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Pilot Study

Acute effects of whole body vibration on heart rate variability in elderly people

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ABSTRACT

Background: Whole body vibration (WBV) has been widely used as a modality for physical activity. In fact, WBV has been used for physical rehabilitation, and to improve muscle performance; but there is little information about its effects on heart rate variability (HRV).

Aim: The aim of this study was to evaluate the effect of vibration on HRV of the elderly using the vibratory platform.

Methods: Eleven older adults (7 men, 4 women), aged between 60 and 75 years, were subjected to WBV. The study consisted of a single session of WBV with volunteers standing upright for 10 min on the oscillating platform, with frequency of vibration set at 20 Hz (displacement ± 6 mm; orbital vibration). Pre (baseline) and post-WBV electrocardiograph signals were acquired using a cardiac monitor; and data were statistically analyzed using paired Student's t-test or Wilcoxon test, as appropriate.

Results: The results demonstrated an increase in SDNN (standard deviation (SD) beat-to-beat, N–N intervals), rMSSD (square root of the mean squared difference of successive N–Ns) and pNN50 (proportion of N–N50 divided by total number of N–Ns) post WBV ($p = 0.032$, $p = 0.024$ e $p = 0.044$, respectively), compared to baseline. The present study thus demonstrated that time domain variables (i.e., SDNN, rMSSD, and pNN50) increase post WBV.

Conclusions: Older individuals are at high risk of developing cardiovascular diseases. As seen in the study, WBV improves HRV; and may help reduce risk of cardiac ailments. Moreover, WBV does not require extensive physical activity on the part of the participant. This makes WBV potentially beneficial to the elderly population. Further studies on WBV using different frequencies and training schedules may improve its applicability in clinics.

1. Introduction

Physical activity is important in delaying the deleterious effects of aging. The vibratory platform has been widely used as a form of physical activity for elderly population. Vibration can be understood as the alternating movement of a solid body in relation to its center of equilibrium (Aitjà-rabert et al., 2012; Bogaerts et al., 2009).

There are vibration-producing devices available in the market that are used for physical rehabilitation and improving physical performance. These platforms emit constant bell-shaped vibrations, which produces symmetrical waves. This makes it possible to quantify the intensity of the vibration produced by the apparatus, using the oscillation amplitude (Behboudi et al., 2011; Theodorou et al., 2015).

The amplitude is calculated as half the difference between the largest and the smallest displacement value occurring during the oscillation and is reported in millimeters (mm). The frequency of vibration refers to the rate of repetitions of displacements, so it is measured in Hertz (Hz) which are cycles per second (Chen et al., 2014). For example, when a platform works with 5 mm amplitude and 30 Hz frequency, it means that this unit is moving 5 mm around a fixed point and that displacement occurs 30 times in a second (Silva and Schneider, 2011).

Heart Rate Variability (HRV) is the measure of variation in instantaneous heart rate time series reflected by beat to beat RR-

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intervals. It gives an idea of balance between the slow acting sympathetic and fast acting parasympathetic systems, and can be used to evaluate cardiovascular ailments. The current study aims to investigate the effects of WBV on HRV in older adults.

2. Methods

2.1. Design

Eleven healthy elderly subjects (7 men, 4 women) aged between 60 and 75 years, participated in this study. Medical history of all prospective participants was thoroughly checked, and only those deemed 'healthy' were enrolled into the study. Healthy is defined as those devoid of any disease and risk factor, and exhibiting a normal walking gait. Individuals with major trauma, systemic disease, conflicting or ongoing treatments (e.g. cardio-depressive and cardio-stimulating medications), tobacco users, and those who could not understand the maneuvers were excluded from the study.

The study was approved by the Ethics Committee in Research of University of Paraiba Valley (ECR/UNIVAP, opinion number 1.395.981, protocol number CAEE. 51246815.0.0000.5503, Brazil). Subject recruitment was random, and from a pool of elderly people invited to participate in the study at Healthy Science Faculty (UNIVAP). Written informed consent was obtained from all participants after being informed regarding the study aims and procedures.

2.2. Intervention protocol

Electrocardiographic signals were recorded using a cardiac monitor (RS800, Polar Electro, Finland) from subjects for 10 min (baseline) before WBV. They were then subjected to a single 10 min WBV session standing upright on oscillating platform (Vibra 6 mm, Nissan®, São Paulo, Brazil) vibrating at 20 Hz (displacement ± 6 mm; orbital vibration). Post WBV, electrocardiographic signals were collected again immediately. The signals were filtered using Polar Pro Training Software (Polar Electro®, Kempele, Finland) and analyzed using HRV Analysis Software v2.0 (University of Western Finland, Finland) for time domain and frequency. All participants were requested to sit in the same sitting position before the study. Baseline data from all participants were acquired after 10 min adaptation. The entire experiment was performed for all participants at the same time of the day. These precautions were taken to avoid variations due to circadian rhythm, body position, and prior activity level. Since subjects on medication were excluded from the study, the influence of the same on results was also avoided.

For frequency-domain HRV analysis, Fast Fourier Transform was used to calculate the very low–frequency (VLF, 0–0.04 Hz), low-frequency (LF, 0.04–0.15 Hz), and high-frequency (HF, 0.15–0.4 Hz) components, as well as LF and HF components in normalized units (LFun and HFun, respectively). LF and HF were considered to reflect sympathetic and parasympathetic activity, respectively. The autonomic balance was obtained by the ratio between the sympathetic and parasympathetic areas (LF/HF); wherein ratios >1, <1 and 1 were indicative of sympatheticotonia, vagotonia, and sympathovagal balance, respectively. VLF is not a well-defined physiological phenomenon and may be related to the renin–angiotensin–aldosterone system, thermoregulation, and peripheral vasomotor tone (Task Force, 1996).

For the HRV time-domain analysis, the following variables were calculated: average normal R–R intervals (RRmed); standard deviation (SD) beat-to-beat (N–N) intervals (SDNN, measured in ms); number of pairs of successive N–Ns that differed by more than 50 ms (N–N50); proportion of N–N50 divided by total number of N–Ns (pNN50); and square root of the mean squared difference of successive N–Ns (rMSSD).

2.3. Data analysis

Statistical analysis was carried out using a commercial statistical program (Sigma Plot 11.0, Systat®, Chigado, IL, USA). Normality of the distributions was tested by Kolmogorov-Smirnov test. Statistical comparisons between baseline and post-WBV were made using paired Student's t-test or Wilcoxon, as appropriate; and reported as mean ± SD. The level of significance was set at $p < 0.05$.

3. Results

The flowchart depicted in Fig. 1 shows the recruitment rates, drop-offs and refusals. Of 31 individuals, 20 refused to participate for personal reasons and 1 individual was excluded because the inclusion criteria were not fulfilled (see Fig. 1).

With the purpose of determining the effect of WBV on HRV, 11 older adults were subjected to 10 min WBV as described earlier. Baseline and post-WBV, electrocardiograph signals were collected and results expressed as their mean and respective Standard Deviations (SDs). Table 1 shows the results of anthropometric data. It is possible to observe that the individuals had body mass index corresponding to overweight (BMI = 27.48).

All results are reported in Table 2. SDNN, rMSSD and pNN50 increased post WBV compared to baseline ($p = 0.032$, $p = 0.024$ and $p = 0.044$, respectively). None of the data in frequency domain showed any difference (see Table 2).

4. Discussion

WBV is a well-known method for improving muscle performance and bone density, indicating that it may be an effective exercise modality (Gómez-Cabello et al., 2014; Brummel-Smith et al., 2017; Perchthaler et al., 2015). There is a considerable amount of data which supports the beneficial effects of WBV in the general population. In the elderly, it has been reported that WBV promotes positive effects on postural control and walking ability (Zhang et al., 2014). But, its effects on HRV of sn elderly population remain unclear (Zhang et al., 2014; Osugi et al., 2014).

Preliminary research suggests that WBV can influence HRV (Sanudo et al., 2013, Severino et al., 2016, Wong et al., 2016). Wong et al. (2016) reported that WBV training consisting of static and dynamic leg exercises with vertical vibration at 25–40 Hz for 8 weeks improve sympathovagal balance in sedentary obese post-menopausal women. Similarly, Severino et al. (2016) evaluated the effects of a 6-week WBV training regimen on HRV and body composition in obese postmenopausal women. The authors suggested that WBV training improves HRV and body fat percentage in that population. In addition, they correlated the changes in sympathovagal balance with body fat percentage.

There are some methodological differences between the present study and those mentioned above; such as the WBV training duration and body mass index (BMI) of the population studied. Wong et al. (2016) and Severino et al. (2016) examined the effects of more than 6 weeks long WBV training on HRV in obese women. In contrast to both these studies, the current investigation reports the immediate effects of a single 10 min session of WBV in non-obese elderly population; and finds improvement in HRV. This indicates that changes in BMI may not be solely responsible for HRV improvement, as suggested by Severino et al. (2016); but other factors may be involved.

In the present study, the time domain components of HRV such

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