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Review

Effects of whole-body vibration on postural control in elderly: An update of a systematic review and meta-analysis

Slavko Rogan[a,*], Jan Taeymans[a], Lorenz Radlinger[a], Sandro Naepflin[a], Stefan Ruppen[a], Yvonne Bruelhart[a], Roger Hilfiker[b]

[a] *Discipline of Physiotherapy, Bern University of Applied Sciences, Bern, Switzerland*
[b] *HES-SO Valais-Wallis, School of Health Sciences, Physiotherapy, Leukerbad, Switzerland*

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ABSTRACT

The aim of this systematic review and meta-analysis was to offer an updated overview of the current studies on all types of whole-body vibration (WBV), to determine the effects of WBV on balance in Go-Go (active, independent), Slow-Go (some physical activity limitations) and No-Go (in need of care) elderly and to provide recommendations on available evidence on WBV for clinicians and researchers. An electronic literature search was conducted in PubMed, Cochrane Register of Controlled Trials, Physiotherapy Evidence Database (PEDro) and CINAHL (Ebsco Host) to identify studies on WBV therapy in Go-Goes, Slow-Goes and No-Goes. Outcomes were static, dynamic and functional balance. Thirty-tree studies were included in this systematic review. Pooling was possible for static balance and dynamic balance. Effect size (SMD) of WBV on static balance was 0.34 (95% CI 0.18, 0.49) in Go-Goes. Effect size (SMD) of WBV on dynamic balance was −0.15 (95% CI −0.44, 0.15) in Slow-Go and −0.90 (95% CI −1.63, −0.17) in No-Go elderly people respectively.

The results of this current meta-analysis suggest that WBV can be used for improving static balance in Go-Go elderly and that it has the potential to positively influence dynamic balance in Slow-Go and No-Go elderly.

1. Introduction

Whole-body vibration (WBV) is used as a sensorimotor training to conduct stimuli to alpha motor neurons via mono-polysynaptic pathways (Rogan, Hilfiker, Schenk, Vogler, & Taeymans, 2014). This leads to an adaptation of the muscular tension and allows the body to maintain an upright position during vibration. Three types of WBV devices are used in clinical, training and research settings (Rogan, de Bruin, & Radlinger, 2015; Rogan & Hilfiker, 2012): sinusoidal vertical WBV (VS-WBV) with a frequency between 30 and 60 Hz and an amplitude of 0–12 mm (feet on one plate), sinusoidal side-alternating-WBV (SS-WBV) with a frequency of 12 and 30 Hz and an amplitude of 0–12 mm (feet on one plate) and stochastic resonance WBV (SR-WBV), with a frequency of 1–12 Hz and an amplitude of 0–12 mm (each foot on independent motorized plate). VS-WBV stimulation may increase the activity of the extensors and flexors that stabilize the joints around the transverse axis (Rogan & Radlinger, 2015). In addition, SS-WBV stimulates and may increase the activity of the muscles which are around the sagittal axis of the joints (Rogan & Radlinger, 2015). SR-WBV vibrates two-dimensionally vertically up and down as well as horizontally forward and backward. Furthermore, they tilt passively to the right side or left side (Rogan & Radlinger, 2015). This leads to activity of the muscles which are around the joint.

Positive effects of WBV on balance (Kessler, Radlinger, Baur, & Rogan, 2014) and strength (Rogan, de Bruin et al., 2015) in elderly individuals have been described. Long-term effects of WBV on muscle strength were observed in frail (Kessler et al., 2014) and untrained elderly (Rhea, Bunker, Marin, & Lunt, 2009). However, another study found no effects after WBV training in healthy people (Rogan, Radlinger, Portner-Burkhalter, Sommer, & Schmidtbleicher, 2013). These inconsistencies may result from methodological inadequacies across the studies. For example, the current level of the physical performance of the elderly study participants may be a confounding factor. The higher the initial level of the physical performance of a person, the more difficult it will be to detect improvements in balance and strength (ceiling effect). It seems that the lower the initial level of physical performance, the more benefit on balance can be achieved by WBV (Rogan & Radlinger, 2016). Therefore, training stimuli must be adjusted according to the current physical performance level of the study participants. However, to start with a proper training program or to design

* Corresponding author.
E-mail addresses: slavko.rogan@bfh.ch (S. Rogan), jan.taeymans@bfh.ch (J. Taeymans), lorenz.radlinger@bfh.ch (L. Radlinger), sandro.naepflin@bfh.ch (S. Naepflin), stefan.ruppen@bfh.ch (S. Ruppen), ybruelhart@bluewin.ch (Y. Bruelhart), roger.hilfiker@gmail.com (R. Hilfiker).

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this training program progressively, a classification of the physical performance level is required (Rogan, 2015; Rogan & Radlinger, 2016).

There are but few concepts that focus on the evaluation of the current physical performance status and on training classification for elderly individuals in clinical settings. Because elderly individuals show different levels of physical performance, tThe analysis of the physical performance level is an important condition for individual training recommendations. Zeyfang and Braun (2009) described on managing elderly individuals with diabetes which encompass the Go-Go, Slow-Go and No-Go framework when deciding on care plans. The Go-Go, Slow-Go and No-Go framework is also used for training regimes recommendation. In this case, the physical and mental functional capacities are assessed and will be used to classify elderly persons asindependent persons (Go-Go), needy persons with slight handicap (Slow-Go) and persons in need of care with severe functional limitation (No-Go) such as prefrail and frail elderly, and elderly with mobility disability (Rogan, 2015; Rogan & Radlinger, 2016). Until now, this approach was considered in only one systematic review and meta-analysis that found beneficial effects in muscle strength after WBV in No-Go elderly (Rogan, de Bruin et al., 2015). Despite the existence of a systematic reviews and meta-analysis that gives the clinician an overview of indications for using VS-WBV, SS-WBV and SR-WBV while offering application possibilities of the different vibration modalities for the training in Go-Goes, Slow-Goes and No-Goes, more in-depth knowledge and evidence is still lacking. The decision-making approach in the care of elderly individuals is a complex task and should be based on the best available level of scientific evidence based on a well-designed study with methodological rigor that minimizes the chances of bias and which allows a correct interpretation of the results. Therefore, a follow-up study of the meta-analysis that was published in 2011 by Rogan, Hilfiker, Herren, Radlinger, and de Bruin (2011) was conducted. The aim of this study was 1) to update the status quo on the effects of all types of WBV (i.e VS, SS and SR-WBV) on balance in Go-Go, Slow-Go and No-Go elderly and 2) to delineate evidence based implications for clinicians and researchers.

The specific research question was: What is the effect of different types of whole-body vibration on static, dynamic and functional balance in Go-Go, Slow-Go and No-Go elderly individuals?

2. Method

2.1. Design

This current systematic review and meta-analysis is an update of the previously published systematic review and meta-analysis (Rogan et al., 2011). The methods of search strategy were adopted from the first systematic review and meta-analysis. The protocol of this systematic review and meta-analysis was registered (PROSPERO 2015:CRD42015023290). The PRISMA guidelines have been followed for editing this systematic review and meta-analysis (Moher, Altman, Liberati, & Tetzlaff, 2011).

2.2. Identification and selected studies

Following electronic databases were searched: PubMed, Cochrane Register of Controlled Trials, Physiotherapy Evidence Database (PEDro) and CINAHL (Ebsco Host). The unpublished International Clinical Trials Registry Platform from the World Health Organization (WHO) was also searched. In addition, a manual search was completed within the reference lists of retrieved publications. The literature search was conducted from April 2015 until March 2016.

No language limitation was set. Studies reporting on randomized-controlled trials (RCTs) with ahealthy elderly population over 65 years of age were included. Studies with geriatric diseases (Parkinson disease, Stroke, Multiple sclerosis) and investigation studies using electrical vibration were excluded. Intervention of interest was WBV which was defined as a mechanical vibration that was performed in an upright position with unlocked knees (non-squat position). Studies comparing WBV versus control (nothing), WBV + exercise versus exercise or WBV versus sham-WBV were included. The outcomes of interest were static balance, dynamic balance and functional balance.

Two authors (NS, RSt) screened the titles and abstracts for eligibility. In case of disagreement, the two authors discussed up to a consensus. Three Authors (RS, NS, RSt) independently extracted with the Data Extraction Template for Cochrane Reviews (La Trobe University, 2011) the general characteristics from each of the included studies (study design, participants (N + age), intervention, outcomes and results). In case of insufficient data, the corresponding author was contacted for clarification.

2.3. Assessment of methodological quality

The methodological quality was assessed by two authors (NS, RSt) using the Cochrane Collaboration's Risk of Bias (RoB) tool (Higgins, Altman, & Gøtzsche, 2011). The RoB criteria list covers six items that represent the aspects of internal validity. Each item was scored with "−" for no, with "+" for yes, and with "?" if the information was unclear. A study was defined as having a low RoB if all criteria are fulfilled with "yes". A study has a moderate Rob when one or more items are rated "unclear", while a study was coded as high RoB if one or more key domains have been rated with "no". A third author (SR) was used in any time of no full agreement among the two authors to obtain a consensus.

2.4. Data analysis

A meta-analysis was performed if two or more studies reported on the same outcome in participants of the different Go-Go, Slow-Go and No-Go physical performance level categories. If different possible outcome measures per characteristic under investigation were reported, the authors (SR, RH) decided which of those outcome measures should be pooled (Tschopp, Sattelmayer, & Hilfiker, 2011). The decision was based on the reviewers' judgment (SR, RH). Outcome data on a hierarchy of outcomes are: static balance, dynamic balance and functional balance (Rogan et al., 2011). Static balance is the ability to maintain the center of mass over a narrow base of support in an upright position (Orr, Raymond, & Singh, 2008). Dynamic balance is the ability to maintain equilibrium whilst the body's centre of gravity is in motion (Orr et al., 2008). Functional balance assesses the ability to maintain equilibrium whilst carrying out everyday tasks or activities (Orr et al., 2008).

The standardized mean differences (SMDs) and 95% confidence interval of post-intervention values or changes values were used for all comparisons. SMDs were pooled with a random effects model. The effect sizes (ES) for the comparisons between the groups can be interpreted as follows: small ES = 0.2, medium ES = 0.5 and large ES = 0.8 (Higgins, Thompson, Deeks, & Altman, 2003).

The included studies were sampled from a universe of eligible studies defined by the inclusion/exclusion before mentioned criteria. The 95% confidence interval for the effect sizes were calculated as a measure of precision, indicating that the mean effect size in the universe of studies could fall anywhere in this range.

To test the nullhyopthesis that all studies in the analysis share a common effect size, the Q-test and its corresponding p-value for specific degrees of freedom (the number of studies minus 1) was calculated. Higgins' I^2 statistic was used as a measure of the between studies variability. The value shows how much of the total observed variability can be explained by the between studies variability (rather than sampling error) and therefore the I^2 is expressed in%. An I^2-statistic from 0%–40% indicates that the heterogeneity might not be important, 30%–60% represents moderate heterogeneity, 50%–75% represents substantial heterogeneity and 75%–100% represents considerable heterogeneity (Higgins et al., 2003).