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Effects of 12-week overground walking training at ventilatory threshold velocity in type 2 diabetic women

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ABSTRACT

This study analyzed the effects of overground walking training at ventilatory threshold (VT) velocity on glycaemic control, body composition, physical fitness and lipid profile in DM2 women. Nineteen sedentary patients were randomly assigned to a control group (CG; $n = 10$, 55.9 ± 2.2 years) or a trained group (TG; $n = 9$, 53.4 ± 2.3 years). Both groups were subjected to anthropometric measures, a 12-h fasting blood sampling and a graded treadmill exercise test at baseline and after a 12-week period, during which TG followed a training program involving overground walking at VT velocity for 20–60 min/session three times/week. Significant group × time interactions ($P < 0.05$) in glycated hemoglobin (HbA1c), body mass, body mass index (BMI), peak oxygen uptake (VO_{2peak}) and exercise duration were observed as effects of training exercise, whereas intervention did not induced significant changes ($P > 0.05$) in fasting blood glucose, submaximal fitness parameters and lipid profile. Our results suggest that overground walking training at VT velocity improves long term glycaemic control, body composition and exercise capacity, attesting for the relevance of this parameter as an effective strategy for the exercise intensity prescription in DM2 population.

1. Introduction

Glycaemic control is a fundamental component in the management of type 2 diabetes mellitus (DM2) and its complications [1,2], with convincing evidence showing physical training to be an effective strategy for this purpose [3–5] since it increases both glucose transport and skeletal muscle insulin sensitivity [6].

In this framework, walking has been considered a safe, accessible and convenient exercise type for individuals with DM2 without peripheral neuropathy. Given the familiar pattern of movement, walking exercise is easily added into the daily physical activity routine of a patient with DM2 [7,8]. Furthermore, this type of exercise involves large skeletal muscle mass, which plays a major role in peripheral glucose uptake [9], thus triggering more effective improvement in glycaemic homeostasis [10].

In addition to the type of exercise, other key components (i.e., volume, frequency and intensity) must be considered in training programs that intend to maximize health benefits while minimizing risks in DM2 subjects, with special attention being devoted to the exercise intensity [11–15]. In a meta-analysis by Boulé et al. [16], reductions in glycated hemoglobin

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(HbA1c) after training in these patients were better predicted by exercise intensity than volume. Yet, although current position statements from different world leading organizations [17–19] provide exercise intensity recommendations for such population, these suggestions should be viewed with caution given the wide range of moderate and vigorous intensities based on percentages of maximal oxygen consumption (VO_{2max}) (40–59 and 60–84%) and/or maximal heart rate (HR_{max}) (50–69 and 70–89%). It is well known that exercising at a given percentage of VO_{2max} or HR_{max} can elicit different physiological responses for different individuals and that submaximal parameters such as lactate or gas exchange thresholds are better markers of the relative stress induced by exercise [20].

Regardless of the controversy about its physiological background [21], ventilatory threshold (VT), or the exercise intensity above which ventilation begins to increase disproportionately relative to oxygen uptake, has been considered a direct, simple and useful parameter for optimal exercise intensity prescription in DM2 patients [22–24]. While acute exercise at VT reduces plasma glucose [25], training at this intensity improves both the aerobic capacity and the cost-effectiveness of treatment [26]. Moreover, Belli et al. [24] showed the feasibility of VT determination during graded treadmill test in women with DM2 without complications. In spite of this, in most studies adopting walking exercise for DM2 patients, intensity was either subjective [7,27,28] or based on $\%HR_{max}$ [8,11,29–31].

Although VT accessed in a graded exercise test can be expressed in both performance (i.e., power or velocity) and physiological (i.e., $\%VO_{2max}$ and $\%HR_{max}$) terms [24], heart rate (HR) at VT has been the preferred parameter for exercise prescription in clinical settings [20,26]. However, despite the increasing availability of portable monitors, continuous HR assessment during training sessions is not without limitations [32] and can be quite complex due to technical and learning reasons. Alternatively, intensity control by means of velocity in cyclic activities such as running and walking is very practical in field settings, where subjects are commonly aware about covering known distances in particular times. Yet, the effectiveness of training overground at VT velocities derived from treadmill tests in patients with DM2 remains to be investigated. Thus, the purposes of this study were to assess the effects of supervised overground walking training at ventilatory threshold velocity on HbA1c, blood glucose, body composition, physical fitness and lipid profile in type 2 diabetic women.

2. Materials and methods

2.1. *Subjects*

After approval by the São Carlos Federal University Ethics Committee for Human Research (no 034/04), 24 sedentary middle-aged women with DM2 diagnosis [33] were recruited from local health facilities and signed an informed consent volunteering to take part in this investigation. All of them were housewives, non-smokers and not engaged in regular exercise practice, with current physical activity <1 h/week. Patients were included in the study if their diabetes was treated by diet ($n = 5$) or oral agents (sulphonylurea, $n = 6$; metformin, $n = 3$; and sulphonylurea + metformin, $n = 10$), but not if they were treated with insulin given the tendency of an advanced disease state in this case. Absence of long term complications (retinopathy, microalbuminuria, nephropathy, peripheral and autonomic neuropathy) as well as blood pressure greater than 160/95 mmHg were confirmed by clinical history, clinical examination and laboratory tests. After a blinded randomization by means of computer-generated random numbers subjects were allocated in a control (CG) or a trained group (TG), each one with 12 volunteers. Five of the 24 women initially enrolled in the study were not able to conclude the experimental protocol (2 from CG and 3 from TG) due to family responsibilities ($n = 3$), thrombosis ($n = 1$) and spinal disc herniation ($n = 1$), being these last events not attributed to the study procedures. Therefore, our final sample was composed by 10 and 9 subjects in the CG and TG, respectively. No significant differences were found between groups for age (55.9 ± 2.2 vs 53.4 ± 2.3 years, $P = 0.48$), height (155.0 ± 1.6 vs 152.0 ± 2.4 cm, $P = 0.30$) and disease time (3.7 ± 0.8 vs 4.4 ± 1.2 years, $P = 0.71$).

2.2. *Experimental procedures*

Using a longitudinal approach, all patients were submitted to anthropometric measurements, a 12-h fasting blood sampling, dietary evaluation and a graded exercise test on a motorized treadmill at baseline and after a 12-week period. Exercise test (TG only) and dietary evaluation (TG and CG) were also performed at the 6th week. Subjects from the trained group were evaluated 48–72 h after the last training session in order to avoid residual influence of acute exercise.

2.3. *Anthropometry*

Height was accessed using a calibrated stadiometer (Filizzola®, Brazil), while body mass and body composition including percent body fat, fat and fat free mass, were determined using a bioelectric impedance system with the electrodes in contact with soles and heels of both feet (Tanita Body Composition Analyzer TBF-310) [34]. Measurements were performed in a quiet environment after a 12-h overnight fast, being the subjects in the standing position without shoes and using light clothes. Body mass index (BMI) was calculated as body mass divided by squared height (kg/m^2). Waist circumferences were taken at narrowest circumference between the lowest rib and the iliac crest by a single trained evaluator using an inextensible metallic tape (Sanny®, Brazil) placed directly on the skin, perpendicularly to the long axis of the body and horizontally to the floor at the end of normal expiration. For this purpose, subjects stood with feet together, looking straight ahead with the arms hanging by the side of the body [35]. Average values from two measurements were considered.

2.4. *Blood analysis*

Following anthropometrical measures, 4 mL blood samples were taken from subject's antecubital vein into tubes (Vacuette, Greiner Bio-One) with coagulation enhancer for posterior