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Glycemic reductions following water- and land-based exercise in patients with type 2 diabetes mellitus

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A B S T R A C T

Purpose: To assess the acute glucose responses to the first sessions of three mesocycles of water- and land-based aerobic exercise.
Methods: The water-based exercise group (WBE, n = 14; 54.1 ± 9.1 years) performed deep water walking and/or running, while the land-based exercise group (LBE, n = 11; 60.1 ± 7.3 years) performed walking and/or running on athletic track. In the first mesocycle, patients trained at 85–90% of their anaerobic threshold (AT) for 35 min, progressing to 90–95% of the AT in the second mesocycle, and 95–100% of the AT in the last mesocycle. Capillary glucose was assessed before and immediately after the first session of each mesocycle.
Results: There was glycemic reduction ($p < 0.001$) in all sessions, with relative reductions of 19%, 29% and 24% for the WBE and 24%, 29% and 27% for the LBE in the mesocycles 1, 2 and 3, respectively. There were no found differences between groups and between mesocycles.
Conclusions: The acute response of blood glucose to aerobic training between 85 and 100% of the heart rate of AT is effective and independent of the environment in which it is performed. Clinical trial reg. no. NCT01956357, clinicaltrials.gov.

1. Introduction

Most current treatments for type 2 diabetes involve physical activity and dietary modifications in addition to medical management, all of which are crucial for glycemic control [1] Structured and supervised training programs have been found to have a greater impact on glycemic control than general increases in physical activity alone [2]. Aerobic training is found to produce both acute and chronic benefits for these patients, including metabolic and cardiovascular beneficial effects, as well as higher quality of life and wellbeing [3–7]. It can be performed in different ways (cycling, running, walking, rowing, stepping and others), differing in terms of total recruited muscle mass, type of impact or energy expenditure, which may be of importance for patients with diabetes [8]. Few studies analyse the effects of different modes of aerobic exercise on glucose levels in type 2 diabetes. Running is one of the most studied modalities of aerobic exercise; however, the progression of training variables such as duration and intensity may expose patients to moderate to high impact forces on their musculoskeletal system. Importantly, as patients with diabetes are prone to chronic complications, including peripheral neuropathy that increases risk of foot lesions, it is important to find alternatives for the progression of training. Different environments where exercise training is performed could minimize injuries and ulcerations caused by the impact directly absorbed in the foot in contact with the ground.

List of abbreviations: WBE, water-based exercise; LBE, land-based exercise; MDRD-GFR, glomerular filtration rate using the modification of diet in renal disease formula; ECG, electrocardiogram; HR, heart rate.

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Alternative forms of exercises for patients with diabetes are those performed in water, where the impact forces can be attenuated, especially for the lower limbs [9]. Among the modalities of aerobic exercise performed in aquatic environment, water aerobics can be highlighted, as the ground reaction force can be reduced by up to 1.2 times the body weight [10]. Moreover, deep-water running is another interesting modality because the practitioners perform aerobic exercise at high loads with reduced risk of injury, as a float vest is used, keeping the body in an upright position, preventing contact between the feet and the bottom of the pool [11].

Some small studies have addressed the possible metabolic benefits of exercise performed in the aquatic environment, but the results were inconclusive, especially because of the quasi-experimental design of the study [12] and small sample of individuals evaluated [12,13]. Moreover, comparisons of exercise training glycemic effects in patients with type 2 as performed on land or in water, is a yet few discussed subject. Recently, a randomized clinical trial [14] demonstrated similar glucose control, by evaluating HbA1c levels, after aquatic or dry-land aerobic training in patients with type 2 diabetes. Despite of the clinical importance of this finding, to our knowledge, studies with similar design (water-versus land-based exercise) analyzing acute glycemic effects in this population have not been conducted.

Although long-term glycemic control is the primary goal of diabetes treatment [1], knowledge regarding the acute impact of exercise on glucose responses in this population is crucial in ensuring the safety and quality of exercise interventions, as chronic glucoregulatory benefit of exercise training is the result of the added effects of each bout of exercise [15]. However, studies with this objective often compare different sessions, differing in relation to the training variables in a particular state of trainability. This provides knowledge of the isolated impact of a session, in which the increased intensity, increased volume and the consequent change in the state of trainability can change the magnitude of glycemic reduction. Therefore, the present study aimed to analyze the acute glucose responses in the first sessions of three mesocycles of aerobic training periodization. Additionally, the present study aimed to analyze the acute glucose responses to aerobic training in water as compared to similar training performed on land. We hypothesized that the magnitude of glycemic reduction is maintained during a periodization with progression of intensity, that is, no differences would be observed among mesocycles. We hypothesized that the training in water would provide glycemic reductions similar to those derived from training on land.

2. Material and methods

2.1. Subjects

All participants were fully informed of the procedures involved in the study, and provided written consent prior to participation. The study was conducted in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans and was approved by the Research Ethics Committees of the Universidade Federal do Rio Grande do Sul (protocol number 108.997) and of the Hospital de Clínicas de Porto Alegre (protocol number 54475).

The sample consisted of 25 patients with type 2 diabetes (14 men) who had not undertaken any physical exercise in the previous three months and were receiving their usual medical treatment. Patients were identified from the records of the Endocrine Division of a tertiary hospital and also were recruited through advertisements in local newspapers between June and July 2012. They were randomly assigned to water-based (WBE; $n = 14$) or land-based exercise (LBE; $n = 11$), by picking an envelope with predefined group numbers, stratified according to gender. Patients with the following conditions were excluded from the sample: uncontrolled hypertension, autonomic neuropathy, severe peripheral neuropathy, proliferative diabetic retinopathy, severe nonproliferative diabetic retinopathy, decompensated heart failure, limb amputations, chronic renal failure (MDRD-GFR < 30 ml/min) [16] or any muscle or joint impairments which prevented individuals from engaging in physical exercise. The presence of these conditions was confirmed by medical history as well as clinical and laboratory examinations. All patients had undergone electrocardiogram (ECG) stress testing in the six months preceding the study.

2.2. Anthropometric measurements

Prior to the intervention, patients underwent anthropometric measurements at our exercise research laboratory. Body mass and height were assessed using a digital scale and a stadiometer (FILIZOLA; São Paulo, Brazil). These values were used to calculate patient body mass index (BMI) using the following formula: mass (kg)/height^2 (m). Waist circumference was measured at the midpoint between the iliac crest and the last rib.

2.3. Capillary glycemia

Capillary glycemia was assessed before and immediately after the first session of each training mesocycle using a clinical glucometer (Accu-Check Performa, Roche, São Paulo, Brazil), which assesses glycemic levels in approximately 5 s and an Accu-Chek – Multiclix lancet device (São Paulo, Brazil).

2.4. Intervention

Patients underwent 9-week training programs involving deep-water walking or running with a life vest (WBE group) or walking or running on an athletic track (LBE group). Both groups underwent interval-training programs consisting of a three-week adaptation period followed by three mesocycles of three weeks each. Training was conducted three times per week (Monday, Wednesday and Friday), and each 45-min session was divided into a warm-up period (5 min), followed by the main training program (35 min) and a cool down section (5 min). The intensity of the exercise prescribed was adjusted according to each subject heart rate deflection point, which was determined by progressive exercise tests conducted in the water [17] or on land [18] for the water- and land-based groups, respectively. This method was chosen due to its ease of application and association with the second ventilatory threshold in patients with type 2 diabetes [18], a precise indicator of the relative stress caused by exercise [19]. The HRDP was observed in the HR-by-intensity graph. The analysis were carried out by two independent, blinded, experienced exercise physiologists. Participants were asked to wear heart rate (HR) monitors (RSX 300, Polar) during exercise to control training intensity. Each individual was asked to read and report their HR to one of the three teachers who supervised the water- and land-based exercise sessions. Each teacher then used a table containing subjects' training HR ranges to provide feedback on the recommended exercise intensity for each patient. The 9-week training program prescribed to each participant is described in Table 1.

2.5. Statistical analysis

Patients' characteristics data are presented as mean and standard deviation or median and interquartil range (P25–P75) for continuous variables and by number of patients (n) for categorical variables. Baseline comparisons were performed using Student's t-