©Journal of Sports Science and Medicine (2012) **11,** 438-443
http://www.jssm.org

Research article

Reliability and validity of the OMNI-vibration exercise scale of perceived exertion

Pedro J. Marín [1,2], Alejandro Santos-Lozano [3], Fernanda Santin-Medeiros [3], Robert J. Robertson [4] and Nuria Garatachea [3]✉

[1] Laboratory of Physiology, European University Miguel de Cervantes, C/Padre Julio Chevalier, Valladolid, Spain, [2] Research Center on Physical Disability, ASPAYM Castilla y León, Valladolid, Spain, [3] Faculty of Health and Sport Science, Department of Physiotherapy and Nursing, University of Zaragoza, Ronda Misericordia, Huesca, Spain, [4] School of Education, Department of Health and Physical Activity, University of Pittsburgh, Pittsburgh, PA, USA.

Abstract

This study examined reliability and concurrent validity of the newly developed OMNI-vibration exercise scale (OMNI-VIBRO) to measure Ratings of Perceived Exertion (RPE) during vibration exercise in twenty recreationally active students (12 males and 8 females). The criterion variables were muscle activity of the Vastus Medialis (VM), Vastus Lateralis (VL), Biceps Femoris (BF), and Medial Gastrocnemius (MG) muscles, as well as accelerations (12.5, 20.2, 30.9, 36.3, 60.1, and 88.4 $m \cdot s^{-2}$). RPE was registered during the final of each 30 s condition. Each participant attended two laboratory testing sessions. Positive linear regression coefficients ($p < 0.001$) were found between RPE (OMNI-VIBRO) and acceleration ($r = 0.976$) and muscle activity of lower-body muscles ($r = 0.942$). Between session (test-retest), reliability of RPE (OMNI-VIBRO) was good (ICC: 0.790. 95% CI: 0.699-0.854). Conclusions: findings provided concurrent validation of the OMNI-VIBRO to measure RPE for the active muscle and overall body in recreationally active students performing lower-body vibration exercise.

Key words: Validation, perceived exertion, vibration, EMG.

Introduction

Perceived exertion is the ability to detect and respond to sensations that arise as a result of physiological responses to exercise (Noble Robertson, 1996). The cognitive awareness of these sensations is considered a form of biofeedback in which central, peripheral, and respiratory metabolic changes during exercise are assimilated. Borg designed the first rating of perceived exertion (RPE) scale (Borg, 1982), which is widely believed to be one of the best indicators of degree of physical strain during exercise.

Monitoring resistance training (RT) is an essential part of a successful periodized exercise program (Kraemer et al., 2002). Interest in using RPE to regulate and prescribe the intensity of resistance exercise has increased in recent years. Investigations indicate that RPE can be assessed during resistance exercise paradigms that vary the total volume of weight lifted (i.e., volume loading) (Pierce et al., 1993), percent of one repetition maximum (1RM) muscular action (%1-RM; i.e., intensity loading) (Duncan et al., 2006; Pincivero et al., 1999) and rest periods between separate sets and exercises (Kraemer et al., 1987). Several studies have demonstrated the RPE to be an effective measurement to qualifying exercise load during RT (Day et al., 2004; Dishman et al., 1991; Gearhart et al., 2009; Lagally et al., 2002), and have used RPE to prescribe RT program and to track conditioning progress (Kraemer et al., 2001). Evidence supporting similar applications of exertional perceptions for whole-body vibration (WBV) is limited (Cochrane et al., 2008). Although over the last few years there has been a significant increase in the use of WBV platforms as devices for RT, there is still a lack of scientific support for the physiologic effects of WBV. These effects are strongly dependent on the type, frequency, amplitude, and duration of the vibration (Garatachea et al., 2007; Marin and Rhea, 2010a, 2010b). Therefore it is important that experimental protocols to control the magnitude of the vibration. WBV is applied through a vibration platform that evokes a mechanical oscillation that can be defined by frequency and amplitude (Luo et al., 2005). According to Hazell et al. greater Surface Electromyography (sEMG) amplitudes with higher frequency WBV training (40 & 45 Hz) have been reported when compared to lower frequencies (25 & 30 Hz) (Hazell et al., 2007). In addition, Marín and colleges reported that the magnitude of the WBV effect was clearly higher with an amplitude of 4 mm versus 2 mm for the vastus lateralis and gastrocnemius medialis sEMG (Marin et al., 2009).

When undergoing vibration on a platform, most people report an unusual perception. This sensation is partly due to a movement illusion and also a perception of exertion, which is not explicable by metabolic rate (Rittweger, 2010). Several authors have reported the sensitivity of individuals to perceive the change in vibration magnitude and frequency (Forta et al., 2009). Steven´s Law, states that sensation magnitude increases proportionally to the stimulus magnitude raised to some power ($S=cI^m$), where S is the sensation magnitude, c is a constant that depends on the system of units used, I is the stimulus magnitude, and m is the value of the exponent (Mansfield, 2005). Based on this psychophysical law, it can be speculated that perceived vibration response may exhibit a similar pattern. Specifically, higher RPEs can be expected with higher vibration magnitudes.

It has been suggested that rating of perceived vibration can be used during WBV to prescribe training intensities, guide daily training dosages and track training progress (Marín et al., 2012). Thus, the aim of this study

Received: 08 March 2012 / Accepted: 22 May 2012 / Published (online): 01 September 2012

was to examine reliability and concurrent validity of the newly developed OMNI-vibration exercise scale (OMNI-VIBRO) (Figure 1) to measure RPE during vibration exercise. This study is based on the hypothesis that the perception of vibration would present a significant positive correlation with acceleration vibration and lower body sEMG, establishing concurrent validity of the pictorial format of the OMNI-VIBRO.

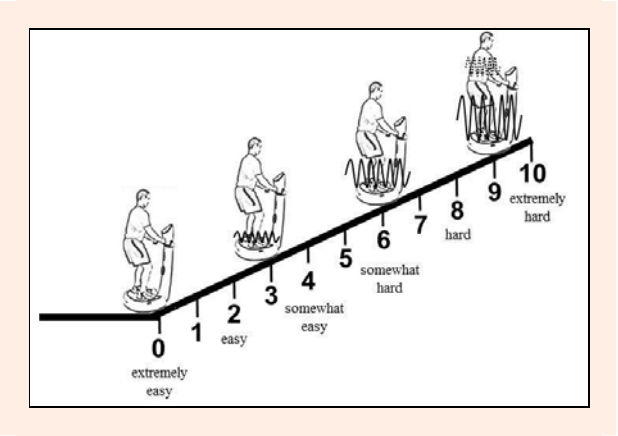

Figure 1. **OMNI-Vibration Exercise Scale (OMNI-VIBRO) of perceived exertion.**

Methods

Subjects

Twenty recreationally active students (12 males and 8 females) participated as subjects. The subjects' mean (± SD) age, height, and weight were 24.5 ± 2.5 years; 1.74 ± 0.08 m; and 71.6 ± 6.9 kg, respectively. Exclusion criteria were diabetes, epilepsy, gallstones, kidney stones, cardiovascular diseases, joint implants, recent thrombosis, as well as any musculoskeletal problems that could affect performance. Prior to data collection subjects were informed of the requirements associated with participation and provided their written informed consent. Moreover, subjects maintained constant sleeping, eating, and drinking patterns throughout study. The research project was conducted according to the Declaration of Helsinki and it was approved by the University Review Board for research involving human subjects.

Experimental design

Orientation trial

During the orientation trial, the purpose of the experiment was explained to the subjects, descriptive characteristics were determined and vibration exercise training status was documented. Instructions and anchoring procedures for the OMNI-VIBRO were then presented to the subject (Figure 1). The exercise techniques and vibration platform were explained. Finally, a supervised practice session to standardize squat position (30º knee flexion) was undertaken.

Vibration exercises

Each participant attended two laboratory testing sessions to check the reliability of RPE from the OMNI-VIBRO between days. Initially, skin was prepared and sEMG electrodes were placed. A standardized 5-minute warm-up of walking at 6 km/h and ramp of 0% was administered before all testing. Subjects then performed 6 different vibration loads in random order to check the influence of vibration acceleration ($m·s^{-2}$) on sEMG and RPE. The order of experimental conditions was randomized. Vibration load of each experimental condition is presented in Table 1. Each experimental condition lasted 30s, with 120s of rest allowed between each condition. The vibration exercises were performed with the subjects standing with their feet on the vibration platform, separated to shoulder-width; and the knee angle pre-set at 30° flexion-isometric squat. All subjects wore athletic shoes.

Table 1. **Parameters for each exercise mode.**

	Vibration exercise	
Frequency (Hz)	**Amplitude**	**Acceleration ($m·s^{-2}$)**
25	Low	12.5
35	Low	20.2
45	Low	30.9
25	High	36.3
35	High	60.1
45	High	88.4

High amplitude (3.1 mm [peak to peak]); low amplitude (1.0 mm [peak to peak]).

The vertical vibration platform used was Fitvibe Excel (Fitvibe, GymnaUniphy NV, Bilzen, Belgium). The vertical component of acceleration of vibration platform was measured using an accelerometer in accordance with ISO2954 (Vibration meter VT-6360, Hong Kong, China).

Rating of perceived vibration

Rating of perceived vibration was measured during each exercise using the OMNI-VIBRO (Figure 1). Subjects were reminded during at the end of each designated estimation time point to "think about your feelings of vibration." The OMNI-VIBRO was in clear view of the subject during the entire vibration exercise. A standardized definition of perceived exertion and a set of instructions pertaining to the OMNI-VIBRO were read to the subject immediately before each trial. These perceived vibration scaling procedures were adapted from those previously published for the original OMNI-RES Scale (Robertson et al., 2000). The definition of perceived exertion and scaling instructions were as follows:

Definition: The perception of physical exertion is defined as the subjective intensity of effort, strain, discomfort, and/or fatigue that you feel during vibration exercise. Instructions: We would like you to use these pictures to describe how your body feels during vibration exercise (show subject the OMNI-VIBRO). You are going to perform vibration exercises using your lower body. If you feel somewhere in between Extremely Easy (0) and Extremely Hard (10) then give a number between 0 and 10. We will ask you to give a number that describes how your active muscles feel. Remember, there is no right or wrong numbers. Use both the pictures and the words to help select the numbers. Use any of the numbers to describe how you feel when lifting weights.

The low and high perceptual anchors for the OM

NI-VIBRO were established using a visual-cognitive procedure (Robertson et al., 2000). This procedure instructs the subject to cognitively establish a perceived intensity of vibration that is consonant with that depicted visually by the vibration perceived at the bottom (i.e., low anchor. rating 0) and top (i.e., high anchor, rating 10) of the incline as presented in the OMNI-VIBRO. Subjects were instructed to use their memory of the least and greatest effort that they had experienced while lifting weights to help in establishing the visual-cognitive link. The OMNI-VIBRO was in full view of the subject at all times during the experimental protocol.

Surface electromyographic activity (sEMG)

Muscle activity of the vastus medialis (VM), vastus lateralis (VL), biceps femoris (BF), and medial gastrocnemius (MG) muscles were measured using sEMG. One set (two measuring electrodes and a differential electrode) of surface electrodes (Ag/AgCl. Skintact, Austria) was placed longitudinally to the muscle fibers direction approximately halfway from the motor point area to the distal part of the muscle. An inter-electrode distance of 2 cm was maintained. The reference electrode was placed in a neutral area away from the measuring electrodes. Before electrode placement, the area was cleaned with isopropyl alcohol, shaved and abraded in order to reduce skin impedance until it was lower than 5 kΩ (De Luca, 1997).

Myoelectric raw signals were detected with a double differential technique. The surface electrodes were connected to a 14-bit AD converter (ME6000 Biomonitor, Mega Electronics, Kuopio, Finland) by pre-amplified cables (Mega Electronics, Kuopio. Finland). The total common mode rejection (CMRR) was of 110dB and data were low pass filtered (8 – 500 Hz) and sampled at 2000 Hz before being stored in a memory card (compact flash memory, 256MB). On the basis of the frequency analysis, a band width of ± 0.8 Hz around each harmonic was excluded from the root-mean-square calculation (Abercromby et al., 2007; Mischi and Cardinale, 2009). sEMG data analysis was performed across the use of specific software (MegaWin V 2.21, Mega Electronics, Kuopio, Finland). Ten seconds of the half of each condition were chosen for data analysis. sEMG raw data were calculated as root mean square in order to obtain averaged amplitude of the sEMG signal. The sEMG values were compared with equivalent baseline during the rest period (no vibration) squatting conditions. Normalization relative to maximal voluntary contractions was unnecessary (Abercromby et al., 2007; Marin et al., 2009). Lower body sEMG were calculated as the mean sEMG of VM, VL, BF and MG.

Statistical analysis

All analyses were conducted using SPSS 15.0 for Windows (SPSS. Inc., Chicago. IL), and the statistical significance level was set at $p \leq 0.05$. All the measures were normally distributed, as determined by the Shapiro-Wilks test.

Descriptive data for perceptual and physiological variables were calculated as mean ± standard deviation (SD).

A concurrent validation paradigm employs a two variable scheme: (a) criterion (i.e., stimulus) variable; and (b) concurrent (i.e., response) variable. In the present investigation, both the acceleration during exercise and the lower body sEMG served as the criterion variables. The RPE desired from the OMNI-VIBRO were the concurrent variable.

Ratings of perceived exertion from OMNI-VIBRO were examined using ANOVA with repeated measures. The main effect for acceleration main factor had 6 levels (12.5, 20.2, 30.9, 36.3, 60.1, and 88.4 m·s^{-2}) and determine differences between intensities on OMNI-VIBRO and lower body sEMG. Bonferroni *post hoc* tests procedures were used to locate the difference between means.

The relative reliability of RPE from the OMNI-VIBRO between days was estimated by calculating the intraclass correlation coefficient (ICC) at its confidence intervals (95% CI) (Shrout and Fleiss, 1979; Streiner and Norman, 1995). The ICC estimates stability of data between days. It indexes mean rater reliability of OMNI-VIBRO data and is interpreted as the extent to which similar mean scores would be obtained if additional vibration exercises were performed repeatedly from different days but in similar conditions. ICC values were considered to reflect: a poor reliability when below 0.20; a fair reliability from 0.21 to 0.40; a moderate reliability from 0.41 to 0.60; a good reliability from 0.61 to 0.80 and. a very good reliability from 0.81 to 1.00 (Altman et al., 2001). Moreover Coefficient of variation for RPE (OMNI-VIBRO) between days was calculated.

Results

Descriptive responses: RPE, lower body sEMG

The means (± SD) of RPE and sEMG responses during the 6 acceleration exercise magnitudes are shown in Table 2. These data were used in the regression analysis to examine concurrent validity of the OMNI-VIBRO. The results of these regression analyses are described below.

The ANOVA indicated that the acceleration main effect was significant for RPE (OMNI-VIBRO) and lower body sEMG responses ($p < 0.01$). Significant *post hoc* tests are indicated in Table 2.

Table 2. OMNI-VIBRO and surface electromyographic activity (sEMG) at six acceleration exercise magnitude (n = 20).

Acceleration (m·s^{-2})	OMNI-VIBRO RPE	sEMG (% increment)
12.5	1.6 (1.1)	28.5 (39.8)
20.2	2.4 (1.7) *	40.7 (21.2
30.9	3.4 (1.2) *	39.8 (24.1)
36.3	3.9 (1.7) *	96.4 (53.9) *#†
60.1	5.4 (1.9) *#†	144.3 (70.5) *#†
88.4	6.3 (2.0) *#†‡§	140.8 (74.2) *#†

* $p < 0.01$ significantly different for 20kg weight exercise or 12.5 m·s^{-2} vibration exercise. # $p < 0.01$ significantly different for 30kg weight exercise or 20.2 m·s^{-2} vibration exercise. † $p < 0.01$ significantly different for 40kg weight exercise or 30.9 m·s^{-2} vibration exercise. ‡ $p < 0.01$ significantly different for 50kg weight exercise or 36.3 m·s^{-2} vibration exercise. § $p < 0.01$ significantly different for 50kg weight exercise or 36.3 m·s^{-2} vibration exercise.

Table 3. Linear regression analysis of OMNI-vibration exercise scale (OMNI-VIBRO) expressed as a function of acceleration and lower body surface electromyographic activity (sEMG) during vibration exercise.

	OMNI-VIBRO RPE					
CRITERIO	INTERCEPT	SEE	SLOPE	SEE	r	r^2
Acceleration	1.265	.329	.061	.007	.976	.953
sEMG	1.216	.532	.032	.006	.942	.888

Concurrent validity

Table 3 lists the results of the linear regression analyses that expressed RPE (OMNI-VIBRO) as a function of increasing acceleration of the vibration or increment of lower body sEMG. The regression analyses were statistically significant ($p < 0.01$). Positive linear regression coefficients ($p < 0.001$) were found between RPE (OMNI-VIBRO) and acceleration ($r = 0.976$) and lower body sEMG ($r = 0.942$).

Reliability

According to the obtained results, between session (test-retest), reliability of RPE (OMNI-VIBRO) was good in recreationally active students (ICC: 0.790. 95% CI: 0.699-0.854). Coefficient of variation for RPE (OMNI-VIBRO) was 20.4 %.

Discussion

The major findings of this study were that lower body sEMG and RPE (OMNI-VIBRO) increased with the acceleration of the vibration. Moreover, the increments of sEMG were highly correlated with RPE (OMNI-VIBRO), establishing concurrent validity of the pictorial format of the OMNI-VIBRO. To our knowledge, the present study is the first to examine the concurrent validity of pictorial-verbal category scale of perception of exertion (OMNI-VIBRO) during lower body vibration exercise on a vibration platform.

OMNI-VIBRO increased significantly ($p < 0.01$) as vibration exercise acceleration increased. Additionally, significant positive relations were identified between lower body sEMG and RPE (OMNI-VIBRO). However, the results showed relatively poor levels of reliability for each of the OMNI-VIBRO (20.4 % CV). These results are similar to those previously reported using RPE scales (Rampinini et al., 2007; Scott et al., 2012).

Several studies have demonstrated that RPE is an effective measure to qualify conventional RT (Day et al., 2004; Dishman et al., 1991; Gearhart et al., 2009). Duncan and colleges (Duncan et al., 2006) reported that there were uniform increases in RPE and sEMG in response to increases in resistance exercise intensity from 30% to 60% to 90% of 1RM during a leg extension exercise. In the same context, Lagally et al. (2002) indicated that monitoring RPE may be a useful technique for regulating resistance exercise intensity. The mechanisms by which vibration acutely increases neuromuscular activity are poorly understood. There are a few theories on how vibration stimuli can have an effect on the neuromuscular system (Luo et al., 2005), such as a stimulation of Ia-afferents via spindle, resulting in facilitating homonymous α-motor neurons, and the possible effects of vibration on the thixotropic properties of skeletal muscle and muscle spindles (Proske et al., 1993). Mechanical vibration of muscle induces a reflex involuntary contraction (Mileva et al., 2006). According to Rittweger (2010) this reflex contraction has similarities with Kohnstamm´s phenomenon.

The relevance of monitoring exercise training load during RT is an integral part of a successful periodized exercise program because careful manipulation of intensity, volume, and recovery phases is vital for optimal results (Kraemer et al., 2002). The exercise intensity of WBV is particularly difficult to quantify outside a laboratory setting. According to Day et al. (2004), muscle forced to overcome a heavy load requires greater tension development, which requires an increase in motor unit recruitment and firing frequency. For greater motor unit recruitment to be accomplished the motor cortex may send stronger signals to the sensory cortex; this gives rise to increased perception of exertion (Gearhart et al., 2002). This theory may be the primary cause of the differences in perception of exertion for varying sEMG signals as shown by the present study. Nevertheless, Rittweger (2010) studied the RPE on a scale of 6-20 during either simple squatting exercise or WBV exercise on an oscillating platform. They found that RPE was significantly greater in vibration (11.9 ± 2.4) than in squatting (9.3 ± 2.1) exercise despite that both conditions were designed so that the metabolic rates were matched (squatting: 11.4 ± 0.7 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$), vibration 10.7 ± 1.0 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$) ($p = 0.3$). This suggested that perceived exertion is at least partly dominated by factors unrelated to metabolic rate (Rittweger, 2010). In contrast, Cochrane et al. investigated the physiologic effects of acute WBV exercise (Cochrane et al., 2008). They reported that WBV elicited the equivalent of a 0.35 metabolic equivalent (MET) increase. Additional loads equivalent to 20% and 40% body mass increased metabolic demand by 0.8 and 1.2 METs, respectively. Additionally, vibration and load produced a significant increase in RPE. According to this study, the increased RPE during WBV could be related to some metabolic factors and the results of the present study clearly support the notion that perceptual responses to vibration exercise on a platform are positively related to muscle activity.

Conclusion

In summary, the results from this study suggest that using the OMNI-VIBRO method in conjunction with WBV exercise would allow coaches, fitness professionals, or health-care personnel to assess the intensity that corresponds to the level of the vibratory stimulus. The OMNI-VIBRO could be a useful tool of measuring the different intensities of a vibratory-training session and altering the vibratory stimulus in a periodized fashion.

Acknowledgements

The authors thank Teca srl for technical support given during the study and for the supply of technical equipment.

References

Abercromby, A.F., Amonette, W.E., Layne, C.S., McFarlin, B.K., Hinman, M.R. and Paloski, W.H. (2007) Variation in neuromuscular responses during acute whole-body vibration exercise. *Medicine and Science in Sports and Exercise* **39**, 1642-1650.

Altman, D.G., Schulz, K.F., Moher, D., Egger, M., Davidoff, F., Elbourne, D., Gøtzsche P.C., Lang T. and CONSORT GROUP. (2001) The revised CONSORT statement for reporting randomized trials: explanation and elaboration. *Annals of Internal Medicine* **134**, 663-694.

Borg, G.A. (1982) Psychophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise* **14**, 377-381.

Cochrane, D.J., Sartor, F., Winwood, K., Stannard, S. R., Narici, M.V. and Rittweger, J. (2008) A comparison of the physiologic effects of acute whole-body vibration exercise in young and older people. *Archives of Physical Medicine and Rehabilitation* **89**, 815-821.

Day, M.L., McGuigan, M.R., Brice, G. and Foster, C. (2004) Monitoring exercise intensity during resistance training using the session RPE scale. *Journal of Strenght and Conditioning Research* **18**, 353-358.

De Luca, C.J. (1997) The use of surface electromyography in biomechanics. *Journal of Applied Biomechanics* **13**, 135-163.

Dishman, R.K., Graham, R.E., Holly, R.G. and Tieman, J.G. (1991) Estimates of Type A behavior do not predict perceived exertion during graded exercise. *Medicine and Science in Sports and Exercise* **23**, 1276-1282.

Duncan, M.J., Al-Nakeeb, Y. and Scurr, J. (2006) Perceived exertion is related to muscle activity during leg extension exercise. *Research in Sports Medicine* **14**, 179-189.

Forta, N.G., Morioka, M., and Griffin, M.J. (2009) Difference thresholds for the perception of whole-body vertical vibration: dependence on the frequency and magnitude of vibration. *Ergonomics* **52,** 1305-1310.

Garatachea, N., Jimenez, A., Bresciani, G., Marino, N.A., Gonzalez-Gallego, J., and de Paz, J.A. (2007) The effects of movement velocity during squatting on energy expenditure and substrate utilization in whole-body vibration. *Journal of Strenght and Conditioning Research* **21**, 594-598.

Gearhart, R.F., Jr., Goss, F.L., Lagally, K.M., Jakicic, J.M., Gallagher, J., Gallagher, K.I. and Robertson, R.J. (2002) Ratings of perceived exertion in active muscle during high-intensity and low-intensity resistance exercise. *Journal of Strenght and Conditioning Research* **16**, 87-91.

Gearhart, R.F., Jr., Lagally, K.M., Riechman, S.E., Andrews, R.D. and Robertson, R.J. (2009) Strength tracking using the OMNI resistance exercise scale in older men and women. *Journal of Strenght and Conditioning Research* **23**, 1011-1015.

Hazell, T.J., Jakobi, J.M. and Kenno, K.A. (2007) The effects of whole-body vibration on upper- and lower-body EMG during static and dynamic contractions. *Applied Physiology, Nutrition, and Metabolism* **32**, 1156-1163.

Kraemer, W.J., Adams, K., Cafarelli, E., Dudley, G. A., Dooly, C., Feigenbaum, M.S., Fleck, S.J., Franklin, B., Fry, A.C., Hoffman, J.R., Newton, R.U., Potteiger, J., Stone, M.H., Ratamess, N.A., Triplett-McBride, T. and American College of Sports Medicine (2002) American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. *Medicine and Science in Sports and Exercise* **34**, 364-380.

Kraemer, W.J., Keuning, M., Ratamess, N.A., Volek, J.S., McCormick, M., Bush, J.A., Nindl, B.C., Gordon, S.E., Mazzetti, S.A., Newton, R.U., Gómez, A.L., Wickham, R.B., Rubin, M.R. and Häkkinen K. (2001) Resistance training combined with bench-step aerobics enhances women's health profile. *Medicine and Science in Sports and Exercise* **33**, 259-269.

Kraemer, W.J., Noble, B.J., Clark, M.J. and Culver, B.W. (1987) Physiologic responses to heavy-resistance exercise with very short rest periods. *International Journal of Sports Medicine* **8**, 247-252.

Lagally, K.M., Robertson, R.J., Gallagher, K.I., Goss, F.L., Jakicic, J.M., Lephart, S.M., McCaw, S.T. and Goodpaster, B. (2002) Perceived exertion, electromyography, and blood lactate during acute bouts of resistance exercise. *Medicine and Science in Sports and Exercise* **34**, 552-559; discussion 560.

Luo, J., McNamara, B. and Moran, K. (2005) The use of vibration training to enhance muscle strength and power. *Sports Medicine* **35**, 23-41.

Mansfield, N.J. (2005) *Human response to vibration*. Boca Raton, FL: CRC Press.

Marín, P.J., Bunker, D., Rhea, M.R. and Ayllon, F.N. (2009) Neuromuscular activity during whole-body vibration of different amplitudes and footwear conditions: implications for prescription of vibratory stimulation. *Journal of Strenght and Conditioning Research* **23**, 2311-2316.

Marín, P.J. and Rhea, M.R. (2010a) Effects of vibration training on muscle power: a meta-analysis. *Journal of Strenght and Conditioning Research* **24**, 871-878.

Marín, P.J. and Rhea, M.R. (2010b) Effects of vibration training on muscle strength: a meta-analysis. *Journal of Strenght and Conditioning Research* **24**, 548-556.

Marín, P.J., Herrero, A.J., García-López, D., Rhea, M.R., López-Chicharro, J., González-Gallego, J. and Garatachea, N. (2012) Acute effects of whole-body vibration on neuromuscular responses in older individuals: implications for prescription of vibratory stimulation. *Journal of Strenght and Conditioning Research* **26**, 232-239.

Mileva, K.N., Naleem, A.A., Biswas, S.K., Marwood, S. and Bowtell, J.L. (2006) Acute effects of a vibration-like stimulus during knee extension exercise. *Medicine and Science in Sports and Exercise* **38**, 1317-1328.

Mischi, M. and Cardinale, M. (2009) The effects of a 28-Hz vibration on arm muscle activity during isometric exercise. *Medicine and Science in Sports and Exercise* **41**, 645-653.

Morioka, M. and Griffin, M.J. (2000) Difference thresholds for intensity perception of whole-body vertical vibration: effect of frequency and magnitude. *Journal of the Acoustical Society of America* **107**, 620-624.

Noble, B.J. and Robertson, R.J. (1996) *Perceived Exertion*. Champaign, IL: Human Kinetics. 320.

Pierce, K., Rozenek, R. and Stone, M.H. (1993) Effects of High Volume Weight Training on Lactate, Heart Rate, and Perceived Exertion. *Journal of Strength and Conditioning Research* **7**, 211-215.

Pincivero, D.M., Lephart, S.M., Moyna, N.M., Karunakara, R.G. and Robertson, R.J. (1999) Neuromuscular activation and RPE in the quadriceps at low and high isometric intensities. *Electromyography and Clinical Neurophysiology* **39**, 43-48.

Proske, U., Morgan, D.L. and Gregory, J.E. (1993) Thixotropy in skeletal muscle and in muscle spindles: a review. *Progress in Neurobiology* **41**, 705-721.

Rampinini, E., Impellizzeri, F.M., Castagna, C., Abt, G., Chamari, K., Sassi, A. and Marcora, S.M. (2007) Factors influencing physiological responses to small-sided soccer games. *Journal of Sports Science* **25**, 659-66.

Rittweger, J. (2010) Vibration as an exercise modality: how it may work, and what its potential might be. *European Journal of Applied Physiology* **108**, 877-904.

Robertson, R.J., Goss, F.L., Boer, N.F., Peoples, J.A., Foreman, A.J., Dabayebeh, I.M., Riechman, S.E., Gallagher, J.D. and Thompkins T. (2000) Children's OMNI scale of perceived exertion: mixed gender and race validation. *Medicine and Science in Sports and Exercise* **32**, 452-458.

Scott, T.J., Black, C., Quinn, J. and Coutts, A.J. (2012) Validity and reliability of the session RPE method for quantifying training in Australian Football: A comparison of the CR10 and CR100 scales. *Journal of Strength and Conditioning Research.* **Mar 24** [Epub ahead of print].

Shrout, P.E. and Fleiss, J.L. (1979) Intraclass correlations: uses in assessing rater reliability. *Psychological Bulletin* **86**, 420-428.

Streiner, D.L. and Norman, G.R. (1995) Reliability. In: *Health Measurement Scales: A Practical Guide to their Development and Use*. Eds: Streiner, D.L. and Norman, G.R. Oxford: Oxford University Press. 104-127.

Key points

- The pictorial-verbal category scale of perception of exertion (OMNI-VIBRO) during lower body vibration exercise on a vibration platform showed good concurrent validity.
- The OMNI-VIBRO method in conjunction with WBV exercise would allow coaches, fitness professionals, or health-care personnel to assess the intensity that corresponds to the level of the vibratory stimulus.
- The OMNI-VIBRO could be a useful tool of measuring the different intensities of a vibratory-training session and altering the vibratory stimulus in a periodized fashion.

AUTHORS BIOGRAPHY

Pedro J. MARÍN

Employment

Laboratory of Physiology, European University Miguel de Cervantes, C/Padre Julio Chevalier, Valladolid, Spain

Degree

PhD

Research interest

Vibration training and injury prevention.

E-mail: pjmarin@uemc.es

Alejandro SANTOS-LOZANO

Employment

Faculty of Health and Sport Science, Department of Physiotherapy and Nursing, University of Zaragoza, Ronda Misericordia, Huesca, Spain

Degree

MSc

Research interest

Assessment tools for physical activity.

E-mail: alexsanloz@hotmail.com

Fernanda SANTIN-MEDEIROS

Employment

Faculty of Health and Sport Science, Department of Physiotherapy and Nursing, University of Zaragoza, Ronda Misericordia, Huesca, Spain

Degree

MSc

Research interest

Acute and chronic effects of whole-body vibration exercise.

E-mail: fepersonal@gmail.com

Robert J. ROBERTSON

Employment

Professor in the Department of Health and Physical Activity and is also a Co-Director of the Center for Exercise and Health Fitness Research at the University of Pittsburgh.

Degree

PhD

Research interest

Scaling exertional perceptions and directed the investigative team that developed and validated the OMNI pictorial scale.

E-mail: gabry.digiacinto@libero.it

Nuria GARATACHEA

Employment

Associate Professor, Faculty of Health and Sport Science of the University of Zaragoza, Zaragoza, Spain

Degree

PhD

Research interest

Physical activity and health as well as aging.

E-mail: nuria.garatachea@unizar.es

✉ **Nuria Garatachea, PhD**

Faculty of Health and Sport Science, Department of Physiotherapy and Nursing, Universidad de Zaragoza, Ronda Misericordia 5. 22001-Huesca, Spain