in those devices, *well in excess of 8.0g, are well beyond the limits recommended for human tolerance by ISO and OSHA,* are 35 times greater in amplitude than those mechanical signals that we study, are inherently dangerous, and to our knowledge, show little if any evidence that their devices are safe for bone, cartilage, muscle, tendon, ligaments or any of the major organs.

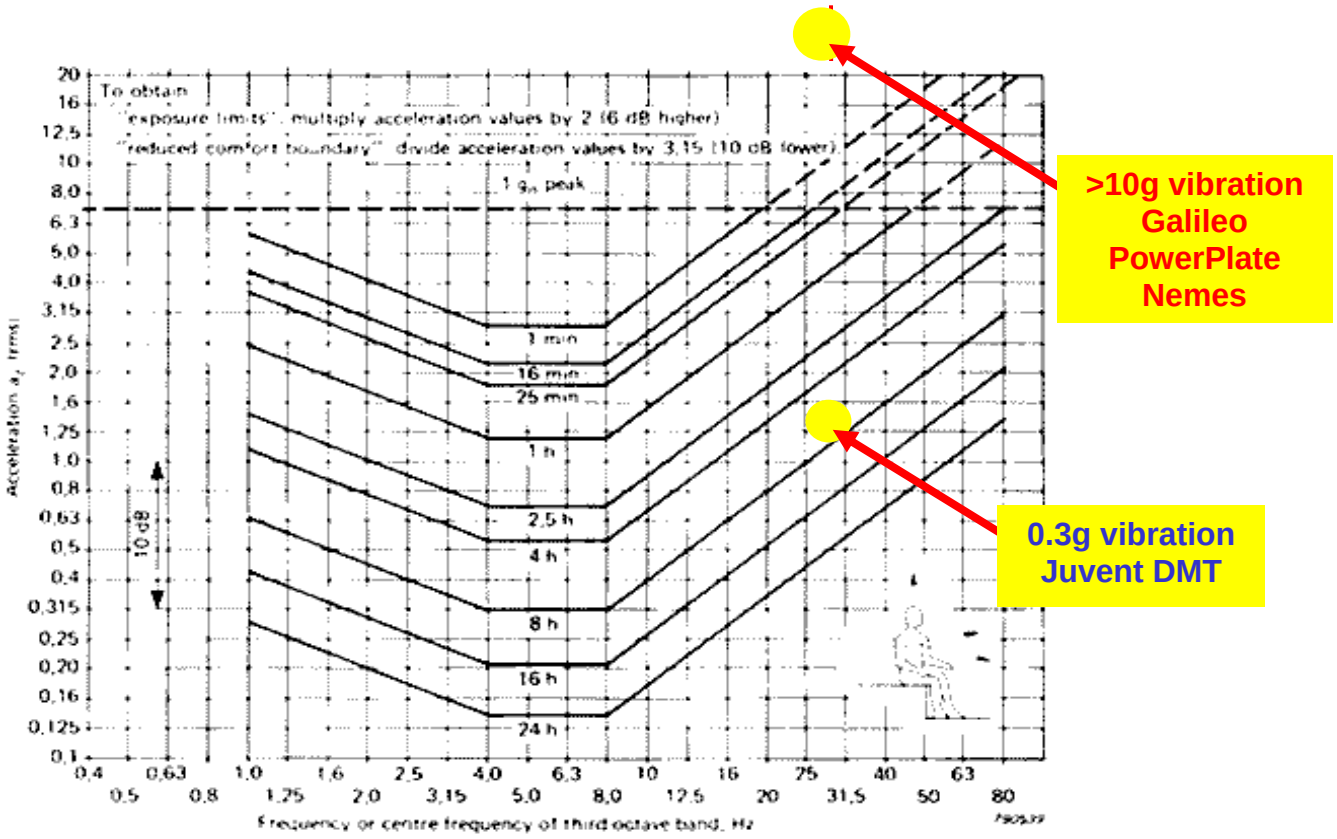
Please also note that our work has brought us to this point following several decades of searching for the mechanical signal to which bone is responsive. It is important to emphasize that although this low-level intervention is considered safe and beneficial, other frequencies and amplitudes may cause ***damage*** *to* bone and connective tissues, *and many amplitudes of vibration are considered pathogenic to the musculoskeletal (e.g., vertebral disc, cartilage, ligament, tendon), neurovestibular, and cardiovascular systems.* One should always be concerned that *"too much of a good thing"* may be true in mechanical stimulation, as well. Just because one aspirin is good for you, doesn't mean that you should take 50 aspirin per day.

Questions regarding safety:

What do you believe would be the potential short-term and long-term risks, if any, of using vibration to "treat" musculoskeletal conditions?

You have to remember that the principal reason scientists study vibration is because of the potential HARM it can do. Vibration is considered one of the principal pathogens in the high incidence of low-back pain in truck drivers and helicopter pilots, and is notorious for causing circulatory dysfunction in the extremities in occupations that use hand-held machinery. In other words, vibration is potentially very dangerous indeed, and should be approached with caution.

It is because of this concern that OSHA and the International Safety Org (ISO) have come out w/ specific advisories on duration thresholds for human tolerance, which is dependent on both frequency and duration. In the figure, below, from ISO-2631, it shows frequency (bottom), and acceleration (vertical), w/ the dark "hockey-sticks" indicating how much time you can safely be exposed to these signals.



I'm assuming that 0.3g at 30Hz is still much lower than the lower-vibration setting on the Power Plate, Galileo or other "fitness" devices? Is this true?

To try to answer this question, please refer the figure, below to mark where 30Hz (cycles per second) is, and where 0.3g shows up, indicating four hours of safe exposure each day. There is also placed a mark where "PowerPlate" and others are, in which the devices generate well over 10g… based on this graph, you should not subject yourself to any more than one second of such g-force on any given day! So, if your musculoskeletal system survives PowerPlate, there is some likelihood that there will be some long term damage. In answer to your question, 0.3g, the work we do, is 50x less, at least, than the powerplate-type devices.

References

1. Anderson JA**,** Otun EO, Sweetman BJ 1987 Occupational hazards and low back pain. Rev Environ Health **7**:121-160.
2. Seidel H**,** Harazin B**,** Pavlas K**,** Sroka C**,** Richter J**,** Bluthner R**,** Erdmann U**,** Grzesik J**,** Hinz B, Rothe R 1988 Isolated and combined effects of prolonged exposures to noise and whole-body vibration on hearing, vision and strain. Int Arch Occup Environ Health **61**:95-106.

3. Dandanell R, Engstrom K 1986 Vibration from riveting tools in the frequency range 6 Hz-10 MHz and Raynaud's phenomenon. Scand J Work Environ Health **12**:338-342.
4. Bongers PM**,** Boshuizen HC**,** Hulshof CT, Koemeester AP 1988 Back disorders in crane operators exposed to whole-body vibration. Int Arch Occup Environ Health **60**:129-137.
5. de Oliveira CG**,** Simpson DM, Nadal J 2001 Lumbar back muscle activity of helicopter pilots and whole-body vibration. J Biomech **34**:1309-1315.
6. Griffin JJ 2001 Handbook of human vibration.
7. Bongers PM**,** Boshuizen HC**,** Hulshof CT, Koemeester AP 1988 Long-term sickness absence due to back disorders in crane operators exposed to whole-body vibration. Int Arch Occup Environ Health **61**:59-64.
8. International Standards Organization 1985 Evaluation of Human Exposure to Whole-Body Vibration. ISO **2631/1**:
9. Coermann R 1938 Untersuchung ueber die Einwirkung von Schwingungen auf den menschlichen Organismus. 73-117.
10. Goldman DE 1948 The effect of mechanical vibration on the patella reflex of the cat. Am J Physiol **155**:79.
11. Roll JP**,** Martin B**,** Gauthier GM, Mussa IF 1980 Effects of whole-body vibration on spinal reflexes in man. Aviat Space Environ Med **51**:1227-1233.
12. Dupuis H, Hartung E 1980 Einfluss von Vibrationen auf die optische Wahrnehmung. Research Report Wehrmedizin BMVg-FBWM 80-10 1-141.

13. Ward K**,** Alsop C**,** Brown S**,** Caulton J**,** Adams J, Mughal M 2001 A randomized, placebo controlled, pilot trial of low magnitude, high frequency loading treatment of children with disabling conditions who also have low bone mineral density. J Bone Miner Res **16S**:1148.
14. Pitukcheewanont P**,** Safani D**,** Gilsanz V, Rubin CT 2002 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**:
15. Recker R**,** Rubin C**,** Cullen D**,** Belongia D**,** Ryaby J, McLeod K 1997 Non-invasive biomechanical intervention for the prevention of post-menopausal osteopenia. J Bone Miner Res **12**:S242.
16. Bernard B**,** Nelson N**,** Estill CF, Fine L 1998 The NIOSH review of hand-arm vibration syndrome: vigilance is crucial. National Institute of Occupational Safety and Health. J Occup Environ Med **40**:780-785.
17. Griffin MJ 1998 Predicting the hazards of whole-body vibration--considerations of a standard. Ind Health **36**:83-91.
18. Wilder DG, Pope MH 1996 Epidemiological and aetiological aspects of low back pain in vibration environments - an update. Clin Biomech (Bristol , Avon) **11**:61-73.