

Whole Body Vibration: A new exercise approach

Presented by:

Martha R. Hinman, PT, EdD

Associate Professor

Department of Physical Therapy

The University of Texas Medical Branch

What are we talking about?

- Whole body vibration (WBV) is a mechanical stimulus characterized by **oscillatory motion** that is delivered to the entire body (usually in a vertical manner)
- a.k.a., vibration exercise (VE) or vibration training (VT)
- Biomechanical parameters include amplitude, frequency, magnitude, and duration

Effects of WBV depend on the training parameters used:

- Amplitude (*mm or cm*) = the extent of the vertical displacement
- Frequency (*Hz*) = number of impulses delivered per second
- Magnitude (*G*) = the acceleration power/force of the movement
- Duration (*sec. or min.*) = the amount of time one spends on the apparatus

Commercial devices that deliver WBV

- Galileo™ platform
 - *manufactured by Novotec (Germany)*
 - *available from Orthometrix Inc., White Plains, NY*
- NEMES™ platform
 - *manufactured by Nemesis (The Netherlands)*
- Power Plate™
 - *Power Plate of No. America, Culver City, CA*
- Exogen platform
 - *manufactured in USA*
 - *currently an investigational device*

Galileo™ Vibrating Platform

- Works as a **teeterboard** with 0 –5 mm amplitude (medial to distal) and variable frequency
- **25 – 27 Hz** seems optimal for increasing muscle power
- This frequency corresponds with time required for a single up–down movement to cause a natural stretch reflex plus relaxation of the agonists and antagonists



www.galileo2000.de/english/ehome.htm

The Galileo 2000™



"The 25 Hz speed of the Galileo produces 1500 repetitions per minute, and therefore a very strong training effect. Additional reflex benefits can be achieved by adding voluntary movements such as rotating the hips, moving the arms, etc. during the Galileo session."

www.orthometrix.net

Galileo 100™ (handheld dumbbell for UE exercise)



“The Galileo is particularly suited for such people because it is easy to use, and its exercise sessions are short (due to its fast 25 Hz stimulation rate). The Galileo allows people with osteoarthritis to enjoy the benefits of exercise.”

NEMES™ Vibrating Platform



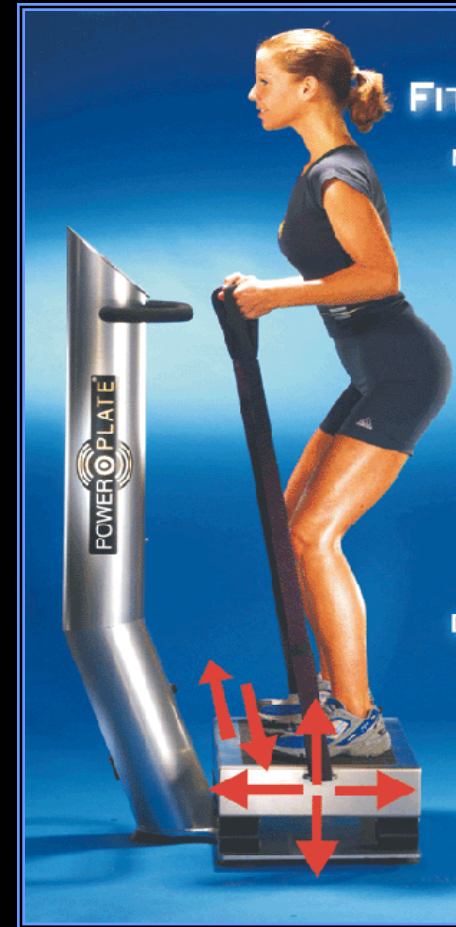
- NEMES is the abbreviation for **NEuro-MEchanical-Stimulation**
- Provides vertical mechanical vibration in the **30-50 Hz** range
- Shown effective in several muscle strengthening studies

www.nemes.com

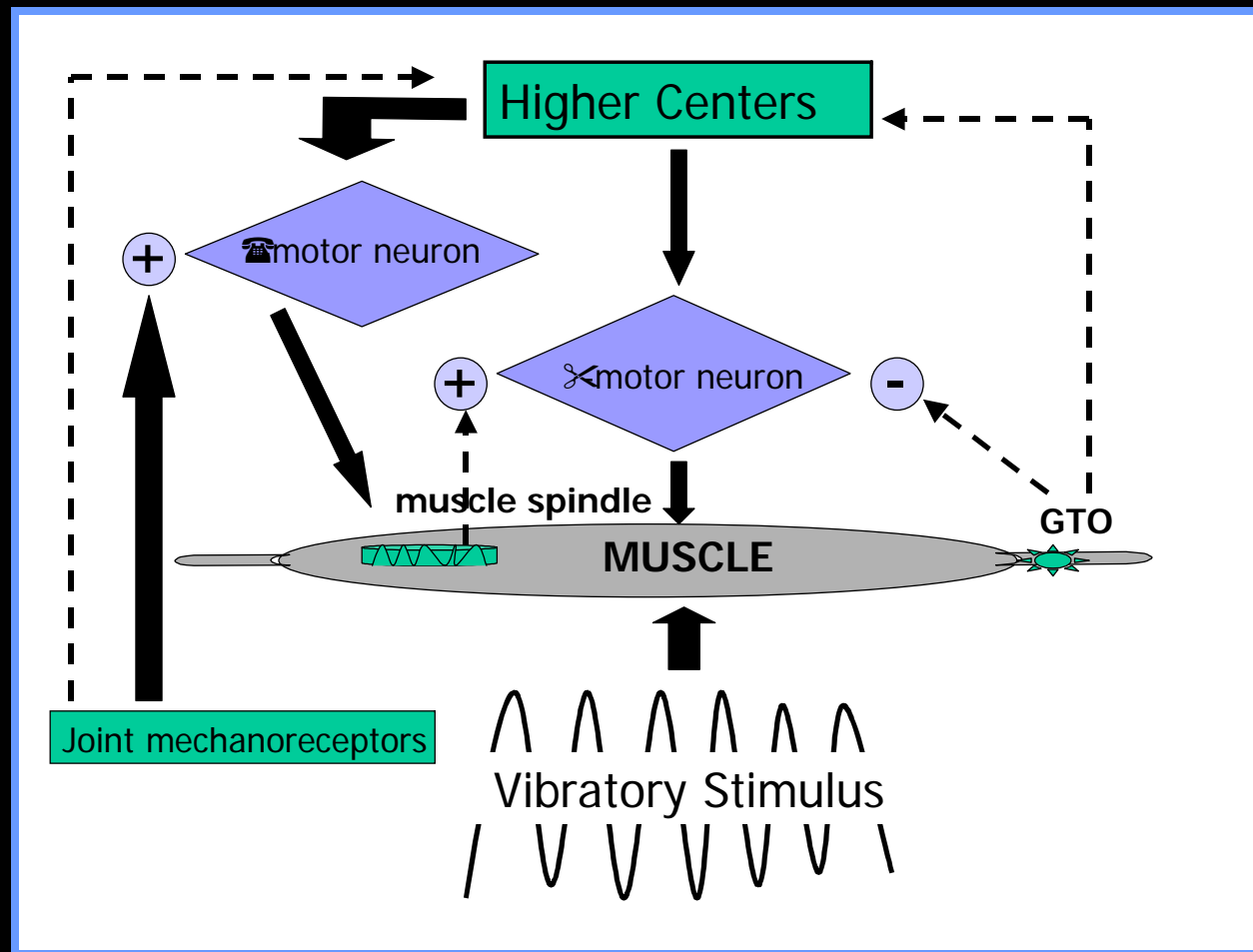
Power Plate™ Vibrating Platform

- Developed by an Olympic coach in The Netherlands
- Vibrates at 30–50 Hz
- Similar in design to the NEMES

www.powerplateusa.com



Physiology of WBV - stretch reflex



from Cardinale & Bosco, *Ex Sport Sci Rev*, 2003, 31:3-7

Conditions treated in Europe with WBV

- strength and power training for athletes
- ligamentous knee injuries/repairs
- acute back problems
- osteoporosis
- neuromuscular disorders
- obesity (via hormonal effects)
- PVD/diabetes (to improve circulation)
- incontinence (via muscle strengthening)
- postural stability

Contraindications/Precautions

- pregnancy
- recent or possible thrombosis
- cardiovascular complaints, e.g. valve disorder
- advanced arthrosis, arthropathy, acute RA
- recent sutures, scars and fresh wounds
- foot, knee and hip implants
- any metal/synthetic implants, e.g. pacemaker
- lumbar disc problems
- acute inflammations or infections

How much research has been done to support the efficacy of WBV?

- WBV to enhance the performance of Soviet athletes began in the '60s & '70s by **Nazarov**; studies continued by the Israeli scientist, **Issurin**.
- Introduced in Western Europe ~ 1994
- **Carmelo Bosco**, Italian physiologist, studied neuromuscular & hormonal effects of high-magnitude WBV (developed NEMES platform)
- **Jörn Rittweger** (Germany) and **Saila Torvinen** (Finland) have also published several studies using the Galileo platform

How much research has been done to support the efficacy of WBV?

- **Clinton Rubin**, anatomist and biomechanist at SUNY @ Stony Brook, NY, has studied skeletal effects of very low magnitude vibrations mostly on animal subjects
- Two pilot studies on human subjects using Rubin's platform have also been presented (but not published)
 - *Children with disabilities (e.g., CP) (Ward, et al)*
 - *Post-menopausal women (Rubin, et al)*

Immediate and Short-Term Effects of WBV

- Muscle strength and power
- Motor performance
 - *Vertical jump*
 - *Running speed*
 - *Balance*
- Other measures
 - *Hormone concentrations*
 - *Cardiovascular changes*

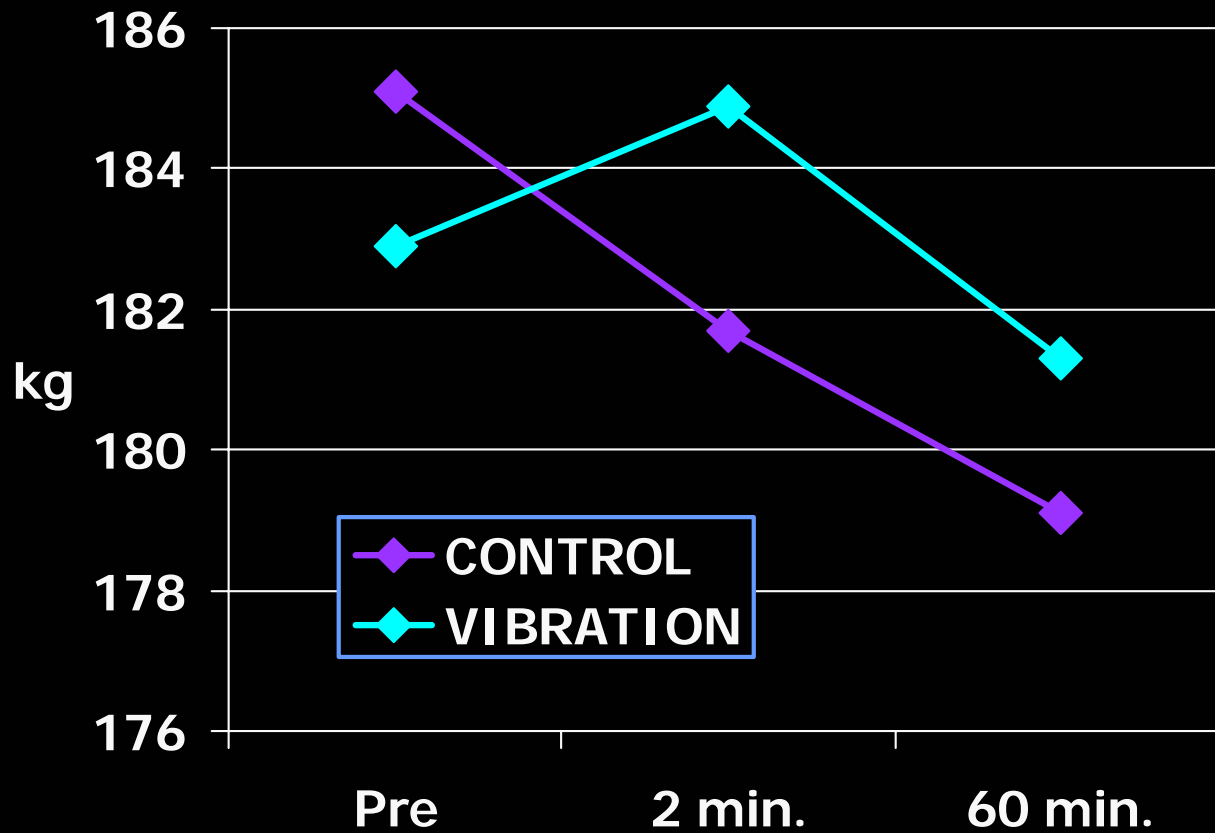


Effect of WBV on Muscle Strength and Motor Performance

- Torvinen tested 16 young adults who performed a single bout of WBV x 4 min. on 2 days (WBV vs. none)
- Used Galileo platform: amplitude = 28 mm; frequency increased from 15 – 30 Hz; est. acceleration force = 3.5 – 14 g

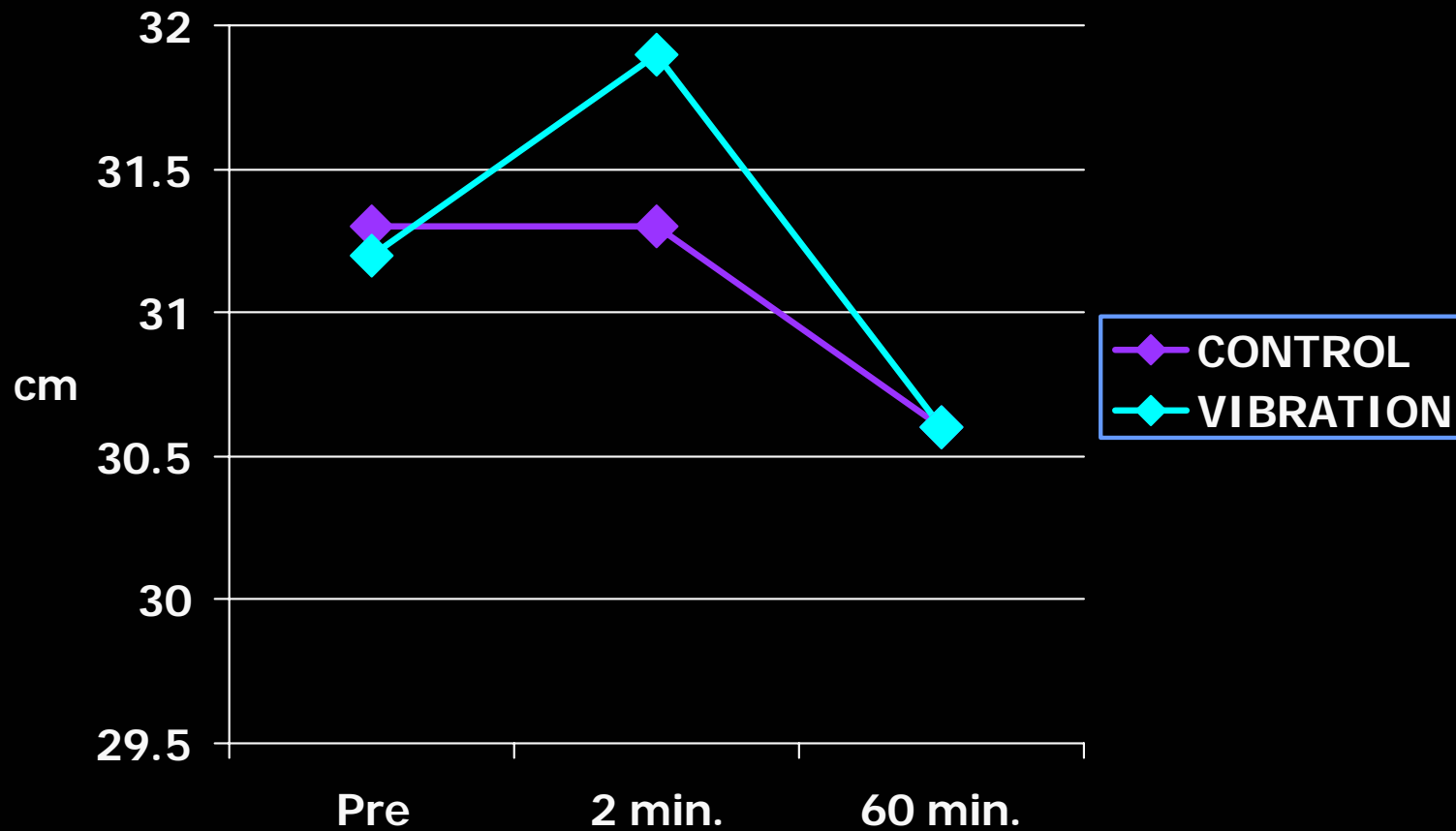
Torvinen et al, *Clin Physiol & Finc Im*, 22:145-152

Changes in leg extension strength



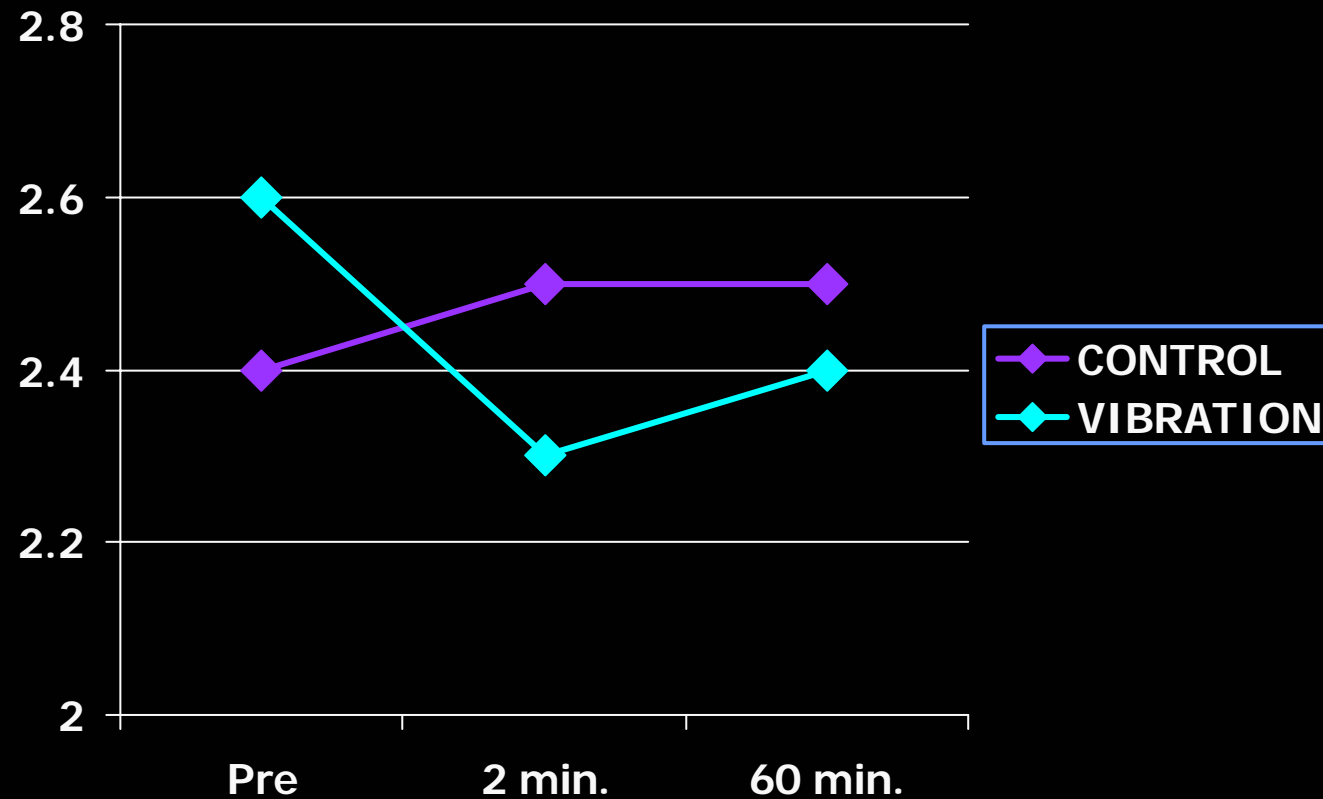
Torvinen et al, *Clin Physiol & Finc Im*, 22:145-152

Changes in vertical jump



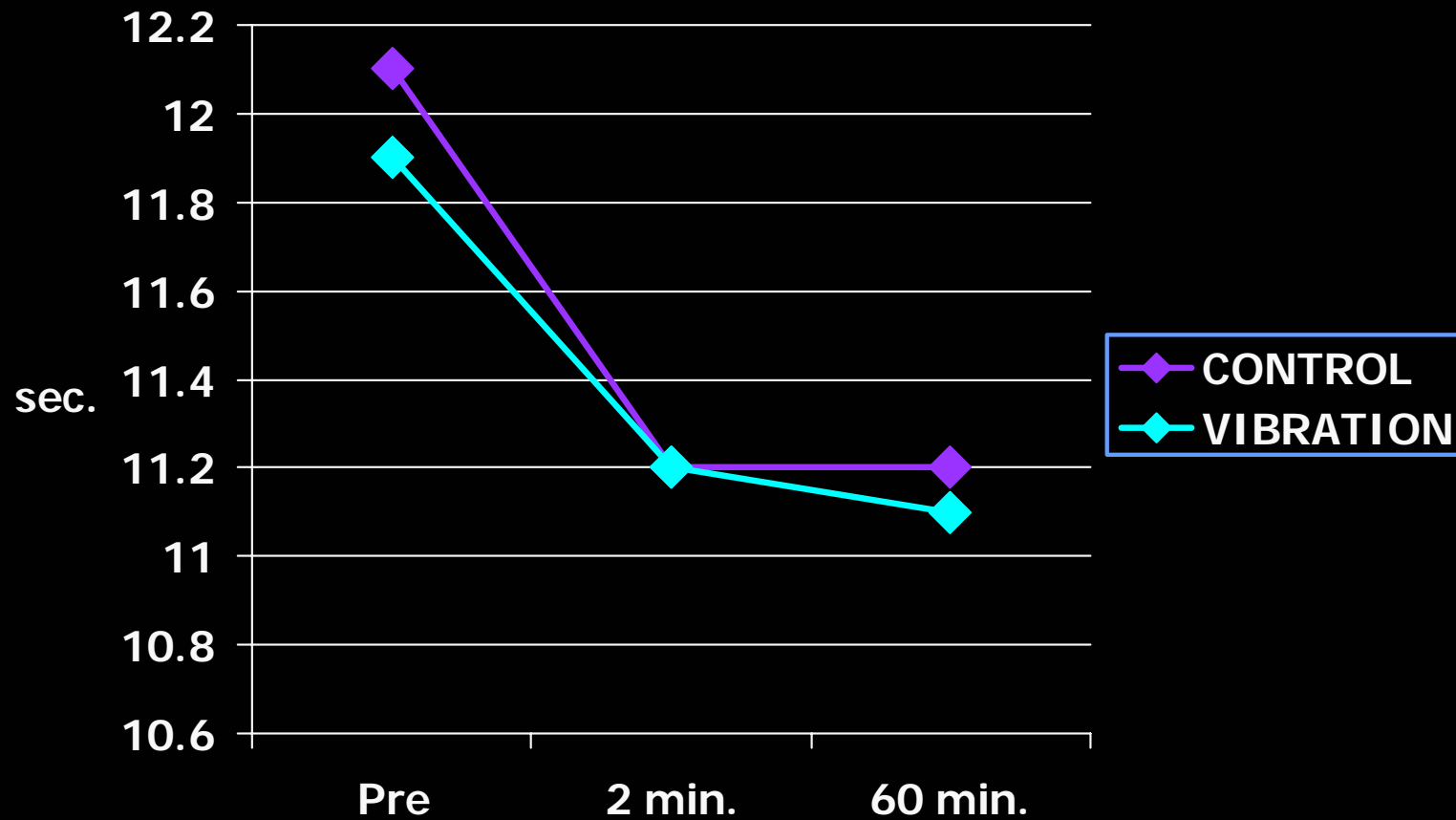
Torvinen et al, *Clin Physiol & Finc Im*, 22:145-152

Changes in Balance (using Biodex Stability Index)



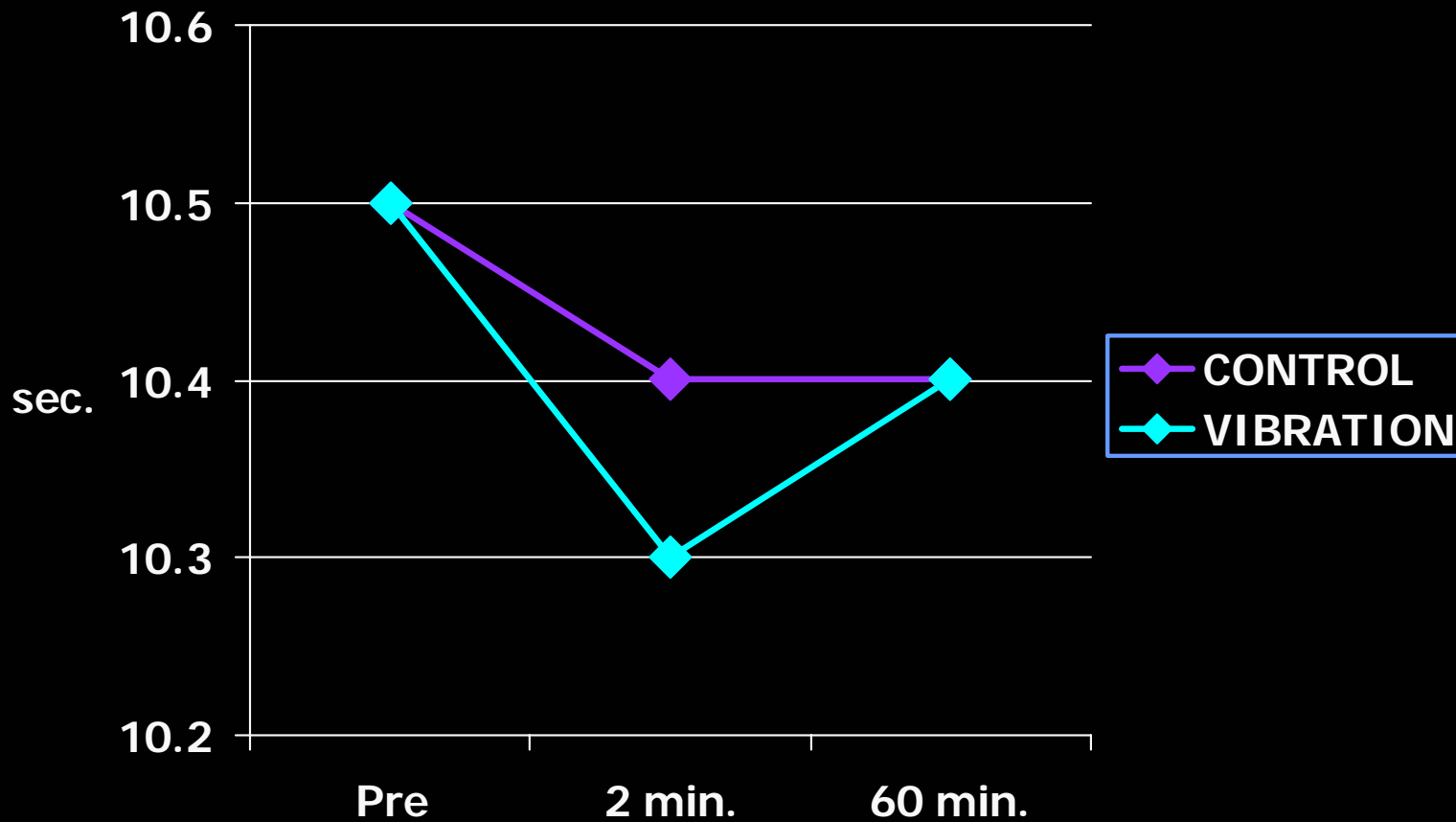
Torvinen et al, *Clin Physiol & Finc Im*, 22:145-152

Changes in Tandem Walk



Torvinen et al, *Clin Physiol & Finc Im*, 22:145-152

Changes in Shuttle Run



Torvinen et al, *Clin Physiol & Finc Im*, 22:145-152

Effects of WBV on Muscle Power

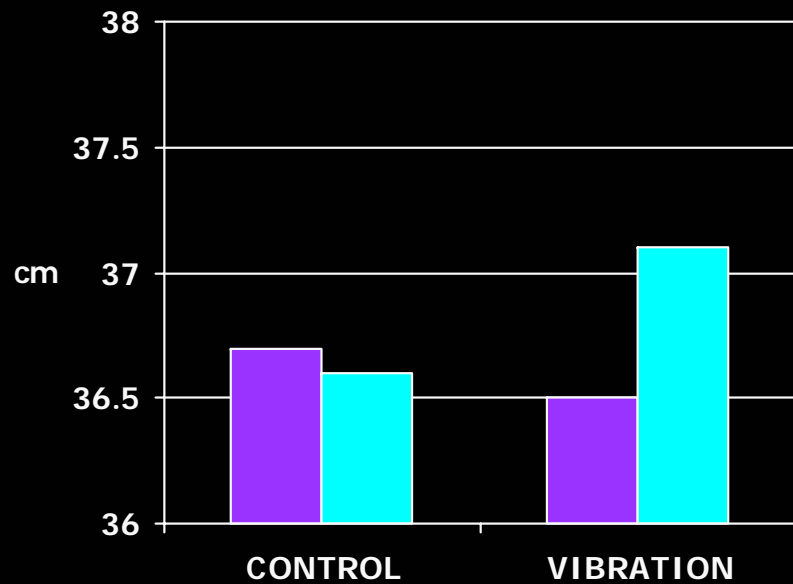
- Bosco examined effect of WBV on vertical jump in 14 active young adults who underwent 5, 90-120 sec. bouts of WBV x 10 days
- Used Galileo platform: amp. = 10 mm, frequency = 26 Hz

Bosco et al, 1998, *Biol Sport*, 15:157-164

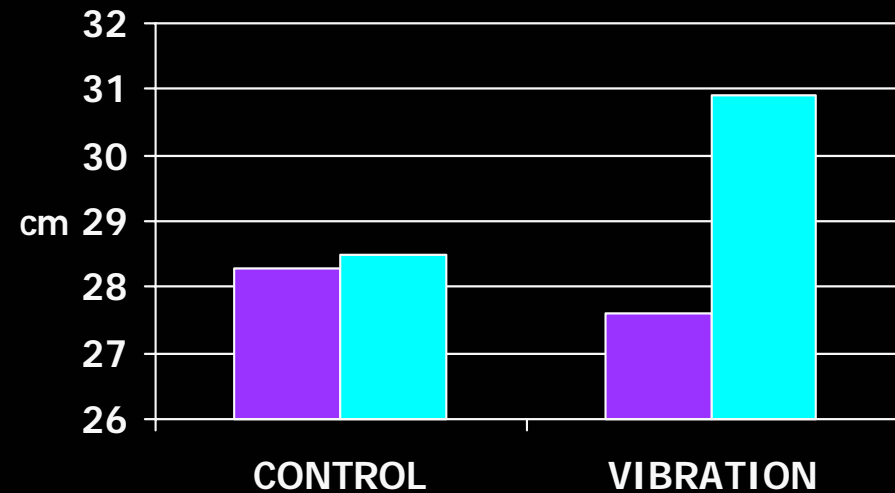
Effect of WBV on Vertical Jump

■ Pretest ■ Posttest

Single Jump



Repetitive Jumping



Bosco et al, 1998, *Biol Sport*, 15:157-164

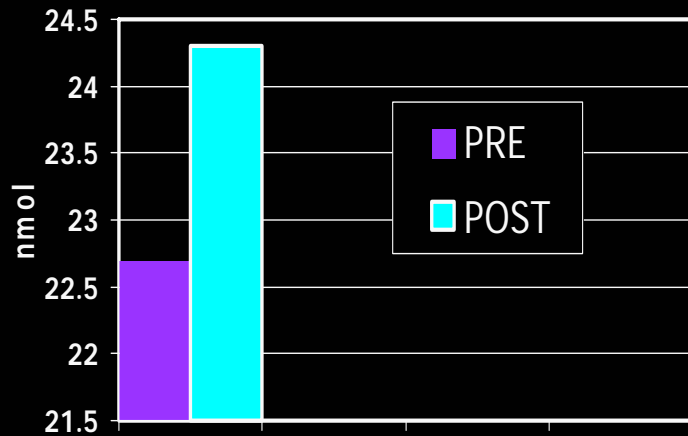
Hormonal Responses to WBV

- Bosco observed changes in neuromuscular performance and plasma hormone levels in 14 young, athletic men following WBV
- 60 sec. WBV followed by 60 sec. rest, repeated 10 times
- Used NEMES platform: amp. = 4 mm @ 26 Hz; est. acceleration force = 17 g

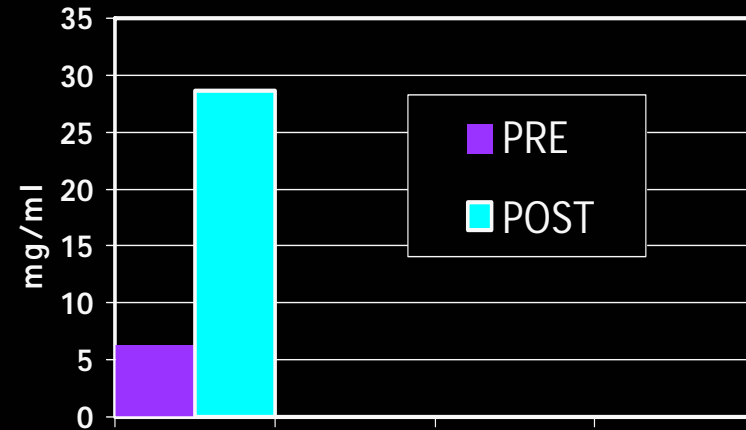
Bosco et al, *Eur J Appl Physiol*, 2000, 81:449-454

Hormonal Changes after WBV

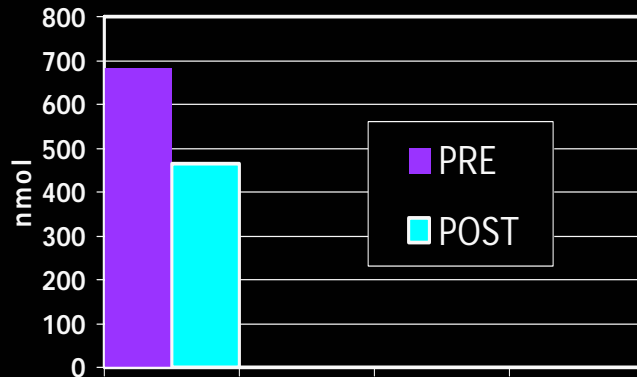
TESTOSTERONE



GROWTH HORMONE



CORTISOL



Bosco et al, *Eur J Appl Physiol*, 2000, 81:449-454

Other Findings and Conclusions

- Mechanical work output of leg extensor muscles was significantly enhanced while EMG activity was reduced
- Jumping performance also improved
- Increased plasma concentrations of T and GH suggest “neural potentiation effect” similar to power weight training but without the general stress response (i.e., decreased cortisol levels)

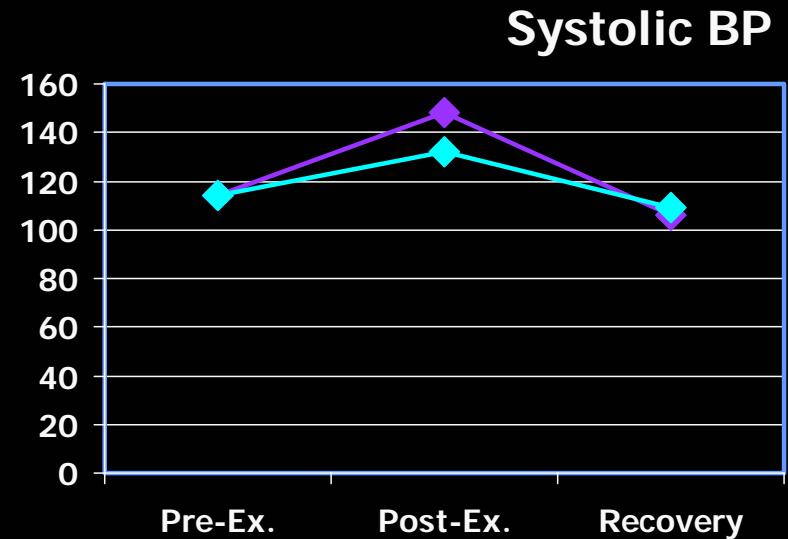
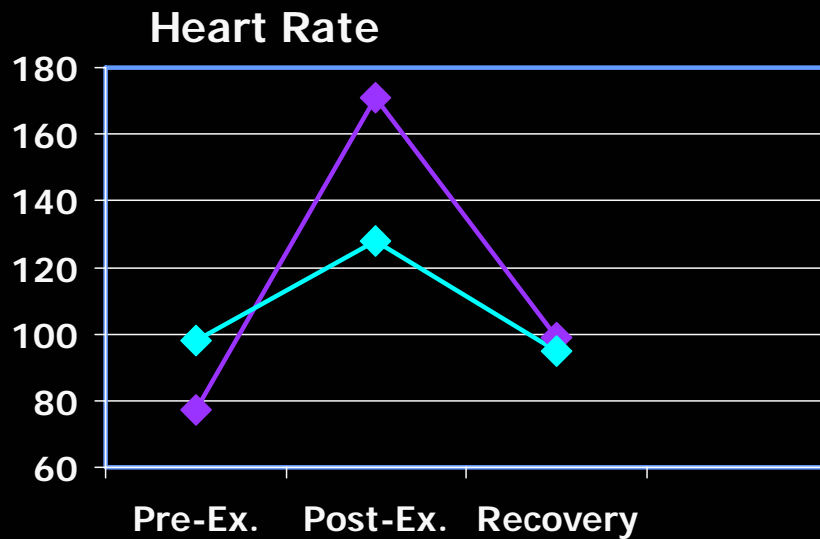
Acute Physiological Effects of WBV

- Rittweger examined HR, BP, oxygen uptake, lactate levels, and perceived exertion in 37 young adults who exercised to exhaustion with weights added to their waists
- Results of two WBV exercise sessions compared to bicycle ergometry
- Used Galileo platform: amp. = 1.05 cm @ 26 Hz; est. acceleration force = 15 g

Rittweger et al, *Clin Physiol*, 2000, 20(2):134-142

Cardiovascular Effects of WBV

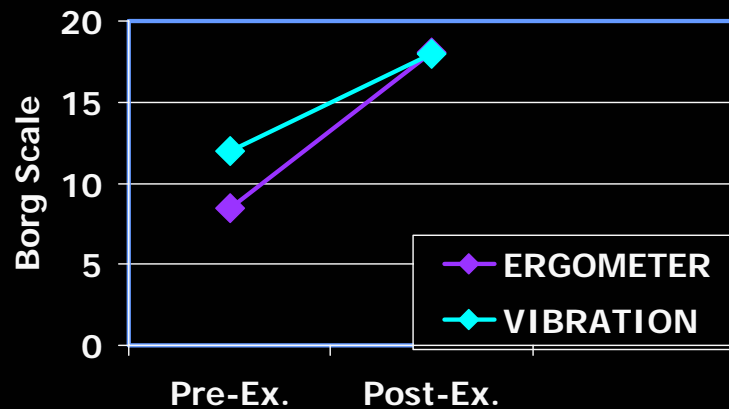
◆ ERGOMETER ◆ VIBRATION



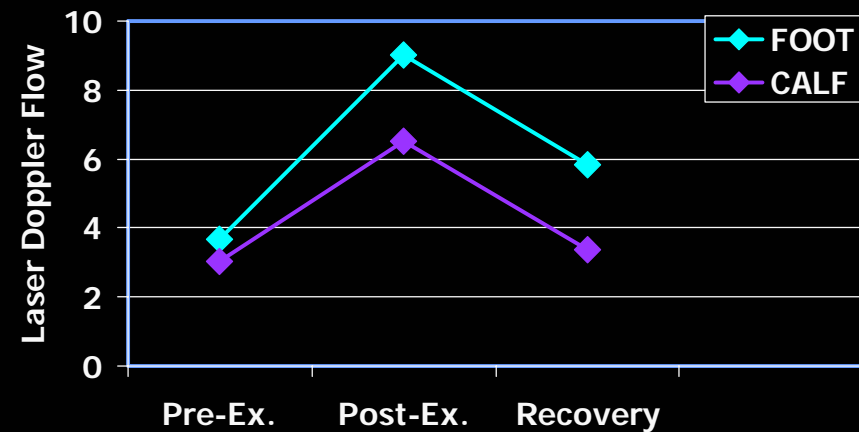
Rittweger et al, *Clin Physiol*, 2000, 20(2):134-142

Exercise Effects of WBV

Perceived Exertion



LE Blood Flow



Rittweger et al, *Clin Physiol*, 2000, 20(2):134-142

Other Findings and Conclusions:

- Perceptions of fatigue were comparable
- Some subjects experienced leg edema, erythema, and itching from WBV
- Fatigue associated with intense WBV attributed to neuromuscular system, not cardiovascular insufficiency
- Cardiovascular risk for this exercise with elderly considered "negligible."

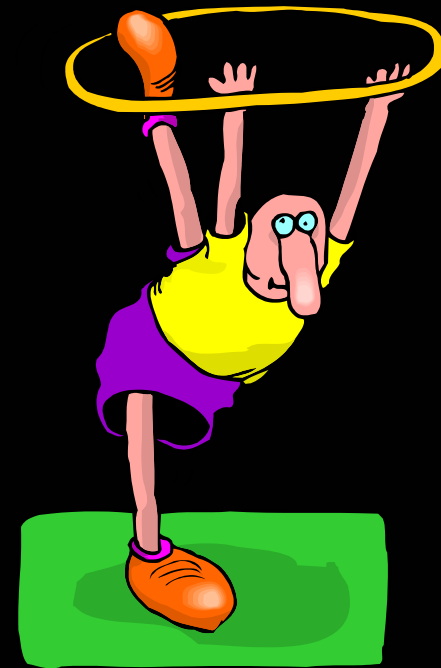
Other Short-Term Systemic Effects

- Temporary vestibular impairment and motion sickness with high-amplitude vibration of long duration
- Increased gastric secretions, but no effect on rate of stomach emptying
- Decreased attention to other stimuli, but no sig. reduction in reaction time, eye-hand coordination, or visual acuity

Kjellberg et al, *Ergonomics*, 1985, 28(3):535-544

Long-Term Effects of WBV

- Muscle strength/performance
- Motor control
- Balance
- Chronic pain
- Bone density/strength



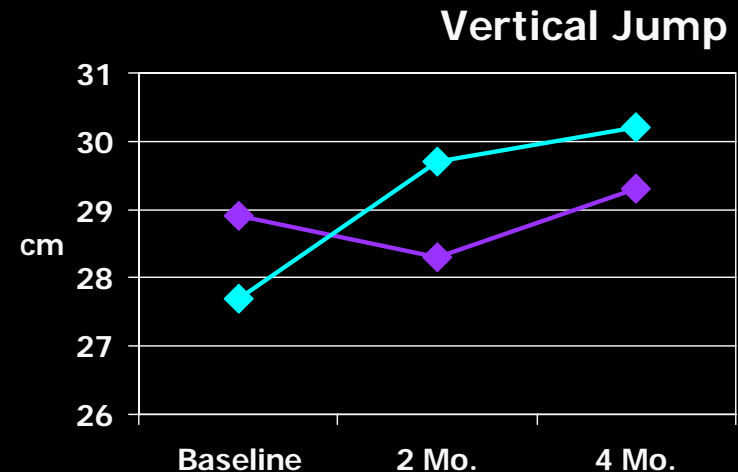
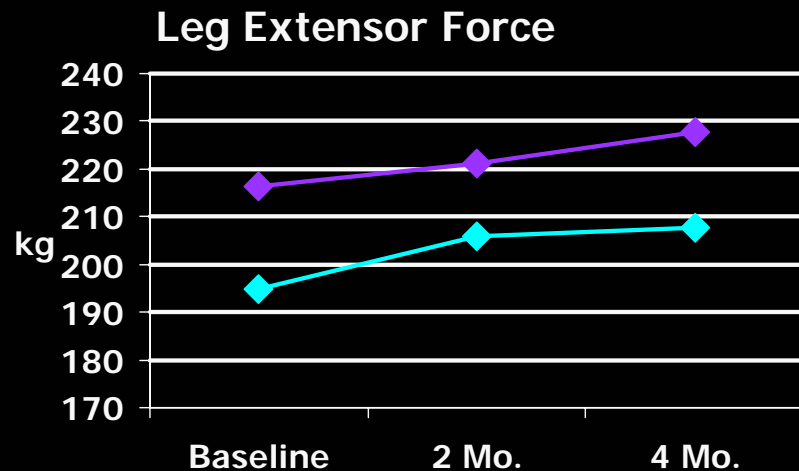
Long-Term Effects of WBV

- Torvinen studied physical performance effects of a 4-month WBV program in 56 young adults who trained 2-4 min., 3-5 times/week, in various positions
- Platform vibration amp. = 2 mm; frequencies ranged from 25 to 40 Hz; est. acceleration force = 2.5 – 6.4 g

Torvinen et al, *Med Sci Sports Exerc*, 2002,34:1523:1528

Changes in Muscle Strength

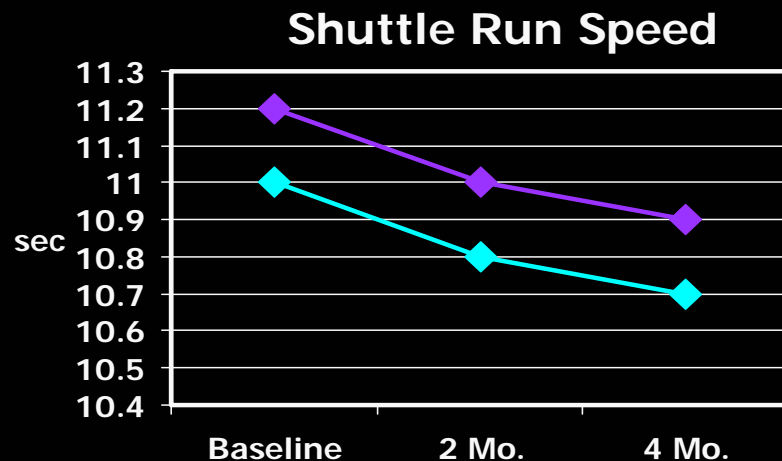
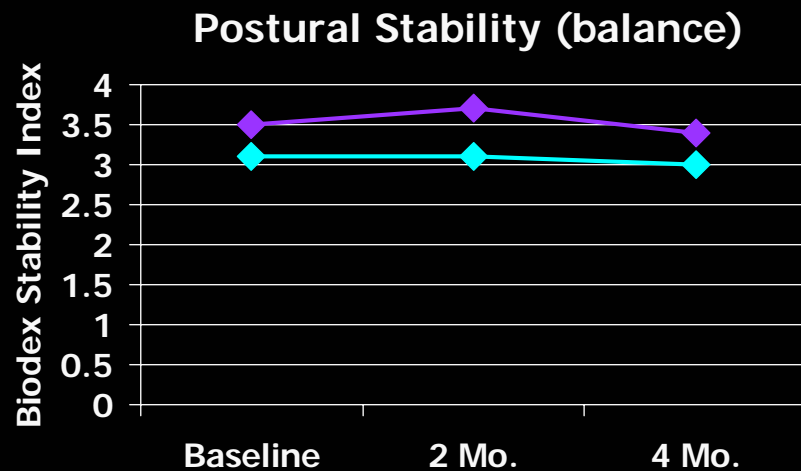
—◆— CONTROL —◆— VIBRATION



Torvinen et al, *Med Sci Sports Exerc*, 2002,34:1523:1528

Changes in Motor Performance

—◆— CONTROL —◆— VIBRATION



Torvinen et al, *Med Sci Sports Exerc*, 2002,34:1523:1528

Changes in Bone

- Torvinen continued study for a total of 8 months; results presented at ASBMR meeting in Sept. 2002
- Bone mass, structure, and strength of tibia measured with pQCT; BMD in other sites measured with DEXA
- No significant change reported in BMD or bone biomarkers
- Overall 7.8% improvement in vertical jump but no other performance benefits

Summary of Rubin's work on vibration and bone

- Has used 10-20 min. of low-magnitude (0.2-0.3 g), high-frequency (~20-90 Hz) vibration with various animal models
- 2 pilot studies with humans
- Planning NASA flight study

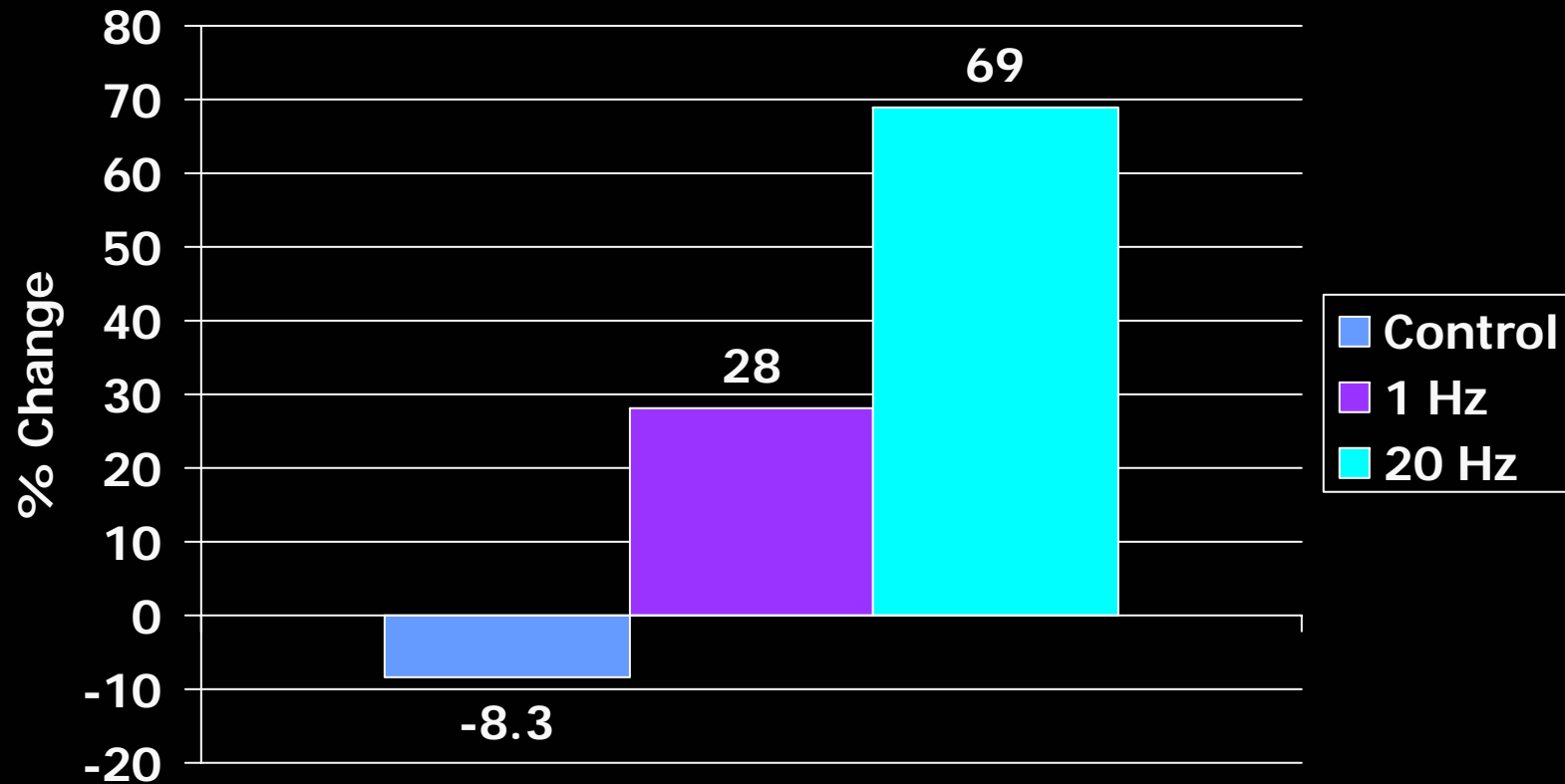


Percent differences in bone parameters for vibrated vs. control sheep (after 1 yr.)

Total bone density	+ 6.5%	Trabecular density	+ 34.2%
Total bone volume	+ 32%	Trabecular number	+ 45%
Bone formation rate	+ 113%	Mineralizing surface	+ 144%

Rubin, et al, *Nature*, 2001, 412:603-604

Percent of Bony Ingrowth @ 8 wks. (titanium implant in turkey ulna)



Rubin & McLeod, *Clin Orthop Rel Res*, 1994, 298:165-174

Rubin's overall findings suggest:

- Doubling of bone formation rates
- 25% increase in strength of trabecular (vs. cortical) bone
- Inhibition of disuse and post-menopausal bone loss
- Postulated relationship between age-related sarcopenia and osteoporosis

Rubin et al, *Drug Discov Today*, 2001, 6(16):848-858
(overview of work; has numerous other publications)

Other animal studies of bone loss

- Fleiger, et al (1998) studied ovariectomized rats vibrated at 50 Hz, 2 g, 30 min./day for 12 weeks; vibrated rates demo. significantly **less bone loss** than sham & non-vibrated rats
- Oxlund, et al (2003) compared vibration frequencies in ovariectomized rats and found that **45 Hz increased bone formation and inhibited resorption** the most and **preserved biomechanical strength** of bone.

Human Pilot Studies: Prevention of bone loss in postmenopausal women

- RCT of 67 postmenopausal women in US who underwent 20 min./day WBV for 1 year (vs. placebo)
- Placebo group lost 3.8% in spine and 5.5% in femur
- WBV group **only lost 1.0% in spine and 1.5% in femur**

Rubin et al, *Bone*, 1998, 23:S174 (abstract)

Human Pilot Studies: Treatment of low BMD in disabled children

- RCT on 20 British children with disabilities (e.g., CP) who underwent 10 min./day WBV for 6 mo. (vs. placebo)
- Observed **net gains in trabecular BMD** in subjects exposed to WBV
 - +3.8 mg/nl in spinal vertebrae
 - +18.2 mg/nl in proximal tibia

Ward et al, *J Bone Miner Res*, 2001, 16:S1, #1148

Effect of WBV on Back Pain

- Rittweger compared effects of WBV and isometric exercise on lumbar strength, pain, and disability ratings in 60 patients with chronic LBP
- Used Galileo platform: amp. = 6 mm @ 18 Hz; progressed from 4 to 7 min.
- Twice a week x 6 weeks, then weekly

Rittweger et al, *Spine*, 2002, 27(17):1829-1834

Effect of WBV on LBP

- Subjects demonstrated significant, but comparable **reductions in pain and disability ratings.**
- Exercise group demonstrated greater increases in lumbar extension torque than vibration group.
- Vibration did not aggravate pain or limitations in any subjects.

Are there any geriatric studies?

- Runge conducted a crossover study involving 34 older adults in Germany who underwent 6 min. of WBV 3 times/week x 6 months
- Used Galileo platform: amp. = 7-14 mm @ frequency of 27 Hz
- Preliminary data (n=19) – chair rise time decreased by 18% in WBV group; no adverse effects reported

Runge et al, *J Musculoskel Neuron Interact*, 2000, 1:61-65

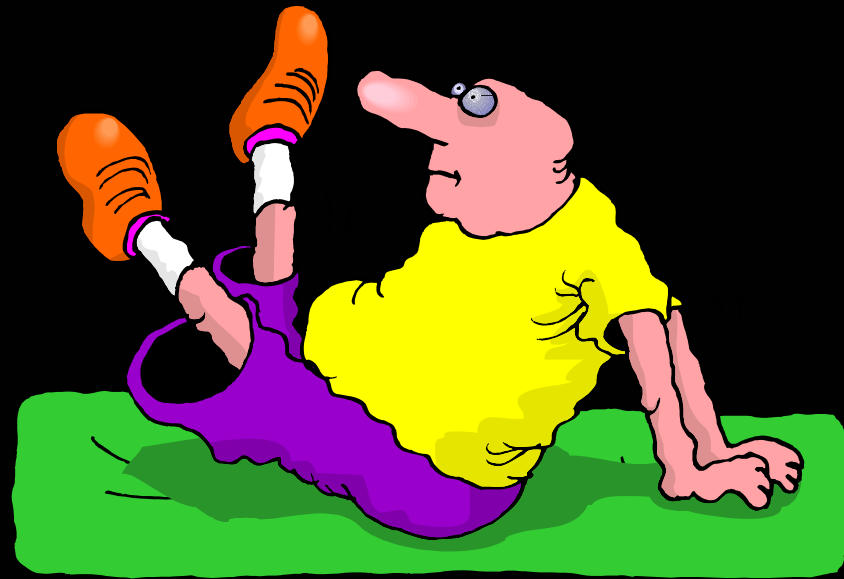
Effect on Urinary Incontinence

- Runge, et al are also investigating the effects of WBV on incontinence in older adults; no published studies yet
- Hypothesized mechanism is strengthening of pelvic floor muscles via activation of the stretch reflex

Runge et al, *Der Hausarzt*, 2002, 2:56-61

Other fertile grounds for WBV research:

- Effects on muscle strength/tone
 - *Parkinson's, MS, CVA, ABI*
- Bone healing and strengthening
 - *osteopenia and osteoporosis*
 - *fracture repair*
 - *post-arthroplasty*
- Pain reduction
 - *arthritic*
 - *post-op*
- Other effects:
 - *LE circulation*
 - *continence*



Other areas of research (cont.)

- *Countermeasures Evaluation & Validation Project (CEVP)* at NASA
- High priorities include countermeasures to mitigate the adverse effects of a microgravity environment on bone and muscle
- Bed rest and ambulatory studies needed to compare effects of WBV to resistive exercise approaches currently in use



We invite your interest or
collaboration with our work!

Contact:

Martha (Marty) Hinman
Dept. of Physical Therapy, Rt. 1144
University of Texas Medical Branch
Galveston, TX 77555-1144
Phone: (409) 772-9493
e-mail: mhinman@utmb.edu