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Revisión
Whole-body vibration training as complement to programs aimed at weight loss

Carlos Cristi-Montero\textsuperscript{1}, María J. Cuevas\textsuperscript{2} y Pilar S. Collado\textsuperscript{2}

\textsuperscript{1}GICEFYD, Grupo de Investigación en Ciencias de Ejercicio Físico y del Deporte. Universidad Viña del Mar. Chile. \textsuperscript{2}Instituto de Biomedicina (IBIOMED). Universidad de León. León. España.

Abstract

Introduction: Whole-body vibration training (WBVT) has been shown to be an extremely useful tool for increasing muscle mass, bone tissue, muscle power, flexibility, and strength, among others. However, to date, there are few studies on the effects of WBVT on energy metabolism and whether this tool could be able to enhance weight loss in addition to a nutritional plan and/or exercise.

Objective: The aim of this review is to analyse the most recent studies on vibration training in order to determine whether this method constitutes a reliable complement to programs aimed at weight loss.

Methods: An updated literature search was conducted using PubMed, SciELO and SPORTDiscus. In addition, a detailed search was also performed from references given in selected studies.

Results: WBVT appears to be associated with three pathways involved in weight loss: inhibition of adipogenesis and reduction of fat mass, increased energy expenditure, and increase in muscle mass. After analysing the literature, none of the results for the proposed pathways are consistent, and indeed are often contradictory.

Conclusion: Further in-depth research is required on this subject. However, WBVT would appear to be a safe method, and may possibly yield benefits, mainly as regards muscle mass, which in turn might promote weight loss when combined with a nutritional plan and a traditional exercise program.

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Key words: Whole-body vibration training. Adipogenesis. Fat mass. Muscle mass. Energy expenditure.

Resumen

Introducción: El entrenamiento de vibraciones de cuerpo completo (EVCC) ha demostrado ser de gran utilidad para aumentar la masa muscular, el tejido óseo, la potencia muscular, la flexibilidad, y la fuerza, entre otros. No obstante, hasta la fecha es escasa la literatura respecto a sus efectos sobre el metabolismo energético y si esta herramienta podría ser capaz de potenciar la pérdida de peso como complemento a un programa nutricional y/o de ejercicio físico.

Objetivo: El objetivo de la presente revisión es analizar los últimos estudios sobre el EVCC con la finalidad de determinar si puede ser un método fiable para complementar los programas orientados a la reducción del peso corporal.

Métodos: Se realizó una búsqueda bibliográfica en Pubmed, Scielo y SPORTDiscus, así como una búsqueda manual entre las referencias de los estudios seleccionados.

Resultados: El EVCC parece estar vinculado a tres vías relacionadas con la reducción del peso corporal: inhibición de la adipogénesis y reducción de la masa grasa, aumento del gasto energético y aumento de la masa muscular. Tras analizar la literatura, ninguna de las vías propuestas es consistente, y en muchas ocasiones los resultados son contradictorios.

Conclusión: Se concluye que es necesario profundizar sobre esta línea de investigación. No obstante, el EVCC parece ser un método seguro y posiblemente tendría beneficios, principalmente sobre la masa muscular, lo que podría promover la pérdida de peso si se combina con un plan nutricional y un programa de ejercicio tradicional.

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Introduction

Recent decades have witnessed a variety of economic, urban and especially technological changes which have transformed the habits and lifestyle of our society. This social transition has led to a drastic reduction in people's levels of physical activity, which has been associated with a steady increase in the incidence of overweight and obesity.

Various methods and programs have been proposed to help prevent, control and reverse excess weight gain. Although the implementation of a low calorie diet without exercise may reduce body weight rapidly, this occurs at the expense of loss of muscle mass. In contrast, a weight loss program consisting solely of physical exercise may be effective. It has been shown that exercise can help maintain or increase muscle mass and stimulate metabolism, etc. However, the effects of exercise on body composition tend to develop slowly if not accompanied by a proper diet. For this reason, the combination of diet and exercise is proposed as the ideal and most reliable weight loss method.

A nutritional plan combined with aerobic exercise or resistance training, or combination of both, has proved useful in improving the body composition of people who engage in a weight loss program, producing favourable changes in fat and muscle mass.

Recently, the use of whole-body vibration training (WBVT) has become increasingly popular as a useful tool in both sports and rehabilitation centres. The main advantage of WBVT is that in a short period of time (~10 minutes per session) it has the capacity to stimulate a large number of muscle fibers and produce a great many contractions, which helps to increase strength, balance and muscle power, enhance mobility, reduce chronic pain, stimulate blood circulation in the extremities and improve bone mineral density, among other effects.

In addition to inducing significant benefits in variables related to physical condition, WBVT has also been shown to be an extremely useful tool for reducing arterial stiffness, blood pressure and sympathovagal balance in a population of overweight or obese women. In recent years, several authors have suggested that WBVT could contribute to weight loss, indicating that it generates an increase in energy metabolism and a reduction in body fat percentage. However, no clear consensus exists on this issue to date. Therefore, the aim of this review was to analyse the most recent studies on vibration training in order to determine whether this method constitutes a reliable complement to programs aimed at weight loss.

To this end, an updated literature search was conducted using various metasearch engines such as PubMed, SciELO and SPORTDiscus, and employing keywords such as “Body vibration”, “Whole body vibration”, “Vibration training”, “Vibration exercise”, “Whole-body vibration”, “Body vibration training”, “Fat”, “Low weight program”, “Hypertrophy” and “Body composition”. In addition to the computer search, a manual literature search was also performed based on the references given in the selected studies.

An analysis of the literature indicated that there are three main pathways through which WBVT could act to reduce body weight (fig. 1), although the results of the studies appear to be rather contradictory, mainly depending on the study population, exercise intensity and the amplitude (mm), frequency (Hz) and duration of the program.

Table I lists the main studies which have been conducted on the inhibition of adipogenesis, reduction in fat mass, increase in energy expenditure and increase in muscle mass as a result of vibration training.

**Inhibition of adipogenesis and reduction in fat mass**

In studies conducted on rats, it was concluded that WBVT reduced the accumulation of body fat and decreased serum leptin levels, but did not affect bone density or mineral content, or lean mass.

Furthermore, Rubin et al. (2007) published a study based on molecular techniques in which the authors indicated that if their results on rats were extrapolated to humans, vibration training could contribute as a non-pharmacological approach to the prevention of obesity and its sequelae. They found that after 15 weeks of short daily exposure to high-frequency vibrations, adipogenesis in rats was inhibited by 27%, esterifica-
<table>
<thead>
<tr>
<th>Reference</th>
<th>Sample</th>
<th>Protocol</th>
<th>Results</th>
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<tbody>
<tr>
<td>Maddalozzo et al., 2008</td>
<td>Fischer Rats, n = 344 Females, 7 months old</td>
<td>30-50 Hz, 6 mm, 5 times/week, 12 weeks</td>
<td>Vib. group: 10%, 2% and 46% less weight, fat and leptin, respectively.</td>
</tr>
<tr>
<td>Rubin et al., 2007</td>
<td>Male mice, n = 40, 7 weeks old</td>
<td>15 weeks, High frequency, 0.2-g peak acceleration displacement of ≈12 µm</td>
<td>Inhibited adipogenesis by 27% more than the control group.</td>
</tr>
<tr>
<td>Yoo et al., 2009</td>
<td>112 students, men and women</td>
<td>10 min, 3 times/week, 3 months</td>
<td>Women vib., slight increase of 0.8 kg weight and 1.1 kg fat.</td>
</tr>
<tr>
<td>Roelants et al., 2004</td>
<td>48 untrained women, ~21 years old</td>
<td>24 weeks, 3 times/week, 35-40 Hz, 2.5 to 5.0 mm plus cardiovascular exercise and strength training</td>
<td>Vibration group reduced fat mass by 2.2% compared to controls.</td>
</tr>
<tr>
<td>Song et al., 2011</td>
<td>15 healthy, obese, postmenopausal women, &gt; 50 years old</td>
<td>10 min, 3 times/week, 8 weeks</td>
<td>Weight: -1.18 kg, BMI: -0.49, Waist circ.: -2.34 cm</td>
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<tr>
<td>Wilms et al., 2012</td>
<td>14 obese women, ~43.1 years old</td>
<td>6 weeks, 2 mm, 30 s/30 s, 30 Hz</td>
<td>Weight: no difference, Waist circ.: -1.7 cm, Fat mass: -0.2%</td>
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<tr>
<td>Vissers et al., 2010</td>
<td>79 overweight/obese participants, ~44.5 years old</td>
<td>6-month intervention, 6-month follow-up, 30-40 Hz, 2-4 mm, 30-60 s/exercise, 10-22 exercises</td>
<td>Vibr. group at 6 months: Weight: -10.3 kg, BMI: -3.4 kg/m², Visceral fat: -47.8 cm², Adipose tissue: -154.4 cm², Fat bioimpedance: -7.0%, Waist-hip circ. ratio -0.05</td>
</tr>
<tr>
<td>Von Stengel et al., 2012</td>
<td>151 postmenopausal women, ~68 years old</td>
<td>2 times/week, 18 months, 25-30 Hz, 1.7-2.0 mm</td>
<td>Weight: no difference, Fat: -0.8%, Abdominal fat: -0.4 kg, Lean mass: +0.4 kg, Abdominal and body fat: significant differences compared to the control group.</td>
</tr>
<tr>
<td>Fjeldstad et al., 2009</td>
<td>55 sedentary, postmenopausal women, ~63.2 years old</td>
<td>3 times/week, 8 months, 15-40 Hz, 3 mm</td>
<td>Fat: -1.3%, Fat: 0.7 kg, Lean mass without bone: +1 kg, Fat decreased significantly in the region of the arms and trunk, but not in the legs.</td>
</tr>
</tbody>
</table>

Table I

*Main studies conducted on the inhibition of adipogenesis, reduction in fat mass, increase in energy expenditure and increase in muscle mass as a result of vibration training.*
<table>
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<tr>
<td>Da Silva et al., 2007</td>
<td>17 active university students</td>
<td>Acute effect 5 sets/10 rep 2 min/rest/set</td>
<td>Energy during and after exercise was significantly higher in the vibration training group. ~7.8 kcal.</td>
</tr>
<tr>
<td>Wilms et al., 2012</td>
<td>14 obese women ~43.1 years old</td>
<td>Long-term effect 6 weeks 2 mm 30 s/30 s 30 Hz</td>
<td>Resting energy: +9 kcal</td>
</tr>
<tr>
<td>Rittweger et al., 2000</td>
<td>16 women 21 men ~23.5 years old</td>
<td>Acute amplitude effect a0 = 1.05 cm Frequency: 26 Hz Additional load 40% weight in men and 35% in women</td>
<td>Vibration training: ~21.9 ml/kg/min approx. ~48.8% of VO2max.</td>
</tr>
<tr>
<td>Cochrane et al., 2008</td>
<td>12 young adults ~21.5 years old (6M and 6W) and 12 healthy older adults ~69.2 years (6M and 6W)</td>
<td>Acute effect 30 Hz 0%, 20% and 40% body weight</td>
<td>MET increased by 0%, 20% and 40% at 0.35, 0.8 and 1.2, respectively. Corresponding to 19.7%, 26.7% and 62.9% of VO2max. VO2 was increased in both groups.</td>
</tr>
<tr>
<td>Garatachea et al., 2007</td>
<td>9 recreationally active men ~24.2 years old</td>
<td>Squats (90º) in cycles of 6, 4 and 2 seconds. 30 Hz 4 mm 30% extra body weight</td>
<td>6-second vibration cycles increased VO2, total energy expenditure and fatty acid utilisation compared to cycles of 4 and 2 seconds.</td>
</tr>
<tr>
<td>Ceccarelli et al., 2012</td>
<td>Cells in vivo and in vitro (CD1 mice muscle tissue)</td>
<td>Low amplitude 30 Hz</td>
<td>The vibratory stimulus promoted satellite cell fusion. 30 Hz was sufficient to suppress atrophy both in vivo and in vitro.</td>
</tr>
<tr>
<td>Martínez-Pardo et al., 2012</td>
<td>38 physically active people Two groups, high and low frequency</td>
<td>Group: 2 mm Group: 4 mm Group: control 2 times/week 6 weeks 50 Hz 60 s exercise 60 s rest Static exercise or half-squat</td>
<td>Both groups increased isokinetic strength. Lean mass was significantly increased in the high-frequency group (4 mm), fat mass did not differ between groups.</td>
</tr>
<tr>
<td>Osawa and Oguma, 2013</td>
<td>32 untrained, healthy subjects (22-49 years old)</td>
<td>Vibration training plus strength training 13 weeks Group with and without vibration training</td>
<td>Group with vibration training: significant increase in the cross section of the psoas muscle (+6.9%) and erector spinae (+3.8%) compared to strength training without vibration.</td>
</tr>
<tr>
<td>Fjeldstad et al., 2009</td>
<td>55 sedentary, postmenopausal women ~63.2 years old</td>
<td>8 months Strength training group and vibration plus strength training group Strength: 3 sets 10 reps at 80% maximum force. 15-40 Hz 3 mm</td>
<td>The vibration plus strength training group presented a significant increase in lean mass (~1 kg) compared to the control group. Mainly on the trunk and arms.</td>
</tr>
</tbody>
</table>
The study by Yoo et al. (2009) focused on the effect of 10 minutes exposure three times a week in a group of 112 students. After three months of training, the group exposed to vibration training did not present significantly different changes in weight, fat mass or visceral fat compared to the control group. These results are similar to those found by Roelants et al. (2004), who concluded that 24 weeks of WBVT did not reduce body weight or total and subcutaneous body fat in untrained women.

In a more recent study involving overweight, postmenopausal women, it was reported that despite presenting no change in body weight with the use of WBVT, waist circumference, bioelectrical impedance and resting energy expenditure increased slightly compared to the group that did not use vibration training.

Moreover, in a research on obese women, it was reported that despite presenting no change in body weight with the use of WBVT, waist circumference, bioelectrical impedance and resting energy expenditure increased slightly compared to the group that did not use vibration training.

Other studies have obtained favourable results for WBVT when used as a complement to low calorie diets. Vissers et al. (2010) concluded that combining aerobic exercise or WBVT with a low calorie diet can help achieve significant weight loss (5-10%) in the long term. It is worth highlighting that this was one of few studies employing a randomised, controlled design which analysed a group of people throughout a 6-month intervention and a 6-month follow-up period. Furthermore, it should also be noted that a significant reduction in visceral fat was achieved in the group that used WBVT.

Another study investigated the long-term (18 months) effect of WBVT on older adult women, and found that an exercise program which included aerobic exercise, coordination and upper and lower body strength training did not benefit from the addition of vibration training. However, both groups —normal training and training plus vibration— presented significantly modified fat mass and visceral fat mass compared to the control group. These results are very similar to those found in another study on postmenopausal women using resistance training exercises.

### Increased energy expenditure

To date, few authors have investigated whether WBVT has the capacity to increase oxygen consumption, energy expenditure and fat oxidation. Furthermore, no consensus appears to exist regarding the frequency, duration and amplitude required in order to increase energy expenditure.
In male university students, performing half-squat exercises on a vibration platform generated greater energy expenditure than the same exercise performed without the platform. Researchers concluded that combining WBVT with regular training programs aimed at muscle hypertrophy could, in the long term, achieve a reduction in body fat.21

The aforementioned effect has also been reported by Wilms et al. (2012), who observed that resting energy expenditure in obese women increased slightly when aerobic exercise was combined with vibration training, compared to the group that did not use vibration. However, it should be noted that the increase was very slight (vibration training group: 77 ± 33 kcal/24 h; non-vibration training group: +68 ± 34 kcal/24 h).19

Although there is clear evidence that use of WBVT induces an increase in muscle activation,25,26 this increase does not appear to be proportional to that which occurs in oxygen consumption and energy costs, but rather, is much lower.27

Increasing the workload with additional weight on the platform has been shown to increase oxygen consumption. Cochrane et al. (2008) found that WBVT (frequency: 30 Hz and amplitude: 1 mm) generated an increase of 0.35 metabolic equivalents (METs) when the load was increased by 20% and 40% up to values of 0.8 and 1.2 METs, respectively.28

In addition to the proportional increase in oxygen consumption, when the frequency, amplitude of vibration and load (40%) was increased, Rittweger et al. (2002) observed that the rate on the platform (rise time vs fall time of the exercise) also influenced energy expenditure.27 this latter being greater the more rapid the rate —1 s: 1 s than 2 s; 2 s and 3 s; 3 s—, although the latter was found to oxidise more fat than the faster rates.29 Despite the above evidence, authors concluded that the increase in oxygen consumption was small and unlikely to be of help in reducing body weight. In fact, it has been reported that 15 minutes training on the vibrating platform produces a difference of about 14.2 kcal.30

Considering the current recommendations for weight control,1 which suggest training at an intensity of between 3 and 5.9 METs and completing between 150-200 minutes of aerobic exercise a week, it appears that the use of WBVT is not an appropriate means to achieve the objective indicated, although if it is combined with a low calorie diet it might generate certain benefits.25

### Increased muscle mass

Muscle mass is the active tissue mainly responsible for the body’s energy consumption. A healthy male adult can have between 35 and 50 kg of muscle mass.30

An increase in muscle volume raises resting energy expenditure, which could help in reducing body weight and in fatty acid oxidation. A report by Wolfe (2006) indicated that each kg of lean mass generates an energy difference of about 10 kcal/day, which would imply almost half a kilogram of fat a year.31

In an interesting study by Ceccarelli et al. (2012), low amplitude and high frequency vibrations were stimulated in animals in order to analyse their effect on muscle hypertrophy/atrophy pathways, and the authors concluded that a frequency of 30 Hz was effective in suppressing the pathway associated with muscular atrophy and in enhancing the fusion of satellite cells,32 thus promoting muscle hypertrophy.33

In recreationally active subjects who trained twice a week for six weeks at a frequency of 50 Hz, 60 s of exercise and 60 s rest, it was shown that the use of greater amplitudes (4 mm instead of 2 mm) was much more effective in increasing strength and lean mass (0.9 ± 1.0 kg).34

In a recent article, it has also been shown that 13 weeks of a combination of WBVT plus resistance training is much more effective in generating muscle hypertrophy (cross-sectional area of the psoas major) than resistance training alone (+10.7% and +3.8% compared to baseline and the group who did not use WBVT, respectively).35

The effects also appeared to be pronounced in the older adult population. For both men and women, it has been shown that WBVT is effective in increasing lean and muscle mass, and it has also been suggested that this type of training has the potential to prevent or reverse the effects on muscle mass that occur with aging.22,36

However, it should also be noted that several studies have been published in which no differences were found after using WBVT. Furthermore, Song et al. (2011), Yoo et al. (2009) and Osawa et al. (2011) observed a reduction in muscle mass in overweight postmenopausal women, in students (27.4 years old) and young, healthy adults (21-39 years old), respectively.36,18,17 Therefore, the question of the effects of WBVT on muscle mass remains open.

### Conclusions

WBVT appears to be associated with three pathways involved in weight loss: inhibition of adipogenesis and reduction of fat mass, increased energy expenditure, and an increase in muscle mass. After analysing the literature, none of the results for the proposed pathways are consistent, and indeed are often contradictory. We conclude that further in-depth research is required on this subject. However, WBVT would appear to be a safe method, and may possibly yield benefits, mainly as regards muscle mass, which in turn might promote weight loss when combined with a nutritional plan and a traditional exercise program.

### References


