PREVENTION. CARE. RECOVERY.

Te Kaporeihana Āwhina Hunga Whara

Considered Judgement Form

This form is a checklist of issues that may be considered by the Purchasing Guidance Advisory Group when making purchasing recommendations.

Meeting date: 9 September 2008

Topic: Whole Body Vibration Training

Background and Purpose:

Athletes and their trainers', geriatricians and patients would all like simple methods to improve musculoskeletal performance and recover more speedily from injury.

Resistance training is one method used to build strength, however, for populations such as the elderly that type of training is often unachievable or may be unattractive. Scientists have, therefore, sought ways to enhance muscular performance in other ways. One strategy that has been developed is to administer a low frequency mechanical vibrating stimulus to parts or all of the body. This has been termed vibration training. *Whole* body vibration (WBV) involves the person standing or sitting on a platform whilst vertical vibrations are applied to the body, usually through the feet. WBV training may involve the subject maintaining an isometric squat in varying positions on the vibrating plate or the subject may perform squatting and jumping type exercises with or without additional load. Literature reports, amongst other potential effects that muscle strength and bone density gains can result from vibration training, and it is thought that gains occur as a result of the stimulation of muscle reflex pathways and osteogenesis.

ACC from time to time are approached by manufacturers of WBV devices to purchase equipment and treatments and, therefore, Research Services has been requested to assess the safety and effectiveness of WBV.

Health Technology

There are a number of commercially available WBV appliances. Appliance specifications vary across the brands. The vibration stimulus can be varied by; (i) amplitude, which is the extent of oscillatory motion from peak to trough it is measured in mm, (ii) frequency, which is the number cycles per second (measured in Hz) and (iii) the acceleration at which one traverses the amplitude; this is measured in units or fractions of the Earth's gravitational force ($9.8ms^{-2}$). Most vibration platforms are motor-driven systems that generate vibration via eccentric discs or off-centred motors. Vibration platforms are often hydraulically powered enabling the operator to carefully control the vibration characteristics; typically WBV interventions involve relatively low frequencies (25-50Hz) and small amplitudes (2 to 10mm).

The platform of the appliance may vibrate in one of two ways and these are shown in figure 1 (provided at the end of this document). An example of the 'teetering' system that produces side-to-side vibration movements is the Galileo brand. The Powerplate® vibration platform is an example of a platform that produces vertical vibrations. Other commercially available WBV platforms/appliances include the Nemes® Nemisis; Novotech; Vibrablaster and the Juvent. Costs of WBV platforms are discussed in a later section.

WBV is thought to improve strength by activating sensory receptors and muscle reflex pathways. Mechanical stimulation of the human body at a low amplitude and frequency excites sensory receptors, specifically, muscle spindles. This results in reflex activation of motor neurons which then in turn result in muscle contraction. If the WBV machine delivers vibrations at 25Hz then the muscles will contract and relax at approximately the same frequency. Normal exercise recruits muscle fibres variably and this depends on the mode, intensity and duration of the exercise employed. WBV may result in greater recruitment of muscle fibres during exercise due to the need of the lower limb muscles to dampen the vibration. It is thought the mechanical effect of the vibration stimulus has an osteogenic[1] effect on bone.

1. Effectiveness, Volume of Evidence, Applicability /Generalisability and Consistency

Comment here on the extent to which the service/product/ procedure achieves the desired outcomes. Specific reference needs to be made to safety. Report number needed to treat and harm where possible, report any issues concerning the quantity of evidence and its methodological quality and the extent to which the evidence is directly applicable or generalisable to the New Zealand Population, and the degree of consistency demonstrated by the available evidence. Where there are conflicting results, indicate how the group formed a judgement as to the overall direction of the evidence

Studies – types, quality and populations and WBV parameters

Fifty-three studies met the project brief and were evaluated for this review. These papers primarily evaluated the effects of WBV training on musculoskeletal parameters (including: muscle strength, power, balance and bone quality/density) for a range of subjects (athletes[2] to the elderly). A small number of these papers evaluated the effect of WBV on the endocrine and cardiovascular systems, including its effect on body mass index. Over half of the studies involved healthy young male or female adults. The biggest single focus across the papers was on muscle strength and associated outcomes – strength parameters were investigated for both single sessions and longer term programmes for both young and old.
Most of the 53 primary studies involved small samples, although the range across all studies was 8-220 subjects.

WBV parameters were variable across the studies. There was no consistent treatment protocol used across the WBV training studies with respect to amplitude, frequency or acceleration (frequency range 1Hz- 50Hz;acceleration range .1g-10g, amplitude range 2-11mm). It was also evident that the WBV stimulus (type and dose) varied significantly also within sub-groups of studies (studies were grouped based on the purposes or the sub-populations that were enrolled in the studies. This is discussed in further detail below). That said it did appear that for the elderly and/or infirm populations, amplitudes (e.g.2-5 mm) and acceleration parameters (e.g. 0.3g acceleration) were at the lower end of the available ranges. WBV stimulus session length varied from a few seconds to several minutes as did the number of sessions prescribed over a week per week (1-5) for longer programmes. Most studies included rest-periods within individual WBV training sessions (e.g. bouts of 1 minute of WBV followed by 30 seconds rest). The duration of exposure to WBV across all trials ranged from one day to 12 months. A feature of many of the studies was the progressive nature of the longer WBV training programmes; with low doses administered at the start of a programme and higher doses at the end. This is consistent with the overload principle that other exercise modalities use. Most studies identified for this EBH review used commercially available machines such as the Nemes® Nemisis; Galileo 2000®, Novotech; and PowerPlate® brand appliances.

Overall the quality of the studies was moderate. Thirty-three of the 53 primary studies used an RCT methodology. Ten of the 33 RCT's were rated highly (1+) and one only was classified as of very high

[1] ***Osteogenesis*** is the process of laying down new bone material by osteoblasts.

[2] For this report, 'athletes' are those subjects as identified from the studies themselves that have engaged in any type of sport or fitness training on a regular basis. The definition of 'elite' athletes applies further to those that are competitive or nationally ranked athletes as indicated by the studies. Trained individuals involves both these above groups

quality (1++). In 16 of the 33 RCT's, the application of vibration was the only difference between control and intervention groups (either a concurrent comprehensive programme was administered or the subjects performed the same exercises without the vibration stimulus). Eight studies involved a 'no treatment' arm; five of these studies also included an alternative resistance or cardiovascular activity programme; a 'no treatment' group was the sole control group in three studies. Comparing WBV interventions with 'no treatment' group may raise significant issues of confounding as exercise and vibration are in fact components of all WBV interventions, either through static squat postures or exercise through a range of motion. The variability in control group interventions makes it difficult to draw conclusions regarding efficacy.

Outcome measures

There were a variety of outcome measures used across the studies. Dynamic synergistic muscle power was measured by countermovement jump (CMJ) height; isometric strength and dynamic strength of the knee extensors was typically measured using a motor driven dynamometer; the shuttle run test over a 30m course was used to assess dynamic balance or agility and motor capacity was reported in some studies as being assessed using the "timed up-and-go" (TUG[3]) test. The Tinetti[4] test, single-leg stance and posturography (postural sway platform) were used for body balance and some studies reported locomotion (i.e. walking) parameters e.g. step length.
Other outcome measures were biochemical serum tests measuring bone turnover or computed tomography (CT) and dual energy X-ray absorptiometry (DEXA) scanning for bone mineral density (BMD). Arterial blood flow was assessed in one trial using a Doppler sonograph. Other outcomes included heart rate, blood pressure and oxygen (O_2) uptake as a measure of aerobic capacity and body mass index to measure weight loss.

Main Findings: These are addressed under two main sections; WBV training for specific purposes e.g. muscle strength and associated parameters and those that administered WBV training to specific populations e.g. the healthy elderly. There was some overlap between these groups.

WBV training for specific purposes

Effects of vibration training on muscle performance

- **Short-term applications of WBV - < 1 week muscle strength, torque and countermovement jump and balance parameters** (5 controlled studies and 3 case series)
- **Longer term applications - > 1week for muscle strength, torque and countermovement jump** (16 RCT's and 2 controlled studies)
- **Effects of WBV training on locomotion and balance parameters** (7 RCT's and 3 controlled trials)
- **WBV training for flexibility** (3 RCT's and 1 controlled trial)
- **Effects of WBV training on bone mineral density and bone parameters** (7 RCT's and 1 controlled trial)
- **Effects of WBV training on the endocrine system** (1 RCT, 2 controlled trials and 1 case series)
- **Effects of WBV training on the cardiovascular, peripheral vascular system and BMI** (3 RCT's, 1 controlled trial and 4 case series).

WBV for specific populations

[3] The timed up and go test is a valid measure of the time an individual takes to rise from a standard chair, walk 3 metres, turn, walk back to the chair and sit back down.
[4] The Tinetti Balance Test is a subjective ordinal measure of balance in the elderly and neurological subjects. Subjects are ranked 0-2 by the assessor on their ability to sit, stand from a chair, turn, balance with perturbation and eyes shut. There is also a 12 point Tinetti gait measure.
[5] Dynamic posturography, which tests gaze and postural stability[53] was the primary outcome measure. This "provides clinical information specific to the patient's use of individual sensory inputs and motor reactions under a variety of daily life conditions" and reportedly "relates well with the patient's symptoms and functional complaints."
[6] The GMFM is a motor skill assessment used for children with cerebral palsy validated for children between 5 months and 16 years.

- **WBV training for post-menopausal women** (8 RCT's measuring locomotion, bone and strength parameters)
- **WBV training in the healthy elderly** (3 RCT's and one controlled trial measuring muscle strength, bone, balance and locomotion parameters)
- **WBV training for rehabilitation populations:**
  Diseases and conditions of the nervous system (5 RCT's, 1 controlled trial and 1 case series)
  Anterior cruciate ligament (ACL) reconstruction rehabilitation (1 RCT)
- **Other studies** (1 RCT).

WBV training for specific purposes

Short-term applications of WBV - < 1 week muscle strength, torque and countermovement jump

Eight studies investigated the effects of short-term WBV training, five were controlled studies (subjects serving as own controls) and three were case series. Subject numbers across the studies ranged from 9-37 and comprised mainly young healthy males between the ages of 21-35 years. WBV frequencies varied from 15-40Hz and amplitudes 2-10mm.The quality of this group of papers was overall moderate.

Two studies indicated positive, statistically significant improvements in maximum voluntary contraction (MVC) of the knee extensors and one study reported improved leg press power following single sessions of WBV training. Conversely, one quality study measured no change in either isometric knee extension force, stability, vertical jump and a shuttle run following a single WBV session.
A further study reported a 7% decline in force production during the maximal voluntary contraction of the knee extensors. The study period was extended to six sessions over two weeks, however, no improvement in muscle performance was seen despite this longer training period.

Statistically significant improvements in CMJ height (2.5%-8.1%) were reported in four papers. Evidence to the contrary exists, however, from a quality study administering a single 4-minute session of WBV training. Results from this study also indicated no change in CMJ or other performance measures.

In summary, considering the quality of the controlled studies reviewed for this report are relatively poor and present conflicting evidence, it is reasonable to conclude that the efficacy of short-term WBV for muscle power and/or strength and/or CMJ improvement is to date unclear.

Despite the fact that WBV interventions are brief, and thus far, no serious adverse events have been reported, safety issues have to date been poorly considered.

Longer term applications > 1week for muscle strength, torque and countermovement jump

Eighteen studies assessing long term WBV programmes for the purposes of muscle strength torque and/or countermovement jump were reviewed. These papers crossed a variety of populations and comprised sixteen RCT's and two controlled trials. These papers primarily studied *healthy* adults of all ages (n=9 studies) and studied trained (n=6 studies) and untrained individuals. Three studies enrolled post-menopausal women and one, male and female rest-home-dwelling elderly subjects. These specific sub-populations are discussed in subsequent sections.
RCT's compared WBV interventions with either the same exercise regime without vibration (n=11) or no treatment – either as one arm or the only alternative (n=2 and n=3 studies respectively). WBV parameters varied considerably, although in general administered higher frequencies and amplitudes (12-45 Hz), higher acceleration (2-8g) and higher amplitudes (2.5-11mm). It may be reasonable to presume that tolerance and benefit may be successfully achieved with the lower dose applications and adverse events less likely. Sample sizes across this group of papers varied from 14-89 with by and

large, larger samples involving the elderly.

WBV training regimes ranged from 9 days to 8 months across this group of papers. Study durations were clustered around the 4-8 week mark, with subjects participating in on average three sessions per week (ranging from an unspecified session duration to 30 minutes) with at least one day in between sessions.

Healthy untrained adults

Improvements in CMJ height of up to 8.5% and knee extensor strength of 3.7% were reported from one controlled study that administered a 4-month intervention. The WBV training group was measured against a 'no-treatment' control. The same cohort continued treatment up to 8 months however, results at the end of the 8 months of treatment indicated that CMJ height gains *declined compared with results at 4 months;* a *reduction* in knee strength was also seen at the end of 8 months of training.
A further controlled study assessed the impact of a 24-week WBV programme on body composition and knee extensor strength. Isometric knee extensor strength improved 24.4%, and isokinetic strength improved from 5.9-8.3% from baseline to follow-up. There were no between-group differences reported; the alternate treatment groups were a cardiovascular and resistance programme and a 'no treatment' group.

Only one RCT to date has investigated the impact of WBV training on different WBV frequencies. Subjects were randomised to WBV training groups of 20, 27 and 34 Hz. Subjects held a static posture and exercised 3 times per week for 4 weeks. Peak knee extensor torque increased by 9.4% from baseline across all groups. No differences were found between the different groups. This study sample was small (28).

Only one study has reported the superiority of WBV training over a comprehensive conventional resistance training programme. CMJ height improved by 7.6% after four months of training ($p<0.001$). No differences were found between the resistance training group and the WBV group with respect to isometric knee strength.

In summary, evidence to date points to some improvements in muscle strength and/or power gains for young healthy untrained adults from longer-term WBV interventions, however, evidence also suggests that improvements may not be better than those seen with comprehensive resistance training and/or a "gymnastics" programmes.

Trained adults

Five RCT's and one controlled trial studied trained (recreational or elite athlete) subjects. Sample sizes were small, ranging from 14-28. Programme duration ranged from 9 days to 8 weeks. WBV parameters for this group varied; amplitude 2.5-11mm, frequency 25-40 Hz. Acceleration was reported in one study only and varied through the programme (2.5-6.4g).

Three RCT's and one controlled trial indicated there was no effect of WBV training on muscle strength or CMJ outcomes. One study administered a 9 day programme comparing exercises on the WBV platform with identical exercises without vibration. Outcomes were CMJ height, squat jump, sprint and agility parameters. The two remaining papers were for a 5 and 11 week programme respectively. One paper compared static postures on the WBV appliance with static posture alone; the other intervention group underwent conventional sprint training. One low quality RCT allocated 'moderately trained' subjects into a squat training programme, 'squat and WBV' group and a 'WBV alone' group. No between-group differences were seen for MVC, with only 'squat' and 'squat and vibration' groups showing improvements from baseline. Mean power showed a greater increase in the 'squat' group (25.9-27.4 W kg^{-1}) as compared to the 'vibration group' (25.3-24.7W kg^{-1}) and 'squats and WBV' (26.3-26.6 W kg^{-1}). WBV and resistance training did not increase MVC and CMJ height compared to squat alone. The authors could not explain these findings.
This group of papers were of low to moderate quality.

Two RCT's of low to moderate quality showed some positive effects from WBV training with respect to muscle strength parameters with programmes ranging from 10 days to 8 weeks. Control groups varied across the studies; one compared squat exercises with vibration with squats alone and one compared to WBV with ‘specific programme training’.

Evidence to support added benefit from the addition of WBV training to a squat programme comes is supported by one study after 5 weeks of treatment. CMJ heights increased significantly as compared with a squats without vibration group (p<0.01). Finally an 8-week WBV training programme indicated leg press peak force (p=0.038), total work (p=0.004) and CMJ height (0.00002) improved following WBV training. Some questions remain, however, regarding the control group intervention. This was poorly described as ‘specific programme training’.

There is, therefore, conflicting evidence of effectiveness for longer term WBV interventions in trained subjects. CMJ height or CMJ centre of gravity measures only appeared to consistently be better than groups that receive conventional other treatments; there is variability, however across some other parameters e.g. peak force.

No papers to date have investigated whether changes from either short or longer term WBV training programmes are enduring, or if the measured improvements enhance sports performance and/or function. No serious adverse events have been reported to date with longer-term interventions in healthy trained or untrained adults.

One moderate quality RCT investigated the impact of WBV following 6 weeks of WBV in child skiers Improvements over and above a standard programme related to box jumps (67.06 mean reps WBV vs 55.19 reps control, p=0.013) and plantarflexor strength (90.09 WBV vs 68.18 control). Side effects were not mentioned.

Effects of WBV training on locomotion and balance parameters

Ten studies (seven RCT’s and three controlled studies) measured balance (static and/or dynamic) parameters following WBV training programmes. This section, reviews only those studies that reported outcomes in younger adults. Locomotion and balance is discussed in further sections for post-menopausal women and the healthy elderly.

Two controlled studies of moderate quality measured balance parameters following a single WBV training session. These two studies were almost identical in their design, the only difference being the actual individual subjects (same general cohort). A single 4-minute session delivering WBV training using 10mm amplitude and variable frequencies (frequencies increased for each minute of vibration; started at 15Hz, increased 5Hz/minute) indicated a 15.7% increase in body balance. This study also reported significant findings for other outcomes in the WBV group. To the contrary, an almost identical study by the same authors failed to show effect in either control or WBV interventions in any outcome measure, including balance. This could not be explained. The difference in the WBV amplitudes appeared to be the only difference between the two studies.

Three studies (two RCT’s and one controlled study) investigated balance parameters with WBV training regimes greater than one week.

Two RCT’s of moderate quality by the same authors assessed the impact of exercises on a longer-term WBV in healthy untrained adults. One paper reported results at 4 months, and the subsequent paper followed subjects through to 8 months. WBV frequency was increased throughout the programme in a standardised fashion (25-45Hz) yet the amplitude was kept stable throughout at 2mm. No changes in either static or dynamic balance (assessed by 30m shuttle run) were identified at either 4 or 8 months.

A further moderate quality controlled study administered 9 days of WBV training (5 days successive WBV, 2 day break, 4 further days WBV) in a group of athletic students. Agility as measured by the “up and back test” (2 x15 m sprint with turns) was unchanged, as were other parameters of CMJ, squat jump and sprint from baseline to follow-up.

In summary, the evidence appears conflicting for WBV training for the improvement of balance and/or locomotion for short term WBV training. The two longer programmes thus far published, one study each with trained and untrained subjects, have thus far shown no effect.

Safety aspects have thus far been poorly considered in short programmes. No adverse events were reported in either long-term study.

WBV training for flexibility

It is thought WBV training may be able to enhance muscle and soft-tissue flexibility through its stimulation of receptors involved in the stretch-reflex pathway. As soft-tissue flexibility and/or shortening is linked to restricted joint movement and possibly to a higher risk of muscle tears and other injuries a further modality that has the potential to improve muscle flexibility could prove valuable.

Three RCT's and one controlled trial measured aspects of flexibility following WBV training. The single study to investigate this in a general elderly population will be discussed in the 'WBV in healthy elderly' section.

Two of the four studies involved trained young women. Sample sizes varied from 18-26 subjects. All four studies used a commonly used outcome of posterior knee soft-tissue and hamstring muscle group extensibility (the sit-and-reach test). The elderly cohort also had a functional measure of shoulder flexibility assessed ('hand-behind-head' test).

Programme duration was variable and ranged from a single session to 8 weeks. Frequencies varied between 25-40Hz with amplitudes ranging from 2-10mm. The elderly cohort used amplitudes of 2-5mm. The quality of these studies was variable.

The single study to assess the impact of a mixed gender cohort (untrained subjects) identified that the addition of a static WBV programme over 4 weeks produced significant hamstring muscle length gains compared with a contract-relax stretching routine (26.8° vs 12.4° (p=0.002)). The authors suggested three possible mechanisms for the improvement seen; 1. A vibration-increase in local blood flow which increased muscle and connective tissue flexibility; 2. An enhanced quadriceps stretch-reflex loop and 3. Vibration-induced pain inhibition, which meant subjects could stretch beyond earlier limits.

The two remaining papers which were of moderate quality investigated the effect of WBV in physically fit young women. The first paper involved a single session of WBV, with hamstring flexibility measured as part of a battery of outcomes. Outcomes from a WBV static posture routine were compared to those from a group that stood on a non-vibrating platform standing and with a third group that performed a seated cycling routine. Results following a single session indicated hamstring flexibility measured by the sit-and-reach test improved by 8.2% (both alternate treatment groups 5.3%). The second of the two studies measured hamstring flexibility after a thrice weekly, 8 week programme and compared results with subjects that performed an unspecified sprint training programme designed for sprint athletes. The WBV intervention was platform standing in two different static postures. Control participants' sit-and-reach distance was a mean average of 19.59cm and for WBV subjects 22.6cm at 8 weeks (p=0.00004).

Neither of these two studies included other stretching techniques, and whilst doing so may have confounded outcomes; the suggestion that flexibility improves as a result of some of the treatment arms alone may be ambitious. Both studies were small (n=18 and 26) and both involved female athletes. This may mean results may not be generalisable to untrained women or trained males.

In summary, evidence from one quality RCT with a healthy mixed gender cohort indicates WBV in conjunction with a contract-relax programme is effective in producing a clinically important improvement in posterior knee soft-tissue extensibility after four weeks. This study did not analyse outcomes with respect to gender. Two further studies of lesser quality involving trained female athletes indicate positive outcomes after both short and longer term interventions.

No safety issues were identified, although one lower quality paper failed to report these.

Effects of WBV training on bone mineral density and other bone parameters

Seven RCT's and one controlled trial that measured bone mineral density (BMD) and other bone parameters (volume, turnover and other aspects of quality) were reviewed for this report. Five studies involved post-menopausal women. The evidence from these papers is discussed in the section 'WBV for post-menopausal women'. One RCT studied BMD effects in physically disabled children. This study is discussed in the 'WBV for rehabilitation populations' section.

Two RCT's specifically assessed the effect of WBV training on females with diagnosed bone density reduction; one examined bone density parameters in a young healthy, mixed gender group.

Osteoporosis is currently defined as a BMD score of 2.5 standard deviations below the average. BMD scores are compared with norms from a North American caucasian female population.

One RCT investigated 12-month BMD outcomes following a WBV training programme in a cohort of 50 caucasian females (15-20 years) who had sustained previous fractures and had low BMD. WBV training was 10 minutes daily (in-home) at 30Hz and 0.3 g acceleration. WBV subjects also took a calcium supplement. Results were compared with a group who took the same calcium supplement alone. Statistically significant improvements were reported in controls for femur bone cross sectional area at the study end, however, *all* axial and appendicular measures had shown a statistically significant improvement in the WBV group ($p<0.001$-0.003) at the end of the study. Between-group changes for absolute and percentage changes clearly favoured the WBV group.

A second study over 8 months involving both healthy adult males and females measured BMD outcomes from a WBV training regime as compared with a 'no treatment' group. WBV parameters were: 25-45 Hz frequency, 2-8g acceleration; the treatment was a single 4-minute session, 3-5 x per week. Results indicated that WBV training had no impact on mass, structure or bone strength in lumbar spine, femoral neck, trochanter, heel or distal forearm locations. No adverse events were observed in this group. This study was graded highly, although did use a 'no treatment arm', which may be inappropriate.

In summary, the effect of WBV training on BMD and/or other bone parameters in younger age groups is unclear with evidence from two studies only; one in young females with low BMD indicating some positive outcomes at 12 months, and one paper reporting no effect in a healthy mixed gender adult group.

No safety issues have been identified to date.

Effects of WBV training on the cardiovascular, peripheral vascular system and BMI

Eight studies (3 RCT's, 1 controlled trial and 4 case series) were reviewed. These papers evaluated the effects of WBV training on the cardiovascular system, including the ability to impact on aerobic capacity and its potential for weight loss. The effects of WBV training on the peripheral vascular system has been studied by two authors.

One controlled study and two case series investigated the impact of WBV on cardiovascular exertion/aerobic capacity.

These studies indicated that WBV training resulted in increased oxygen demand and heart rate increases. These increases corresponded to WBV training invoking a mild cardiovascular stress and that this may be equivalent to 'moderate walking'. One study that exercised subjects to exhaustion reported an itching erythema was noted in the in almost half of the participants. No drop-outs due to this, however, occurred.

Two RCT's and one case series measured the effect of WBV on BMI. An 8-month RCT targeting post-menopausal women reported significant difference in BMI in favour of the WBV group at the end of the study (.9 WBV vs .1 control, $p=0.049$). This programme administered a thrice weekly programme over 8 months (12.6 Hz, 3mm amplitude, static squat posture on the platform).

A further small case series administering WBV in a group of individuals with Chronic Fatigue Syndrome also reported a reduction in BMI ($p<0.05$) after six months of training (18-22Hz, 10mm amplitude). Subjects performed two minutes each of 4 different static exercise positions on the platform to begin with and the dose was increased over time. Subjects reported feeling more fatigued after the first week of training. The authors report this improved from week two onwards.

To the contrary, results from a final RCT indicated that only fat free mass showed a significant difference in favour of the WBV group (young females) after six months of training (2.2%; no change for weight or BMI). This change appears too small to be of clinical significance. Subjects performed unloaded static and dynamic exercises on the platform at 35-40Hz, 2.5-5.0 mm amplitude. Results were compared with two groups; a 'no treatment' group and a group that underwent a standard cardiovascular and resistance training programme. No other changes were seen in any group for weight, percentage body fat or skin fold thickness.

The only important safety issue in this sub-group of papers appears to be the increase in fatigue noted in the Chronic Fatigue group participants. This indicates care should be taken to minimise the potential for symptom augmentation in such groups.

Two studies (one RCT and one case series) investigated the impact of WBV on peripheral vasculature.

Results from a small case series measuring quadriceps and gastrocnemius musculature blood flow showed increased arterial blood flow following a single session (9 minutes) of WBV. Blood flow changes in both muscles was sufficiently great for the authors to assert the effects of WBV are due to muscle contractions during the WBV rather than passive vibration.

A small RCT investigated the impact on skin blood flow in three groups; vibration only (subject supine with calves resting on the vibration plate), vibration and exercise routine and exercise routine only. Indications are that skin blood flow (SBF) in the right distal calf in the WBV group increased to 250% following the intervention and remained significantly elevated for a further 10 minutes. The other treatment groups showed a slight reduction in skin blood flow. This reduction is explained by the calf muscle's requirement for oxygenated blood, thereby reducing cutaneous blood flow. This may suggest WBV training may be relevant for individuals with peripheral vascular conditions (e.g. Diabetes).

In summary, there is currently insufficient literature to support WBV improves aerobic capacity. Evidence comes from one poor controlled study and two case series. One study has compared the effect of WBV to that of a 'moderate walk'.

Two studies investigated the impact of WBV on peripheral blood flow with the intention of this in future perhaps being useful for peripheral vascular conditions. There is insufficient evidence to support the safety of WBV for these specific purposes.

Evidence from two RCT's indicated reduction in BMI or fat free mass following WBV training regimes. It appears unlikely, however, that the 2.2% reduction reported in one study in fat free mass is important. The minimal increase in metabolic rate reported from other literature and noted from peer review of this document would indicate this modality is unlikely to be an effective modality to effect in significant fat loss and or/bmi reduction.

No substantial safety issues have been identified thus far from the limited number and quality of papers, although few papers reported safety issues.

Effects of WBV training on the endocrine system

Examining hormone levels following WBV is an area of interest for researchers as it may provide information as to how WBV may induce strength related changes and possibly weight loss. To this end four studies (one RCT, two controlled trials and one case series) were reviewed. Sample sizes were low in all studies (8-28 subjects). Three studies administered 1 or 2 sessions and one study delivered 9 weeks of WBV training. WBV parameters ranged from 2.5-4mm and 26-30Hz.

One small case series reported an increase in testosterone but a drop in cortisol and growth hormone following a single session of WBV in a group of healthy males. The authors postulated the WBV stimulus was insufficient to stimulate a general stress response.

The effect of two sessions of WBV training on the of blood glucose and hormone concentrations (insulin, glucagon, cortisol, epinephrine, norepinephrine, GH, IGF-1, free and total testosterone) was studied using an RCT methodology in 10 healthy men. Volunteers were subjected to sessions of 25 min WBV training either in the absence or presence of vibration. Results showed reduced plasma glucose concentration and increased norepinephrine plasma levels. The authors concluded that the intervention may have increased glucose utilisation due to induced muscle contractions, however, they did not expect this to be sufficient to reduce fat mass in obese individuals.

One RCT administering a single session of WBV training in 8 healthy untrained males reported serum free fatty acids significantly decreased in WBV and control groups (sham WBV) but no statistically significant difference was found at any time point between the groups. The authors concluded that although growth hormone increase has in previous studies been linked with a lipolytic effect this was not seen in this study.

A final study explored the hormonal responses to WBV that may be responsible for muscle hypertrophy and therefore strength gains following WBV. Subjects were randomised to a squat-trained group (loaded squat), squat and WBV (loaded squat on platform) or a WBV only group (squat with broomstick) over 9 weeks. WBV did not change the acute hormonal response to a training session. The authors concluded that hormonal changes thought to mediate strength gains were not seen in this study and decided that the WBV intensity may need to be increased to see this effect.

There is a limited body of literature investigating the effects of WBV on the endocrine system. How WBV training may affect hormones that are involved in mediating both strength and weight loss is unclear.

Adverse events are poorly reported in this group of papers. Safety issues may well be unlikely to be of great concern in the single session interventions, however, for longer programmes may be important.

WBV training for specific populations

WBV training for post-menopausal women

The onset of menopause is genetically determined with an approximate age of onset cited in the literature of 50 years. An increase in bone resorption and subsequent osteoporosis following menopause is well documented. In addition, the effects of ageing on the body (respiratory, cardiovascular and muscular system) make this group a population of interest. WBV training is purported as a strategy that may mitigate some of the effects of ageing and the menopause.

Three RCT's investigated the effect of WBV training regimes for lower limb strength gains in post-menopausal women. All studies were 6-months duration in healthy post-menopausal women and all reported positive effects of WBV interventions. Sample sizes varied from 29-89. WBV Parameters varied across studies from 28-45Hz, with acceleration of .5-10g. All studies used the 'teetering' or latera oscillating Galileo platform.

Two studies reported the same knee extensor strength improvements after 6 months of WBV training (15% isometric and 16% dynamic). CMJ height has been reported to improve up to 5% in one study and 19.4% in another. Because of the choice of control groups across the study it is unclear, however, if WBV training programmes are superior to standard resistance training programmes with respect to muscle strength parameters.

Five RCT's investigated the effect of WBV on bone density and/or bone turnover parameters. One RCT specifically targeted osteoporotic women. Three studies excluded individuals with osteoporosis and one paper was unclear. Sample sizes varied from 28-70. WBV parameters varied from12-40Hz and acceleration from 0.2-10g across the studies.

Three studies were positive for improvements in some bone parameters. The positive effects on BMD seem to be evident in the hip region, a common site of fracture following falls. Results are reported below.

One high quality RCT studied the impact of home based WBV appliances in women 3-8 years following the onset of menopause. Subjects spent 10 minutes twice daily, seven days per week for 12 months standing on a WBV platform in their home. As there was a strong positive association between compliance and efficacy, regression analyses were undertaken. Results then showed that with 100% compliance, trochanteric BMD would be projected to increase 5.1% (p=0.085); for the femoral neck, 1.8% (p=0.4) and BMD of the spine would be predicted to show the greatest increase of 7.1% over a year (p=0.0039). Five withdrawals in the WBV group were not explained.

A 12-month home based RCT identified issues with compliance with a twice daily 10-minute WBV regime. Furthermore, post-hoc analyses in this study indicated that WBV training prevented bone density loss better in women with lower body mass.

One average quality RCT administering a 6-minute twice-weekly regime over 6 months reported no bone density or quality improvements or differences in cortical bone density or in the bone turnover biomarkers between controls ('no treatment') group.

One study only investigated the effect of WBV training in women with diagnosed osteoporosis. Results indicated WBV training did not enhance the effect of Alendronate, a conventional medicine used for the treatment of osteoporosis. WBV treatment for this cohort was once weekly. This could be seen as a sub-therapeutic dose. The second study indicating no effect involved thrice weekly treatment for 6 months.

There is, therefore, conflicting evidence for the efficacy of WBV interventions for the purposes of improving or preventing reduction in bone mineral density in post-menopausal women.
No literature has been published to date indicating WBV is effective in reducing the incidence of fractures, largely the purpose of WBV in this population. It is also not clear from studies to date whether the potential for WBV to affect BMD may be different for women with diagnosed osteoporosis as compared with perhaps osteopenic post-menopausal women.

There appears moderate evidence to suggest this is a safe intervention for this population. Adverse events were well reported across the studies for this population and included knee pain, withdrawal due to disinterest, lower limb oedema, leg itching and erythema. No serious adverse events have to date been reported.

WBV training in the healthy elderly

The effects of ageing on body systems are well documented. The effects on the musculoskeletal system in particular include a reduction in muscle bulk and strength and an increase in fat deposition with increasing age. Age-related musculoskeletal changes may be responsible for the balance and locomotion ability impairments seen in the elderly. These changes may contribute to falls risk. How much a contribution reducing activity levels with ageing makes to these changes is unknown. Researchers are striving to find strategies and modalities to arrest these changes. Conventional strength programmes suitable for younger adults are unsuitable for older people for many reasons and additional or alternate modalities would be welcomed.

Four quality RCT's studied groups of healthy elderly subjects for the purposes of improving strength, balance, gait and flexibility. Subject numbers ranged from 24 nursing home residents to 220 community dwelling adults. Programme length varied from 6 weeks (n=2) to 12 months. WBV parameters varied from 10-30Hz, 3-7mm amplitude. A variety of WBV platform brands were used across these studies. Either the Powerplate® or the Galileo WBV appliances were used for this population.

One quality RCT reported a statistically significant difference between body balance scores between the WBV training group and the controls at six weeks (Tinetti test overall score=13.9 vs 11.8, p=0.001). Control subjects stood on the platform without vibration. Both groups also received a concurrent chair based exercise programme. WBV participants also significantly reduced their 'TUG' test scores (15.3 vs 14.8, p=0.029) at 6 weeks. The controls stood on the WBV platform without vibration. The application of vibration, therefore, was the only difference between the groups

The second RCT to administer a 6 week WBV training programme assessed muscular performance and body balance in 42 nursing home residents. The WBV intervention was the adoption of a series of static postures. The WBV group improved by 3.5±2 points on the Tinetti test; the WBV training group were considered 'at risk' of falls at baseline (as assessed by the Tinetti test) (14.9/28; threshold for being considered at risk=19/28); at the study end the WBV group fell outside these parameters (20.5/28). Statistically significant changes were also seen in the WBV group for aspects of general health as measured by the Short-Form 36.

A further 12-week WBV training regime has been administered to 220 community dwelling older adults. WBV group subjects performed a series of exercises on the vibrating platform. The control group undertook a fitness programme; there was a further 'no-treatment' group. Dynamic posturography[5] scores indicated that WBV may contribute to *some* aspects of postural control in a healthy elderly population.

The addition of WBV to a balance and strength programme in a final non-randomised comparative study indicated a reduction in 10-metre walking time and subjects improving their single leg stance and step length (all $p<0.05$) following a once-a-week treatment over 8 weeks. The participants in this study were allocated to the WBV or exercise group based on their willingness to participate and cohort sizes were substantially different between groups (27 WBV vs 40 Fitness). These may be significant study limitations.

The single paper to address upper and lower limb flexibility in the healthy elderly indicated no effect as measured by the sit and reach hamstring flexibility measure and the functional 'hand-behind-head' shoulder test. The programme was 6 weeks in duration and subjects performed a series of static exercises on the vibrating platform.

In summary, there is moderate to strong evidence that administering a WBV regime both as a stand-alone programme and in addition to an appropriate exercise regime reaps balance benefits in older adults, with as short a programme as 8 weeks. Gains identified from three quality trials appear to be realised both with WBV regimes requiring the subjects to exercise on the vibrating platform or hold one or more static postures, with as few as one session per week. Not all studies, however, reported substantial clinical improvements and it is unclear as to the superiority of WBV training programmes over conventional cardiovascular, resistance and/or balance programmes. It is also unknown whether the changes measured may be enduring or if real-life falls reduction is realised.

No conclusion can be made regarding the impact on upper or lower limb flexibility.

One study only in this group of studies failed to report adverse events. One case of groin pain and five withdrawals due to knee pain occurred in the WBV groups in two studies. These were not explained and therefore it was not clear if these were related to the intervention. Minor lower limb tingling was also reported in a further study.
The number and severity of adverse events overall appear relatively minor and at this point seem unlikely to impact on the viability of the intervention.

WBV training for rehabilitation populations

WBV for individuals with neurological diseases or conditions

Seven papers in total administered WBV training to subjects with neurological conditions or diseases for the purpose of, by and large, enhancing balance and/or function. One paper investigated the impact of WBV on bone mineral density in physically disabled children. WBV parameters ranged from upwards of 1 to 90Hz. Amplitudes were by and large 3mm across the studies. All but two papers paper administered a single session (6 and 8 week programmes).

Two papers reported on WBV with stroke populations. A small pilot study reported improvement posture outcomes for 23 stroke patients following a short course of WBV. A subsequent larger RCT indicated, however, that administering WBV training over 6 weeks to a larger group of stroke sufferers resulted in no benefit to balance or other outcome measures. Two patients in the control group suffered a further CVA, whilst one in the WBV group withdrew for non-health reasons. This study was high quality.

Five further studies (two involving Parkinson's subjects, one each involving cerebral palsy and multiple sclerosis sufferers and one study with physically disabled children) were reviewed. Four were RCT's and one a controlled trial.

Two studies investigated the impact of single sessions of WBV training in Parkinson's sufferers. Unified

Parkinson's Disease Rating Scale (UPDRS) scores were unchanged after the control phase (unspecified 'rest period'), however, all subjects showed improvement in their scores after WBV training, with a 16.6% reduction in UPDRS scores in group A (WBV followed by rest intervention) and a 14.7% reduction in Group B (rest followed by WBV). Most improvement was seen in tremor and rigidity (24 and 25% respectively) although all changes excepting cranial scores were significant at the p<0.01 level. No adverse events occurred.

A further trial compared a single session of WBV training with a "moderate" walk around the grounds of a hospital. Narrow and tandem standing scores improved significantly for both groups from baseline to follow-up (7.1%; p=0.04 control and 14.9%; p=0.00 WBV). Only tandem standing improvements were significantly better in favour of the WBV group (24% vs 11.3% improvement in control; p=0.04). Adverse events were not reported.

The effect of a single session of WBV training was piloted with 12 (six WBV training and six control) multiple sclerosis sufferers. Of the three outcome measures; posture, functional reach and TUG, only TUG scores improved. The improvement was significant (p=0.041) at one week (the study end) for WBV subjects but the benefits were lost at two weeks (0.093). One WBV subject complained of fatigue during the study, but no drop-outs were reported.

The effect of WBV training in adults with cerebral palsy has also been investigated. Subjects were administered three sessions per week over 8 weeks. The control group performed a resistance training programme. Outcome measures were: spasticity, isokinetic muscle strength, walking, TUG time and a combined functional measure (Gross Motor Function Measure, GMFM[6]), yet to be validated in adult patients. No between-group differences were found at 8 weeks; furthermore, although an improvement in extensor spasticity (p=0.04) occurred in the WBV training group from baseline to follow-up, there was no carry-over into function. No spasticity changes were significant for other muscle groups. Stiffness following treatment occurred in one subject in the WBV group and three in the control group. The use of the unvalidated GMFM with this group and the small sample affected the quality of this paper.

Finally one RCT has published results following WBV training in physically disabled children, a group well known for reduced bone density and at high risk for falls. Twenty children capable of standing independently but with limited mobility undertook a 10 minutes a daily, 5 days a week WBV standing programme over six months.

Proximal tibial BMD results indicated a 6.3% increase from baseline in the WBV group as compared with an 11.9% reduction in the control group (p=0.0033). Lumbar spine BMD results indicated a 5.5% increase in the WBV group and a 0.3% increase in the control group (p=0.31). The authors believed the lack of change in the lumbar spine reflected the ability of the body to dampen down the effects of vibration to the axial skeleton. No changes were seen between groups or from baseline to follow-up in diaphyseal bone area, cortical thickness and density and muscle area. Notably compliance was low at 44%. No relationship was found between compliance and effect. One subject withdrew due to disinterest.

In summary, WBV training has been trialled with subjects with a variety of neurological conditions or disorders. By and large most trials have been undertaken with the purpose of improving balance and function. WBV regimes appear cautious, as judged by the duration and WBV parameters used. All but two studies administered single sessions with small samples. Some results have been positive for balance, locomotion (TUG) and bone parameters. A high quality RCT administering WBV training in stroke patients indicated WBV was not effective in improving balance or locomotion parameters over and above a comprehensive in-patient rehabilitation programme. One quality RCT has piloted home-based WBV with physically disabled children to investigate the impact on bone mineral density indicating positive effects.

Adverse events across a mixed group of papers are to date small in number and minor. Not all papers reported safety issues.

Anterior cruciate ligament (ACL) reconstruction rehabilitation

One RCT administered WBV training to patients following ACL reconstruction. Subjects in the WBV group received five daily administrations of WBV (30Hz frequency for 1 minute) over a two-week period. There were significant increases in the WBV group with respect to muscle strength (p<0.001) and force peaks (p<0.005) as compared with controls (standard rehabilitation programme). Although the authors concluded that WBV incorporated with a rehabilitation protocol aided recovery of muscle strength, this conclusion should be regarded with caution. Firstly, the number of participants was small; secondly, the WBV training was only two weeks; and lastly, the subjects in each group did not follow exactly the same rehabilitation programme, which may have confounded results. Side effects or adverse events were not mentioned; this is of particular concern as this is a post-surgery WBV application.

<u>Other studies</u>

One pilot study (RCT) was reviewed in this section. A single 5-minute WBV training session was administered to healthy young adults with the purpose of assessing the subject's ability to detect lumbosacral position-sense. This was a small study involving healthy young adults. Individuals that have an awareness of the position of their pelvis and spine at rest or during activity have been shown to recover from back pain episodes more promptly. Modalities that could improve a subject's ability to detect their spine and pelvis position may, therefore, be beneficial in managing patients with back problems. A significant improvement in lumbosacral position sense was seen in the WBV group only (39%, p=0.008). This was a pilot study with a small sample and although failed to report safety issues, was otherwise well carried out.

2. Cost

Comment on any economic costs associated with this service, product or procedure

Galileo and Powerplate are the most commonly published WBV devices in the literature. A 'basic' Galileo brand platform is currently priced at AUS$7,780 +GST with the sport versions at over AUS $18 990 +GST. The current price for Powerplate home platforms ranges from US$1,999 to $10,500 and for commercial models, US$9,250-10,500.

3. Clinical impact

Comment on the clinical impact e.g. size of population, magnitude of effect, relative benefit over other management options, resource implications, balance of risk and benefit.

Whilst WBV is currently trialled on a variety of populations for different purposes, key areas of relevance for ACC appear to be the efficacy and safety for falls prevention, potential improvements to bone density, and although little literature currently, to speed recovery for injury (in the case of rehabilitation following ACL repair).

There is a growing body of positive literature for efficacy for improving balance parameters in older adults. Important limitations to the body of evidence at this point is that there is no literature that reports the transference of balance parameters to function and/or falls prevention, nor whether the gains from WBV are enduring. Compliance with WBV training has been investigated in two in-home treatment regimes with elderly subjects. Whilst ACC currently has falls prevention programmes in place, WBV may be a modality that warrants future consideration. It seems appropriate that further research is undertaken to better define the WBV parameters and populations for whom this treatment may be most beneficial.

4. Equity, Maori Health, Pacific Health, Acceptability

Comment on the extent to which the service, product or procedure reduces disparities in health status (equity of access, resources, health outcome), is consistent with the treaty of Waitangi and encourages Maori/ Pacific participation in providing and using service, product and procedures, and is consistent with values and expectations of New Zealanders.

Nil issues identified

5. Possible Purchasing Options

List the possible purchasing options.

- *Purchase WBV as a specific modality for the prevention or treatment of ACC covered injuries for any purpose*

- *Do not purchase WBV as a specific modality for the prevention or treatment of ACC covered* *injuries for any purpose*

- *Purchase research into the use of WBV for the healthy elderly at high risk of falls as the opportunity arises.*
- *Do not purchase research into the use of WBV for the healthy elderly at high risk of falls.*

6. Evidence Statements

Summarise the advisory group's synthesis of evidence relating to this service, product or procedure, taking the above factors into account, and indicate the evidence level that applies.

WBV training for specific purposes

Effects of WBV training on muscle performance

Short-term applications of WBV - < 1 week muscle strength, torque and countermovement jump

Healthy untrained adults

Evidence for the efficacy of short-term WBV interventions in improving lower limb strength and or force parameters in healthy untrained adults is conflicting. Four controlled studies and one case series were reviewed. One study exercised subjects to exhaustion using WBV.

No conclusion can be made regarding safety in this sub-population as studies failed to report on safety issues or adverse events.

Trained adults

There is insufficient evidence to support the effectiveness of WBV in trained (elite and recreational) individuals. Evidence for improvements in countermovement jump height comes to date comes from two controlled trials and one case series.

Section evidence statement

The evidence to support the efficacy of short-term WBV training applications for the purpose of enhancing muscle power/ strength and/or CMJ parameters is unclear with conflicting evidence from a small number of moderate quality papers. Most studies involved healthy untrained male subjects.

Evidence to support the safety of short-term WBV for muscle power and/or strength and/or CMJ improvement is thus far unclear. Despite the fact that WBV interventions are brief, and thus far, no serious adverse events have been reported, safety issues have to date been poorly considered.

Longer term applications > 1 week for muscle strength, torque and countermovement jump

Healthy untrained adults

There is limited positive evidence that longer term WBV training improves muscle power/strength gains in healthy young adults. Two quality studies report improvements in CMJ height compared with subjects performing identical exercises without vibration. One moderate quality study only reported that CMJ height gains following WBV training provided additional height gains over and above a comprehensive conventional resistance training programme. The duration of the WBV programmes across the studies varies significantly (6 weeks to 8 months).

There is insufficient evidence due to poor reporting of adverse events that WBV interventions of this duration and this purpose are safe.

Trained adults

Evidence for muscle strength and/or power benefits from longer-term WBV training programmes in trained healthy adults is unclear. There is conflicting evidence from five low to moderate quality RCT's and one controlled trial. Whilst there is some positive evidence for strength and/or power gains from randomised controlled trials, the heterogeneity of the studies in terms of control group interventions and WBV parameters makes generalisability difficult.

Adverse events and safety issues are poorly reported across both short and long-term interventions and therefore it is unclear if these interventions are safe.

Effects of WBV training on locomotion and balance – younger adults – trained and untrained

Short WBV training interventions

There is conflicting evidence from two quality controlled studies by the same authors that short-term WBV training interventions improve body balance. These studies enrolled healthy untrained adults. Both studies reported no adverse events or side effects from the single WBV session.

Longer term studies

There is moderate evidence from three quality RCT's that assessed static and/or dynamic balance parameters that WBV training is not effective. Programmes were 9 days, 4 and 8 months. Minor discomfort that diminished over the training period occurred in subjects who undertook the 9 day WBV training programme, however, control participants also reported similar discomfort. The 9 day study involved trained subjects, the latter two studies, healthy untrained subjects.

WBV training for flexibility

Trained adults

There is moderate evidence that WBV may improve hamstring flexibility in young trained adults. Positive evidence comes from two RCT's (4-8 weeks) and one controlled trial (single session). The single *high* quality RCT reported hamstring flexibility improved with a 4 week WBV programme combined with a standard hold-relax stretching routine. This RCT was the only study to involve trained young males. Results were not analysed for gender, however, and whether these improvements apply to young males, who, as a group, are seen as 'less flexible' than females is unknown.

Effects of WBV training on bone mineral density and other bone parameters

The evidence is unclear whether WBV training in healthy untrained adults is effective for improving bone mineral density or other bone parameters of interest. Positive evidence comes from one 12 month trial trial of moderate quality in young women with low BMD. Evidence to the contrary comes from a second study of moderate quality in a mixed gender adult cohort that indicated no change in bone density and/or bone turnover parameters following an 8-month WBV programme.

No adverse events occurred.

Effects of WBV training on the cardiovascular, peripheral vascular system and BMI

There is insufficient evidence to support the safety and efficacy of WBV to improve aerobic fitness. Evidence from one low quality case series and one controlled study both involving healthy adults indicated the addition of WBV to a squat resistance exercise series may provide a mild cardiovascular stimulus. Adverse events and safety issues were poorly reported.

It is unclear whether WBV training reduces body mass. There are a limited number of studies that present conflicting evidence. Evidence comes from two RCT's and one case series. One quality RCT, reported a clinically significant body mass index reduction (.9) following an eight month programme in post-menopausal women. Evidence to the contrary came from a healthy young female cohort following 6 months of WBV training.

Short-term fatigue in a small case series of subjects with diagnosed Chronic Fatigue Syndrome have been the only adverse events reported to date in these papers.

WBV training for specific populations

WBV training for post-menopausal women

Muscle strength/power

There appears moderate evidence that lower limb strength gains and CMJ height result following WBV training in post-menopausal women. Evidence comes from three quality RCT's. It is unclear if WBV training, however, is superior to conventional resistance training programmes. Two RCT's present conflicting evidence in this regard with respect to both CMJ and muscle strength gains.

Balance/Locomotion

There is insufficient evidence to support the efficacy of WBV interventions for balance alone in solely post-menopausal women. This is based on evidence from one moderate quality RCT administering a 12-week WBV training programme that resulted in statistically significant improvements in single-leg balance.

Bone Parameters

There is conflicting evidence to support the efficacy of WBV training to improve or prevent loss of bone mineral density or other bone quality and volume parameters in post-menopausal women. Three randomised controlled trials, of which one was of very high quality provide positive findings for some outcomes. One of the studies that showed no effect on BMD administered WBV to women with diagnosed osteoporosis; this study may be critiqued on the basis of a low overall WBV dose (once weekly application).

There appears moderate evidence to suggest this is a safe intervention for this population. Adverse events were well reported and included a few cases of knee pain. Disinterest was the cause of some drop-outs and compliance has been raised as an issue, particularly where daily home treatments are involved. disinterest. No serious adverse events were reported.

There is no information to whether such gains are enduring. There is an absence of evidence to support that the positive findings that have been reported in some studies to date result in a reduction in falls or fractures from falls.

WBV training in the healthy elderly

Muscle Power/Strength

There is insufficient evidence to support the efficacy of WBV interventions in the general elderly population for muscle power and/or strength improvements. Evidence from one high quality study in a cohort of rest-home residents indicated the addition of WBV did not improve strength over and above a 'chair-based gymnastics programme'.

Balance and Locomotion

Three RCT's consistently report improvements in some balance and locomotion parameters in the healthy elderly population as compared with controls. WBV interventions were 6 weeks (n=2) and 12 months respectively. Evidence is unclear, however, as to whether these gains are superior to other resistance and/or cardiovascular programmes.

Flexibility

One quality RCT that administered a 6 week WBV training programme in a mixed gender rest-home cohort indicated WBV training did not improve either shoulder or hamstring flexibility.

There appears moderate evidence supporting the safety of this intervention for healthy older adults. One large RCT identified 7/220 (5 WBV, 2 control) participants dropped out due to knee pain.

There is no evidence to date, to suggest the balance improvements seen are either enduring or carry-over to general function (e.g. Activities of daily living performance). No studies to date have investigated whether in fact WBV training may reduce falls in the elderly.

WBV training for rehabilitation populations

Stroke

There is limited conflicting evidence to support the efficacy of WBV training for Stroke sufferers. This is based on conflicting evidence from one case series and one quality RCT reporting balance parameters following a single session of WBV training. No adverse events were reported from these studies.

Parkinson's Disease

There is insufficient evidence to support the efficacy of WBV interventions for Parkinson's disease sufferers. Positive evidence comes from two low-moderate quality RCT's reporting balance, rigidity and function improves following a single session of WBV. For the one study that considered safety, no adverse events occurred.

Cerebral Palsy

One small low-quality RCT administering WBV training to a group of adult Cerebral Palsy sufferers reported this treatment effective with respect to spasticity and walking/standing outcomes. Minor side effects were reported.

Multiple Sclerosis

One small RCT of moderate quality administered WBV training to a group of Multiple Sclerosis sufferers. Results were positive with respect to 'timed-up and go' scores at one week after a single application. Posture and functional reach scores did not improve. Minor side effects were reported in this study.

Physically disabled children/young adults

One small yet high quality RCT provides positive evidence that WBV training improves tibial bone mineral density in physically disabled children. This study administered a 10 minute daily WBV regime for six months in a mixed cohort of children aged between 4 and 19 years. No side effects occurred although one subject withdrew due to disinterest.

Chronic Fatigue Syndrome

One small case series indicates positive outcomes with a six-month WBV programme in subjects with long-standing Chronic Fatigue Syndrome. Mood, quality of life improvements and reduction in quadriceps pain threshold and body mass index were reported. There is insufficient evidence to confirm the safety and efficacy, however, of WBV training for this group.

Anterior cruciate ligament reconstruction rehabilitation

Evidence from one quality RCT administering WBV training to individuals following anterior cruciate ligament reconstruction reported positive findings after a two week WBV intervention at 1 month post-surgery for muscle strength and mean force peak. WBV was administered in addition to a standard post-operative rehabilitation programme for this surgery. Adverse events or safety issues were not reported. This is a significant study limitation; a further limitation is its small size.

7. Purchasing Recommendations

What recommendation(s) does the advisory group draw from this evidence?

Do not purchase WBV as a specific modality for injury prevention or treatment of an ACC covered injury.

Figure 1. Vibration variation in WBV platforms