Effect of different neuromuscular training modalities on postural stability in healthy recreation people: A randomised controlled trial

February 19, 2024

Title: Effect of different neuromuscular training modalities on postural stability in healthy recreation people: A randomised controlled trial

Brief Title: "Neuromuscular Training & Postural Stability"

Acronym: STABLEFIT

Study Overview

Brief Summary

Background: Postural stability (PS) is a vital function that helps maintain equilibrium during standing still, locomotion, and any activities requiring high balance performance. Under static and dynamic conditions, PS is a fundamental factor for the quality of movement in everyday activities or sports. PS and adaptive ability are required in sports due to the interactions between the sensory and motor systems, which regulate postural adjustments by processing information from the visual, vestibular, and somatosensory systems, as reported by previous studies. The interest in using different exercises and protocols for improving PS in sports and physiotherapy has grown in the last few decades. Experts have proposed various training modalities to increase neuromuscular stability, balance, postural control, and general stability.

Dynamic Neuromuscular Stabilization (DNS) is a complex of correction exercises with a neuromuscular approach based on improving breathing, fundamental movements, and principles of developmental kinesiology.

Whole body vibration training (WBV) is a neuromuscular training approach that has recently become very popular among researchers and practitioners in health and sport. It is usually used as an additional method in a conventional training routine.

Designing the training program to achieve the optimal benefits for PS in healthy young adults is important in general personal health management. Although different training protocols have improved PS and general stability in everyday activities, there is still considerable debate regarding the optimal exercise modalities within an exercise program.

Aim: The purpose of this study is to determine the effects of dynamic neuromuscular stabilisation (DNS), whole-body vibration (WBV), and a combination of DNS and WBV (MIX) training modalities on postural stability (PS) in healthy recreation participants.

Method and materials: 180 gender-balanced groups were divided into four groups: MIX, DNS, VIBRO, and CONTROL, and underwent two months of treatment. The single and double-leg Center of Force (COF) parameters were collected on the Forceplate.

Detailed Description

Study design

The purpose of this study is to determine the effects of dynamic neuromuscular stabilisation (DNS), whole-body vibration (WBV), and a combination of DNS and WBV (MIX) training modalities on postural stability (PS) in healthy recreation participants. The study presents an Interventional study to improve postural stability, and the main objective is prevention. The study model is parallel with four groups.

Participants

The randomised, controlled interventional trial enrolled a gender-balanced group of 180 healthy young participants. The initial sample of respondents was recruited through an open online application that lasted two months (from 10.2.2022. to 10.4.2022.) (n=250), after which the first selection of respondents was started (n=230). Recruitment was completed after the optimal sample of subjects was filled (15.4.2022). The study sample was divided using stratified randomisation into the MIX group (n = 58), DNS group (n=57), VIBRO (n=57), and CONTROL group (n=58). At the end of the experimental program, the final sample was 180 (MIX=45; DNS=45; VIBRO=44; CONTROL=43). When stratifying, researchers use proportionate sampling to maintain the correct proportions of genders in every group. After explaining the experimental protocol, each subject provided written informed consent before participating in the study, per the Declaration of Helsinki and the Novi Sad University Human Research Ethics Committee guidelines (ethical approval number: 46-06-04/2020-1). The interventional program was conducted from 25.4.2022. to 25.6.2022.

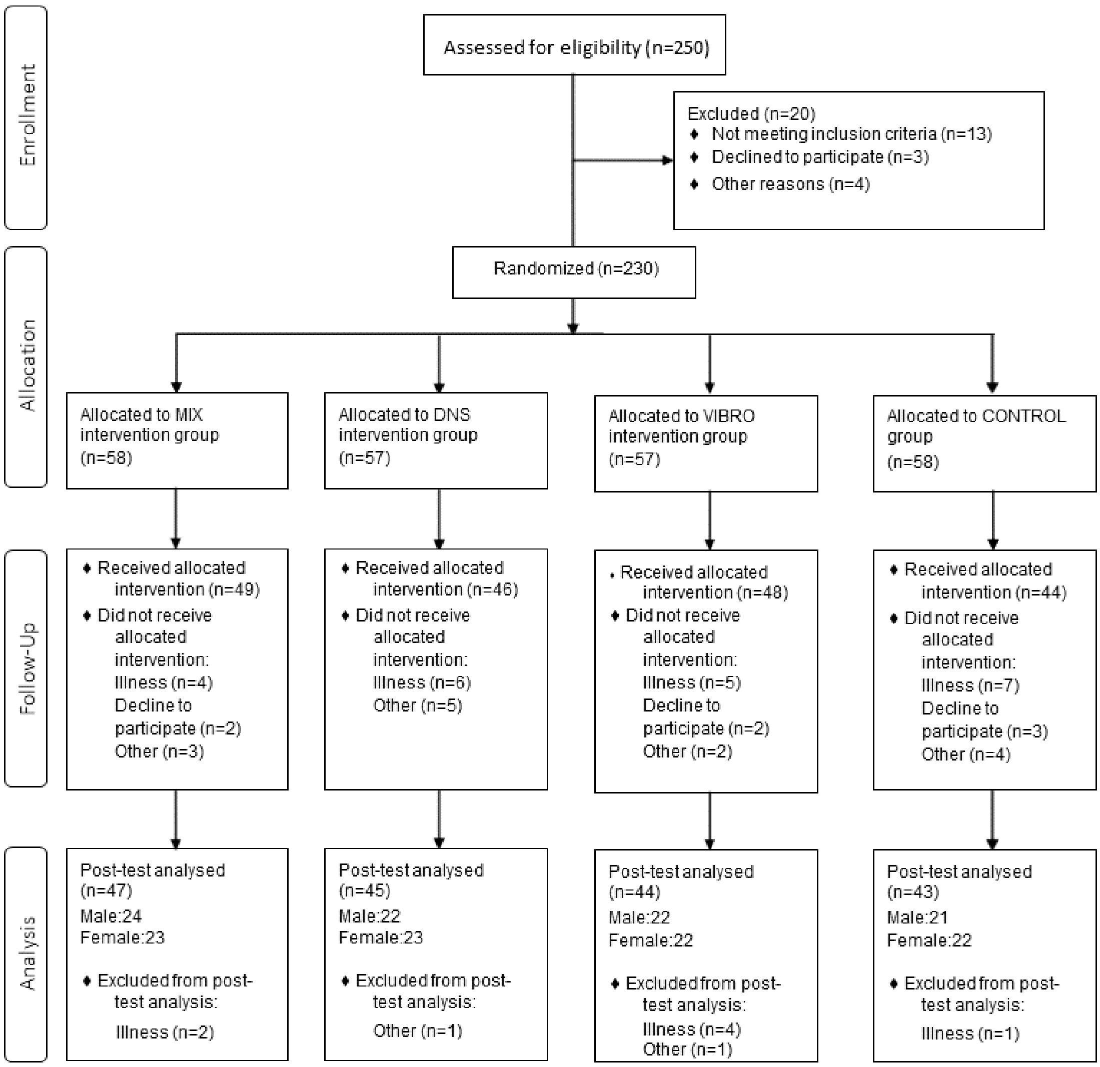
Ethics committee – commission for implementation of scientific project research

The exclusion criteria were:

- history of neurological or musculoskeletal disorders;
- clinical conditions that could impair balance (motor disorders, medical conditions like diabetes, heart disease, stroke, issues with vision, thyroid, nerves, or blood vessels).

The inclusion criteria for this study were:

- the absence of injuries in the past six months
- the absence of other medical conditions, including COVID-19
- no programmed physical activity in the past three months.



Testing procedures

The testing was conducted at the Faculty of Sport and Physical Education, University of Novi Sad, Serbia. All participants were tested in the morning before their training session in indoor environmental conditions (temperature: 18–21°C; relative humidity: 40–60%). Before starting a performance task, general information about the examinees was recorded, including gender, age, height, and mass. Participants were instructed to wear minimal clothing and remove all footwear for height and mass measurements. In addition, they were required to eat and drink sparingly and void their bladder/excrete as needed before presenting for assessment. A stadiometer (0.1 cm accuracy, SECA Instruments Ltd, Hamburg, Germany) is used for height and mass measurements as a secondary outcome. Initial testing was conducted on 20.4.2022 and final on 25.6.2022.

Static PS was assessed with a laboratory-grade 0.5 m Footscan® plate (RSscan International, Lammerdries, Belgium) with 4096 sensors and a scanning rate of up to 300 Hz. The subject performed an individual single and double-leg task with three trials, each lasting 30 seconds with a two-minute break between each trial. During the double-leg stance test, participants were instructed to maintain an upright and as still as possible posture. They were asked to stand in their natural, comfortable position with their eyes open and fixed on a cross positioned at approximately eye level on a blackboard situated 5 meters away. Participants stood barefoot with their feet placed shoulder-width apart on a platform, and their arms were kept by their sides. Each participant was required to maintain this stable posture, and measurement started after 10 seconds (preparation period to avoid transient effects). During the single-limb stance test, participants were instructed to balance on one foot. This foot was positioned to point directly forward, aligning with reference lines in the frontal and sagittal planes. The swinging leg was flexed at the hip and knee joints to approximately 90 degrees while both arms hung naturally and relaxed at their sides. Participants were further instructed to maintain as steady a posture as possible, focusing their gaze straight ahead on a point situated 65 centimetres away on the wall. The order of testing between the left and right legs was randomised. Each participant was required to maintain this stable position, and measurement started after 5 seconds (preparation period to avoid transient effects).

Tests for static PS were the gold standard in measuring balance and were used to obtain biomechanical parameters of static PS (Hass et al., 2008). All measurements were performed in triplicate, and the mean score was retained for subsequent evaluations and analyses. The sequence of performing the balance tasks was randomised.

The software calculated the single and double-leg Sway Area (cm^2), Center of Force (COF) travelled way (mm), Medio-Lateral (ML) displacement (mm), and Anterior-Posterior (AP) displacement (mm) as primary outcomes. The following protocol was chosen based on their varying difficulty and common use as stated in previous research and is cited as reliable (Bauer et al., 2008; Springer et al., 2007; Troester et al., 2018; Verhagen et al., 2005).

Interventions

Dynamic neuromuscular stabilisation group (DNS)

DNS group's protocol involved 5 min a moderate intensity warm-up, 40 minutes of DNS movements according to the DNS approach(Frank et al., 2013), different diaphragmatic breathing, mobility and controlled movement exercises and 5 minutes of cool-down. Exercises gradually increased in complexity and difficulty level regarding DNS training principles (Mahdieh et al., 2020). The participants were instructed to refrain from engaging in high-intensity anaerobic or anaerobic resistance training throughout the study period to prevent potential disruptions in the study results.

Whole body vibration group (VIBRO)

WBV was performed on the Power Plate Next Generation vibration platform (Power Plate North America, Chicago, IL). All training routines were approximately 50 minutes long, commencing with 5 minutes of moderate-intensity warm-up and concluding with a cool-down period. The program consisted of 8-10 static and dynamic exercises for PS that progressively increased in difficulty and complexity. During the training process, the frequency increased from 20 to 35 Hz in the last week of the experiment; the exercise duration was from 20 – 60 seconds (in the previous week), followed by 1-minute seated rest. Moreover, the complexity and difficulty of exercise increased over the experimental period. The resting period between sets was constant from the start to the end of the training process. During the experiment, the WBV intervention group performed three weekly training sessions. The participants were advised to avoid participating in high-intensity anaerobic or anaerobic resistance training during the study to ensure that it would not interfere with the study's outcomes—no changes to trial outcomes after the trial commenced. Principles and basic procedures were adapted from previous research (Fort et al., 2012; Jordan et al., 2005; Piecha et al., 2014; Torvinen, Kannu, et al., 2002; Torvinen, Kannus, et al., 2002).

Dynamic neuromuscular stabilisation with whole body vibration group (MIX)

During the two months, participants in the MIX group performed training consisting of 3 weekly sessions. The protocol consisted of a 50-minute exercise program with a 5-minute moderate-intensity warm-up and cool-down period per training session. The structural core of training included 20 minutes of WBV and 20 minutes of DNS training. Both protocols followed the previous research and training recommendations and were performed with less time and sets. Exercises with VIBRO were performed on the Power Plate Next Generation vibration platform (Power Plate North America, Chicago, IL). The program consisted of 6-8 exercises (static and dynamic) for balance and PS. Exercise progressively increases by the level of difficulty. During the training process, the frequency was also increased from 20 to 35 Hz in the last week of the experiment; the duration of exercise from 20 – 60 seconds (in the previous week), followed by 1-minute seated rest. The resting period between sets was constant from the start to the end of the training process. To prevent any interference with the study's results, participants were recommended to abstain from engaging in high-intensity anaerobic or anaerobic resistance training throughout the study. Basic principles and procedures were adapted from previous research (Fort et al., 2012; Jordan et al., 2005; Piecha et al., 2014; Torvinen, Kannu, et al., 2002; Torvinen, Kannus, et al., 2002). WBV is followed by a 20-min period of DNS training, including specific movement exercises according to the DNS approach accompanied by breathing, coordination, mobility and stability core exercise and routine suggested in previous studies (Frank et al., 2013; Kobesova & Osborne, 2012; Mahdieh et al., 2020; Marinkovic et al., 2022). During the experiment, the MIX intervention group performed three training sessions weekly.

Control group (CONTROL)

The control group did not exercise or use any training intervention or other habitual training during the past two months. During this period, the control group maintained their regular daily routines without any modifications. They refrained from engaging in any form of physical activity or participating in training programs that could influence their fitness levels.

Statistical analyses

G*power 3.1 power analysis software (Heinrich-Heine-University, Düsseldorf, Germany) estimated the minimum total sample size (N=140) given the critical $F_{(3, 136)}$=2.67, an effect size f=0.14 (partial η^2=0.02), p=0.05, 1-β=0.80, groups=4, time points=2, and correlation among the measurements=0.50. The authors presented data as means and 95% confidence intervals [95% CIs]. The Kolmogorov–Smirnov, Leven's, Box's, and Mauchly's tests confirmed the assumptions of normality, homogeneity of variances and covariances, and sphericity, respectively. General linear models (twelve separate 2x4 mixed-design analyses of covariances for each PS measure) estimated whether mean changes [95% CIs] in PS measure from initial to final testing depended on whether participants received the DNS, VIBRO, and MIX exercise program or did not (CONTROL) after controlling for mean-centered BMI (Cibulková et al., 2022; Hue et al., 2007). Following the time-by-group interaction effects, which revealed whether estimated changes over time depended on the participants' group (i.e., differed at least between one group-comparison pair), we computed simple effects tests to estimate mean changes over time (mean difference from initial to final testing) within the groups. The follow-up investigation proceeded with contrast analysis, which assessed the degree to which estimated mean changes of PS measures differed between the group-comparison pairs. The authors calculated the effect size for time-by-group interaction effects and simple effects using partial eta squared (partial η^2: 0.01 small; 0.06 medium; 0.14 large) (Cohen, 2013) and Hedge's g average (Hedge's$_{av}$: <|0.20| trivial; |0.20| small; |0.50| medium; |0.80| large) (Lakens, 2013), respectively. The Bonferroni test corrected p-values and 95% CI; the alpha level was p≤0.05. We used SPSS version 23.0 (SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 8.0 (GraphPad Software, San Diego, California, USA) to analyse and plot the data, respectively.

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UNIVERSITY OF NOVI SAD

FACULTY OF SPORT AND PHYSICAL EDUCATION

ETHICS COMMITTEE – COMMISSION

DECISION No. **46-06-04/2020-1**

ETHICS COMMITTEE - COMMISSION FOR THE IMPLEMENTATION OF SCIENTIFIC PROJECT - RESEARCH

DESCRIPTION
After reviewing the submitted application (on June 17, 2020) for a scientific research project entitled: **Biomechanical parameters of athlete's postural stability** Ethics Committee - Commission - **APPROVES** – Borislav Obradović, PhD, Full Professor to continue with the realization of applied scientific research project.

Novi Sad,

17.06.2020.