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# Effect of 6 weeks of whole body vibration training on total and segmental body composition in healthy young adults

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The applied use of new technologies to enhance performance and improve health has been increasing. Initially, whole body vibration training (WBVT) was used as system to improve elite athlete performance. However, this is also used to improve body composition, especially there is a great attention on the effectiveness of WBVT to reduce fat and body weight, with a potential increase in muscle tissue. The aim of this study was to investigate the effects of a 6-week vibration-training program on total and segmental body composition in a group of physically healthy participants. The final study sample included 64 healthy young adults. Subjects were randomly allocated into the control group (CG: $n = 26$; 16 males and 10 females) and the experimental group ($EG_{WBVT}$: $n = 38$; 19 males and 19 females). The program lasted six weeks with a frequency of three sessions per week and each session varied in intensity. There were not found statistically significant differences in any of the body composition variables analysed. This study suggests that a six-week vibration-training program with an increasing intensity (7.2 g–32.6 g) in healthy young adults that are not overweight did not alter total and segmental body composition.

**Keywords:** bioelectrical impedance, fat-free mass, fat mass, skinfold, whole body vibration

The applied use of new technologies to enhance performance and improve health has been increasing. Whole body vibration training (WBVT) on a platform is considered a suitable training system to increase strength and muscle power (7), obtaining a greater vertical jump height (24) and positive changes in the morphological characteristics of muscle. In addition, vibration-training sessions have been used to counteract skeletal muscle atrophy, loss of bone mineral density (3). Initially, WBVT was used as system to improve elite athlete performance. However, this is also used to improve body composition, especially there is a great attention on the effectiveness of WBVT to reduce fat and body weight, with a potential increase in muscle tissue.

In order to consider the effects of vibration on body composition, a number of general aspects in the interpretation of body composition results must be taken into account. There is

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evidence that more than 50% of human muscle mass is located in the lower extremities and that when there is an increase in muscle mass, there is an increase in the muscle mass of the lower limbs relative to the total volume (13). Some authors suggest that each muscle group has optimal stimulation frequency (4, 23). Therefore, it is necessary to redirect the body composition and vibration training studies, and focus on studies about segmental body composition.

Furthermore, muscle mass loss occurs in human beings once they reach 50 years of age (13) and high-frequency vibrations have an anabolic effect on muscular and bone tissue in elderly people (2). Therefore, when focused on the fat reduction and an increase in lean muscle mass, WBVT should mainly be applied to older people, especially in postmenopausal women (26). Currently, there are few scientific studies analysing the effects of vibration training on the body composition of young, physically-active participants, most of the studies have been conducted in postmenopausal women.

In the studies shown above, it can be interpreted that WBVT is an effective method for improving muscle mass in the elderly, especially in postmenopausal women. In this respect, the research carried out by Torvinen et al. (24) and Verschueren et al. (25) in a group of 70 postmenopausal women (60–70 years) that completed a WBVT program of six months. On the other hand, Roelants et al. (22) concluded that, 24 weeks whole body vibration training did not reduce weight, total body fat or subcutaneous fat in previously untrained females. However, whole body vibration training induces a gain in fat free mass.

The latter suggests that WBVT significantly reduces fat mass in postmenopausal women and increases fat-free mass in young subjects. On the other hand, there are no research studies involving young and healthy subjects that have proven the positive effects of WBVT for this age group. Further studies and results are required to help understand the effects of vibration on this age group, on an untrained population or on patients with metabolic disorders. The body composition and functional/neuromuscular effects are seen in the elderly after WBVT, and functional/neuromuscular effects have been observed in younger individuals, but body composition effects of WBVT in younger populations have not been well studied.

Some factors that determine the appearance of somewhat contradictory results should be considered. On one hand, due to the different methods and tools that can measure body composition, there is a wide range of results. Moreover, the use of different intervention protocols applied to different population groups has led to a great variety of results and trends concerning the effects of vibration training. However, it seems that vibration has positive effects on body composition in older people; the effects on young people are not as clear. However, as described in other studies (20), these effects are not always significantly achieved with vibration training.

Therefore, it is very interesting to apply a short-term WBVT program to optimise the body composition. Thus, the aim of this study was to analyse the effects of a 6-week vibration-training program on total and segmental body composition in a group of physically healthy participants.

## Materials and Methods

This study was a single-blind, randomized and controlled trial. The independent variable was the training on the vibration platform. The dependent variables were segmental and total body composition.

*Participants*

A non-probability sampling method was used for sample selection. Seventy-six healthy young adults (aged 18–25) participated voluntarily in this study. The inclusion criteria included being healthy and light activity, using the International Physical Activity Questionnaire (IPAQ) (11). Physical activity of the participants was assessed with triaxial accelerometers (Actigraph LLC, Pensacola, FL, USA), we obtained that 96% of physical activity performed in a week was light. The exclusion criteria for both groups included any type of injury within the six-month period prior to the study, participation in any competitive sport, sport fitness or strength training, having a medical history of neuromuscular or cardio-respiratory disease, and ingesting energy supplements and/or ergogenic aids during the study or during the six-month period prior to the study. In addition, each subject was instructed to maintain regular physical activity during the study. Ethical approval was obtained from the local university and hospital ethics committees (University Hospital of Albacete, cod.: 025861) and all participants gave their written informed consent prior to any testing.

The final study sample included sixty-four participants. Participants were randomly allocated into the control group (CG: $n = 26$; 16 males and 10 females) (males: 24.5 ± 6.27 years old; 174.44 ± 5.35 cm and 71.01 ± 7.94 kg; females 23.7 ± 3.43 years old, 168.22 ± 7.15 cm and 65.09 ± 9.72 kg) and the experimental group ($EG_{WBVT}$: $n = 38$; 19 males and 19 females) (males: 22.11± 4.97 years old, 174.35 ± 4.36 cm and 74.43 ± 10.93 kg; females 23.89 ± 4.86 years old, 162.47 ± 4.32 cm and 58.55 ± 6.01 kg).

*Measures and tests procedure*

Data collection for the initial evaluation was performed on two different days; on the first day, the participants signed the informed consent documents and filled in the IPAQ. Additionally, there was a WBVT familiarization session. On the second day, anthropometric and bioimpedance data were collected. This consisted of measuring height (cm) and weight (kg) with the stadiometer Seca 700 (Seca® Ltd, Germany).

Furthermore, a body composition analysis using the direct Segmental Multi-frequency Bioelectrical Impedance Analysis Method (BIA) with the Inbody 720® (Biospace, Seoul, Korea) and was performed following the manufacture's guidelines. Thirty impedance measurements were obtained using 6 different frequencies (1 kHz–1000 kHz) for each of the 3 segments (Trunk, Right Leg, Left Leg) using the tetrapolar 8-Point tactile electrode system (8). Finally, a trained sport scientist took all the skinfold measurements with a caliper Holtain® (Holtain LTD, Crymych, UK) of the legs and the gastrocnemius following the recommendations of the International Society for the Advancement of Kinanthropometry (ISAK). This protocol was performed on two occasions, before (prewbvt) and after (postwbvt) the WBVT.

*The whole body vibration training program*

The WBVT was performed on the Fitvibe Excel Pro (Fitvibe Medica, Bilzen, Belgium). The program lasted six weeks with a frequency of three sessions per week and each session varied in intensity, with a necessary rest period of 24 hours between each session. Each session lasted 30 minutes, of which 15 minutes involved vibratory stimuli and 15 minutes were for rest, as, according to previous research instructions, it has been proposed that stimuli for less than 20 minutes cause higher neuromuscular adaptations (6). Frequency and amplitude parameters were 30 Hz and 2 mm in the first week and up to 45 Hz and 4 mm in the sixth week (Fig. 1), respectively, and the peak acceleration of the sinusoidal vibration stimulus varied between 7.2 and 32.6 g and root mean squared acceleration between 5.1–23.1 g ($a_{peak} = (2 \times \pi^2 \times Hz^2 \times m)/g$; $a_{peak}/\sqrt{(2)}$).

Three exercises were performed on the platform (Fig. 1). The manufacturer protocols for the lower body were followed, with a greater degree of plantar flexion of the ankle joint in this case, with the purpose of increasing active contraction of the posterior muscles of the leg (triceps surae muscle). Thus, the muscle contraction added to the vibratory stimuli, which increased the effects of this type of intervention (1). An increased damping of vibration power occurred when the frequency of the input was close to the natural frequency of each soft tissue (27). In the first exercise, the subjects remained with one of their legs in front of the other, at a distance of one meter between the support points of the feet (toes) and with the knees semi-flexed at about 110–120º. In the second exercise, the subjects remained in the squat position, on their toes, with their feet separated by about 50 cm and the knees flexed at approximately 110–120º. Finally, the third position was similar to the second one. However, in this case the subject stood on just one foot.

Study variables: the skinfold measurements taken were as follows: lateral and medial gastrocnemius and thigh of the right and left legs (mm). Body composition variables obtained with BIA were: Fat Mass (FM; %), Lean Body Mass (LBM; kg), Fat-Free Mass (FFM; kg), Musculoskeletal Mass (MM; kg) of the whole body and LBM of the trunk (LBMT; kg), LBM of the right leg (LBMRL; kg) and LBM of the left leg (LBMLL; kg).

| Week | Intensity (Hz) | Amplitude (mm) | Peak Acceleration (g) |
|---|---|---|---|
| 1st Week | 30 – 45 - 60 | 2 | 7.2 – 16.3 – 29.0 |
| 2nd Week | 30 | 4 | 14.5 |
| 3rd Week | 35 | 4 | 19.7 |
| 4th Week | 40 | 4 | 25.8 |
| 5th Week | 45 | 4 | 32.6 |
| 6th Week | 45 | 4 | 32.6 |

Hz = hertz, mm = millimetres, g = gravity

*Fig. 1.* Training exercise and training load

## *Statistical analysis*

Statistical analysis was performed with the Statistical Package for the Social Sciences (SPSS, version 19, SPSS Inc, Chicago, Illinois, USA). Standard descriptive statistics were performed (mean and standard deviations). Data normality was tested with the Shapiro–Wilk and Kolmogorov–Smirnov tests. In addition, for variables that showed a normal distribution, a general linear model test (repeated-measures) was applied. However, the U Mann–Whitney (independent samples) and Wilcoxon (Dependent Samples) tests were applied for variables that did not show a normal distribution. A significance level of $p \leq 0.05$ was set.

## Results

*Skinfold*

**Inter-group differences.** No significant inter-group differences in the leg and thigh skinfolds were found, a difference of 0.35–1.7 mm between the CG and $EG_{WBVT}$ in the preWBVT and of 0.29–0.99 mm in the postWBVT were found (Table I).

*Table I.* Skinfolds inter-group differences

| | | pre-WBVT | | | post-WBVT | | |
|---|---|---|---|---|---|---|---|
| | | CG ($n$ = 26) x ± σ | EG ($n$ = 37) x ± σ | $p$ | CG ($n$ = 26) x ± σ | EG ($n$ = 37) x ± σ | $p$ |
| *Left leg* | Skinfold: Gastrocnemius Lateralis | 15.78 ± 5.81 | 14.51 ± 6.90 | .335 | 15.48 ± 6.21 | 14.94 ± 6.58 | .630 |
| | Skinfold: Gastrocnemius Medialis | 14.31 ± 5.00 | 13.95 ± 6.38 | .594 | 14.09 ± 5.85 | 14.38 ± 6.34 | .812 |
| | Skinfold: Thigh | 16.87 ± 8.63 | 16.35 ± 8.45 | .840 | 16.46 ± 8.72 | 17.46 ± 9.33 | .711 |
| *Right leg* | Skinfold: Gastrocnemius Lateralis | 16.32 ± 5.68 | 14.59 ± 6.65 | .206 | 15.76 ± 6.02 | 13.97 ± 6.13 | .261 |
| | Skinfold: Gastrocnemius Medialis | 13.86 ± 4.84 | 13.52 ± 6.57 | .645 | 13.44 ± 5.83 | 14.09 ± 6.27 | .650 |
| | Skinfold: Thigh | 17.31 ± 8.73 | 16.14 ± 8.48 | .567 | 16.82 ± 8.26 | 17.33 ± 9.12 | .878 |

Average ± standard deviation; CG – Control group; EG – experimental group

**Intra-group differences.** When the effect of the WBVT on $EG_{WBVT}$ was studied, non-significant differences were found between pre- and post-assessments. Furthermore, the effect of time did not significantly change the values of CG (Fig. 2).

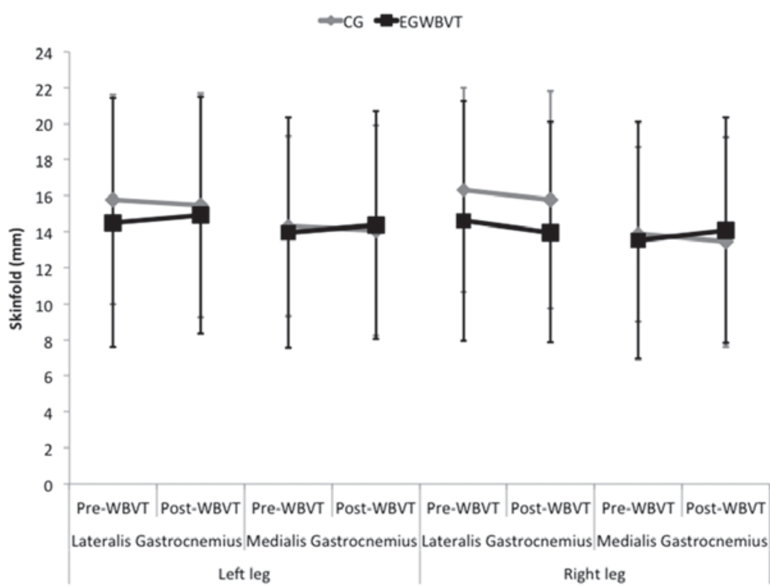


*Fig. 2.* Right and left legs skinfolds.
CG – control group; EG – experimental group; WBVT – whole body vibration training

*BIA – whole body variables*

**Inter-group differences.** There were no significant differences between groups in terms of whole body composition variables. In both groups, there was an insignificant decrease of the total mass (kg) and an insignificant increase in the variables of LBM (kg), FFM (kg) and MM (kg). None of these variables obtained changes greater than ± 1%.

**Intra-group differences.** After the six-week WBVT there were only insignificant differences in the whole body composition variables (Mass, FM, LBM, FFM, MM) (Table II).

*Table II.* Differences inter and intra-groups in whole body values

| Variables | CG (x ± σ) | | EG (x ± σ) | | *p* inter-groups |
|---|---|---|---|---|---|
| Mass pre-WBVT (kg) | 68.24 | ± 8.75 | 66.58 | ± 12.00 | *p* = 0.909 |
| Mass post-WBVT (kg) | 67.81 | ± 8.71 | 66.20 | ± 12.13 | |
| *p intra-groups* | *p* = 0.081 | | *p* = 0.190 | | |
| Fat mass pre-WBVT (%) | 21.98 | ± 7.07 | 23.67 | ± 8.33 | *p* = 0.073 |
| Fat mass post-WBVT (%) | 21.34 | ± 7.77 | 22.99 | ± 8.10 | |
| *p intra-groups* | *p* = 0.295 | | *p* = 0.151 | | |
| Lean body mass pre-WBVT (kg) | 49.98 | ± 6.52 | 47.67 | ± 8.83 | *p* = 0.531 |
| Lean body mass post-WBVT (kg) | 50.40 | ± 6.57 | 47.77 | ± 8.39 | |
| *p intra-groups* | *p* = 0.095 | | *p* = 0.707 | | |
| Fat-free mass pre-WBVT (kg) | 53.07 | ± 6.90 | 50.61 | ± 9.31 | *p* = 0.511 |
| Fat-free mass post-WBVT (kg) | 53.50 | ± 6.94 | 50.69 | ± 8.83 | |
| *p intra-groups* | *p* = 0.112 | | *p* = 0.788 | | |
| Musculoskeletal mass pre-WBVT (kg) | 29.68 | ± 4.17 | 28.23 | ± 5.73 | *p* = 0.764 |
| Musculoskeletal mass post-WBVT (kg) | 29.91 | ± 4.36 | 28.30 | 5.45 | |
| *p intra-groups* | *p* = 0.179 | | *p* = 0.648 | | |
| Body mass index pre-WBVT (kg/m$^2$) | 22.92 | ± 2.19 | 23.41 | ± 3.57 | *p* = 0.248 |
| Body mass index post- (kg/m$^2$) | 22.79 | ± 2.16 | 23.29 | ± 3.70 | |
| *p intra-groups* | *p* = 0.125 | | *p* = 0.167 | | |

Average ± standard deviation; CG – Control group; EG – experimental group

*BIA – segmental body composition variables*

**Inter-group differences.** Insignificant differences were found between the CG and $EG_{WBVT}$, on both occasions (pre- and post-training) for the LBMT, LBMLL and LBMRL variables (Fig. 3) and Δ of change (%).

**Intra-group differences.** There were not any significant differences in the segmental variables for the pre-WBVT vs. post-WBVT in the groups' averages (Table II).

## Discussion

The results obtained with both measurement methods (BIA and skinfolds) showed that $EG_{WBVT}$ participants had insignificant changes in fat and musculoskeletal tissue. In the same way, there were insignificant differences between groups for each measurement, which proves that values remained stable during the 6-week period.

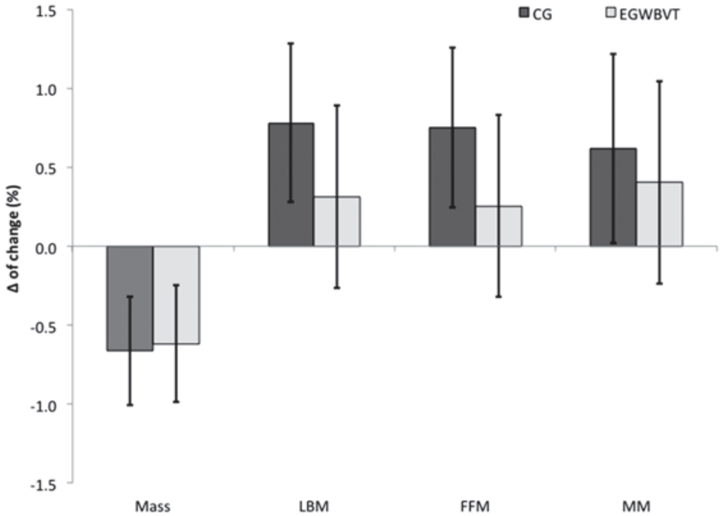


*Fig. 3.* Percentage change in muscular variables of body composition muscular variables. Abbreviations: LBM; lean body mass, FFM; Fat-free mass; MM; musculoskeletal mass

Age, gender, and muscle group are three of a number of factors that are critical to determine morphological adaptations after strength training. Muscular hypertrophy of type II fibers was largely found in studies where training periods were short (9). In the study carried out by Martinez-Pardo et al. (15) it was evident that six weeks of training using a high amplitude vertical vibration platform (4 mm), produced muscle hypertrophy in active participants. Roelants et al. (22), analyzed body composition values in a group of 49 sedentary women (21.3 ± 2 years old), who were divided into three groups (control group, fitness group and vibration group). After 24 weeks of training, significant differences in fat-free mass variables were obtained within the vibration group, rising 2.2%. These results are not consistent with those obtained in our research, as we found no significant changes for the musculoskeletal mass in the vibration group or in the CG. Martinez-Pardo et al. (16) evaluated the effects of whole-body vibration by varying the training frequency (2 or 3 sessions per week) and there were no statistically significant changes in the total fat mass, fat percentage, bone mineral content, and bone mineral density in any of the groups. In turn, the vibration magnitude (2 or 3 sessions per week) of the study presents good adaptation of muscle hypertrophy.

Osawa et al. (17) tested the effects of 12 weeks of WBVT in a group of untrained men and women (8 men and 11 women) divided into two training groups. One group performed a protocol of exercises without using the platform and another group performed it on a vibrating platform, in both groups the subjects carried additional weight. The conclusion found that there were insignificant differences in total and segmental Fat-Free mass between the study groups analysed. It is possible that the lack of conclusive results in this study could be related to the variety of protocols used within the groups, as the intensity of the exercises were individualized and based on the participants perception of vibration, creating different workloads. Similar results were found in the study of Paradisis and Zacharogiannis (18), who analysed the effects of a six-week vibration training program on sprint and jump performance in physically active and experienced, trained subjects. An insignificant difference of –2.1%

fat mass was found, compared with those subjected to WBVT. In the study by Yoo et al. (28) after 3 months of WBVT (3/week, 10 minutes exposure), the group exposed to vibration no significantly decreased weight, and fat mass was found compared to the control group. In this way, it seems that at least 3 months are needed to significantly modify body composition. The changes on body composition after a short-term WBVT training (6 and 24 weeks) show low scientific evidence.

It must be highlighted that previous studies have not evaluated the chronic effects of WBVT on body composition measured with skinfolds in specific areas. Roelants et al. (22) took skinfold measurements and analyzed the changes that occurred in the sum of 12 skinfolds after vibrational training on 48 untrained young women (21.3 ± 2.0 years old) after 24 weeks. They did not find significant differences. Following these results, in our study, the variables obtained with a skinfold caliper did not show any significant change.

This lack of significant results in the body composition may be due to the intensity of the WBVT program. In this way, Hazell et al. (12) claim that the cardiovascular stress produced by exposure to WBVT is moderate, and that the energy requirements could be compared to walking at a moderate intensity (5). Da Silva et al. (5) found that in young men (18.3 ± 0.24 years), WBVT significantly increased energy consumption, and in another study conducted in samples of a similar age group (10), energy consumption, the rate of oxidation of fats and carbohydrates, and oxygen consumption were affected positively with WBVT. The vibration produces substantial changes in the metabolic rate found in the legs, which may provide significant training stimulus and also means that oxygen consumption increases in the lower limbs (14). However, other authors (19) concluded that the data they had analyzed suggested that WBVT could modulate energy consumption, but that specific study was insufficient to determine whether the continued application of WBVT could alter body composition. Therefore, it is necessary to increase the intensity of the sessions in the program to obtain modifications in body composition aspects.

The absence of change in fat mass or muscle mass may be explained by the duration of the vibration sessions (12–15 minutes). This period of time is too short to produce changes in body fat or muscle mass. The stimulation produced by WBVT seems to be insufficient to bring about a high metabolic load and a reduction of fat mass (21). Furthermore, the results suggest that the total volume of vibration training (18 sessions) was too short to modify muscle mass. In conclusion, this study suggests that a six-week vibration-training program with an increasing intensity (7.2 g–32.6 g) in healthy young adults that are not overweight did not alter total and segmental body composition.

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