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Effects of a 12-wk whole-body vibration based intervention to improve type 2 diabetes

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ABSTRACT

Objective: To test the feasibility, safety and effectiveness of a 12-wk whole body vibration (WBV) intervention on glycemic control, lipid-related cardiovascular risk factors and functional capacity among type 2 diabetes mellitus (T2DM) patients in a primary care context.
Methods: Fifty non-insulin dependent T2DM patients were randomized 1:1 to an intervention group that, in addition to standard care, received a 12-wk WBV intervention, and a control group receiving only standard care (from February 2012 through May 2012). Outcomes, including glycated hemoglobin (HbA1c), fasting blood glucose, lipid-related cardiovascular risk factors (i.e., cholesterol, triglycerides, lipoproteins, LDL/HDL and atherogenic index) and functional capacity were measured at baseline and after the 12-wk intervention.
Results: After intervention, there was a reduction in HbA1c and fasting blood glucose when compared to the control group, with a mean difference in change scores between groups of −0.55% (95% CI −0.15 to −0.76) and −33.95 mm/dl (95% CI −51.38 to −3.47), respectively. Similarly, most lipid-related cardiovascular risk factors (i.e., cholesterol, triglycerides and atherogenic index) were also reduced ($p < 0.05$).
Conclusion: A 12-wk WBV intervention in a primary care context is feasible, safe and effective in improving glycemic profile, lipid-related cardiovascular risk factors and functional capacity among T2DM patients.
Trial number: ACTRN12613000021774.

1. Introduction

Type 2 diabetes mellitus (T2DM) is a prevalent and costly chronic metabolic disorder characterized by hyperglycemia and insufficiency of secretion or action of endogenous insulin [1]. Likewise, T2DM is an independent risk factor for vascular diseases and also is frequently associated with other cardiovascular diseases [2]. Therefore, the major causes of morbidity and mortality among T2DM patients are cardiovascular diseases [3]. Consequently, it is necessary to address both T2DM outcomes (i.e., glycated hemoglobin (HbA1c) and fasting blood glucose) and modifiable cardiovascular disease risk factors (e.g., dyslipidemia or blood pressure) for a complete therapeutic approach among this population.

Along with nutrition, exercise has long been recognized as a cornerstone for T2DM management in both primary and secondary prevention. Although there are no definitive conclusions, results from different meta-analyses [4–6] show that aerobic exercise or resistance training reduce HbA1c, fasting blood glucose, dyslipidemia or blood pressure when compared with standard care. Nonetheless, greater achievements seem to be reached by combining both modes of exercise. Moreover, better functional capacity is associated with better outcomes among diabetic patients [7].

Whole-body vibration (WBV) training is a relatively new form of exercise that has been shown to be effective in healthy subjects [8] and individuals with a range of medical disorders [8]. Moreover, WBV training has been shown to be useful among frail individuals who were previously physically untrained [9,10], as most diabetics patients are, and because WBV training takes less time than other kinds of exercise such aerobic or resistance training, this method could be a very good alternative to exercising in clinical contexts. Unfortunately, the effects of WBV training have seldom been investigated among T2DM patients. Existing studies [11–13] have yielded inconsistent results and no studies have been conducted to test the effects of WBV training on cardiovascular risk factors

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among T2DM patients. We therefore conducted a randomized controlled trial to contribute to the ongoing discussion on the effectiveness of WBV training for T2DM management in a clinical context. The aim of this study was 2-fold: (1) to test the feasibility, safety and effectiveness of this intervention on glycemic control, dyslipidemia and functional capacity among T2DM patients in a primary care context and (2) to quantify the possible relationship between functional capacity and glycemic control among participants receiving the WBV intervention.

2. Methods

2.1. Study design and participants

A single-blind (researchers) randomized controlled trial was conducted was conducted from February 2012 through May 2012. The study was approved by the research ethics committee of the University of Seville and conducted in accordance with the Declaration of Helsinki, as revised in Edinburgh, 2008. All participants signed an informed consent form prior to participation in the study. Participants in the study were recruited via health care staff from a primary care center in Seville, Spain. The inclusion criteria were T2DM diagnosis and a level of exercise less than advised by the American Diabetes Association (i.e., 150 min/week of moderate-intensity aerobic physical activity) [14]. Potential participants were excluded if they had a baseline value for fasting blood glucose >250 mg/dl or HbA1c >10%, diagnosed cardiovascular or mental disease, a diabetes-related complication including nephropathy, or retinopathy unrepaired hernia, or any other functional impairment that would preclude safe participation in a WBV-based training program. Out of 57 initial volunteers, 50 fulfilled the inclusion/exclusion criteria and were allocated (randomization was undertaken by a member of the research team not directly involved in the recruitment or assessment of patients) to one of the two study groups using a computer generated random allocation data processing program and a 1:1 ratio (intervention:control).

2.2. Experimental

Participants in both the intervention and control groups had access to the usual care (consisting on outpatient visit for the control of the diabetes-related parameters and on giving advices to improve it) and were asked not to change their nutritional or exercise habits during the 12-wk period. Participants in the intervention group participated in a 12-week WBV-based program on an oscillating or side-alternating vibration device (i.e. two simultaneous movements, one vertical and one horizontal platform) (Phyisio Wave 700, Globus, Italy) consisting of three sessions per week with at least one day between sessions. Description of the WBV intervention is provided in Table 2. Each exercise session was performed with a frequency of 12 Hz for the first month, 14 Hz for the second month and 16 Hz for the last month. Peak to peak displacement of 4 mm was maintained during the entire program. Participants adopted an isometric squat position during all exposures, with knees flexed at 100° for 30 s. After that, participants were asked to perform 8 exercises (lunge, step up and down, squat, calf raises, left and right pivot, shoulder abduction with elastic bands, shoulder abduction with elastic bands while squatting, arm swinging with elastic bands) with slow movements at a rate of 3 s for both concentric and eccentric phases. For the first month, the duration of exercises was 30 s with a recovery time of 30 s between exercises. For the second and third month, the duration of exercises was increased to 45 s and 60 s, respectively, while maintaining the 30 s recovery time. To ensure a correct and safe increase in intensity throughout the program, non-fasted blood glucose tests were performed on each participant during the first day of each increase in intensity including pre-exercise, post-exercise and post 48 h tests.

Table 1
Characteristics of the participants in the study ($n = 39$).

Variables	Control group ($n = 20$)	Intervention group ($n = 19$)	p
Socio-economic variables			
Age (years)	66.80 (10.83)	71.60 (8.54)	0.752
Gender (% females)	50	45	
Marital status			
Married (%)	60	60	0.154
Unmarried (%)	0	15	
Separated/divorced/widowed (%)	40	25	
Income/month			
<USD 1544 (%)	60	50	0.203
USD 1544–2315 (%)	35	25	
>USD 2315 (%)	5	25	
Body composition			
BMI (kg/m^2)	31.55 (5.41)	30.61 (6.8)	0.641
WHR	0.92 (0.85)	0.92 (0.09)	0.893
Body fat (%)	36.02 (10.17)	35.88 (10.02)	0.964
Clinical variables			
Years since diagnoses	8.37 (8.00)	10.11 (7.29)	0.492
T2DM-related drugs	2.10 (1.58)	2.12 (1.62)	0.961
Systolic blood pressure (mmHg)	149 (17.0)	149 (21.9)	0.933
Diastolic blood pressure (mmHg)	71 (12.9)	67 (8.2)	0.323
Heart rate (ppm)	77 (12.0)	75 (10.7)	0.601

Values are mean (SD) unless otherwise indicated; BMI, body mass index; WHR, waist to hip ratio; p, p value from Student's-t for independent measurement or Chi square analysis.

2.3. Outcome measures

Socio-demographic variables (i.e. age, gender, marital status and income) as well as clinical predictor variables (i.e. years since diagnosis, T2DM-related drugs, blood pressure and heart rate) were recorded. Weight, height, and waist and hip circumference were measured to calculate body-mass index (BMI; kg/m^2) and waist to hip ratio. Body-fat percentage was also estimated using an impedance analyzer (Bodystat © 1500, Bodystat Ltd, Douglas, Isle of Man, UK) according to the manufacturer's instructions. Outcome measurements were assessed at baseline and after the 12-wk study period.

2.3.1. HbA1c, fasting blood glucose and lipid-related cardiovascular risk factors

HbA1c (%), fasting blood glucose (mg/dl) and lipid-related cardiovascular risk factors (i.e. cholesterol, triglycerides, high density lipoprotein (HDL) and low density lipoprotein (LDL)) were assessed as part of regular care and performed by a diagnostic center in Seville, Spain. Derived from the lipid assay, LDL/HDL and atherogenic index were calculated for cardiovascular risk assessment purposes [15].

2.3.2. Functional capacity

To assess functional capacity, a test battery consisting of three assessments was used [16]. Motor agility and mobility were assessed by the Timed Up and Go (TUG) test. The participant had to stand up from a chair, walk 2.44 m to and around a cone, and return to the chair in the shortest possible time. The best time of two trials (1-min rest period between each trial) was recorded. To assess cardiovascular fitness, the Six Minute Walking Test (T6MW) was used. Participants were instructed to walk as far as they could at a fast, comfortable pace in 6 min. The maximum distance (m)