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Short Communication

Can an Aerobic Exercise Program Influence Sedentary Behavior and Moderate-Vigorous Physical Activity in Patients with Type 2 Diabetes?

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Keywords
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- Daily activity
- Accelerometer
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- Sedentary
- MVPA

Abstract

Exercise and physical activity are important components in both the management and treatment of type 2 diabetes. Exercise promotes multiple beneficial effects for diabetics; however, some studies have shown that when some individuals undergo an exercise program, this can cause behavioural compensatory responses. Therefore, we investigated whether an aerobic exercise program influences sedentary behavior (SB) and moderate-vigorous physical activity (MVPA) in type 2 diabetics. Eight volunteers (51.1±8.2 years; 4 men) underwent an exercise program (3 d.wk-1, 50–60% of VO2 peak, 30–60 min) for 8 weeks. SB and MVPA were measured by tri-axial accelerometers pre- and post-exercise intervention. Cardiorespiratory fitness, anthropometric assessment and body composition were measured at baseline and post-exercise intervention. Statistical analyses were performed using parametric tests (Paired t-test, p<0.05). We found there was no difference in SB and MVPA in type 2 diabetics, although there is a tendency to increase SB and decrease MVPA. We also did not find statistical differences between weekdays compared with weekend days for SB and MVPA. In summary, despite adequate to induce increases in cardiorespiratory fitness, has not caused statistically significant compensatory responses on SB and MVPA in patients with type 2 diabetes. However, there is a trend towards an increase on SB and reduction on MVPA. Further studies performed with a larger sample size and inclusion of a control group is warranted.

ABBREVIATIONS

SB: Sedentary Behavior; MVPA: Moderate-Vigorous Physical Activity; ADA: American Diabetes Association; BMI: Body Mass Index; HR: Heart Rate; Counts.Min-1: Counts Per Minute; Min.D-1: Average Daily Duration; VO_2: Oxygen Consumption; VO_2 Peak: Peak Oxygen Consumption; D.Wk-1: Days Per Week; $\overline{x}$: Means; SEM: Standard Error Of The Mean; WC: Waist Circumference; % Fat = Body Fat Percentage

INTRODUCTION

Exercise [1] and physical activity [2] are important components in both the management and treatment of type 2 diabetes. Exercise and physical activity are often used erroneously as synonyms by many health professionals although they have different definitions. Exercises refer to planned movements, structured and repetitive performed in order to improve or maintain one or more components of physical fitness [3]. Physical activity (also called "habitual physical activity" or "non-exercise activity") is defined as bodily movement produced by skeletal muscle contraction that causes increases in energy expenditure above resting levels [3].

Exercise promotes multiple beneficial effects for diabetics including improvements in insulin sensitivity, glucose homeostasis and increased energy expenditure [1]. Interestingly, some studies have shown that when some individuals undergo an exercise program, this can cause behavioural compensatory responses like reductions in non-exercise activity thereby increasing sedentary behaviour (SB) and decreasing moderate-vigorous physical activity (MVPA) [4,5].

High SB and low MVPA are directly related to increased risk of developing cardio metabolic diseases including diabetes [6-8]. Studies [9,10] investigating the contribution of SB and MVPA on cardio metabolic diseases such as diabetes have recently revealed that this is an important area for future research.

Thus, our aim was to investigate whether an aerobic exercise program influences SB and MVPA in type 2 diabetics.

MATERIALS AND METHODS

Participants

Twenty volunteers signed up for this study. Fifteen satisfied the inclusion criteria: a) Diagnosed with diabetes according to ADA criteria [11], b) Do not have diabetes complications (cardiovascular disease, neuropathy, retinopathy and nephropathy); c) Have not practiced exercises with professional guidance 2 months preceding the commencement of the aerobic exercise program; d) Agreed not to undertake exercise with professional guidance in addition to those performed in the study, and to maintain their usual diets throughout intervention period. Eleven participants started the study; however, after the first week one was excluded due to ulceration on feet and 2 others gave up for personal reasons. Final sample was composed by 8 participants (average age 51.1±8.2 years; 4 men) from the following professional areas: Housemaid, Technical Administrative and University Professor. All participants use metformin since diabetes diagnosis (5.1±4.6 years ago) [12] and only 3 used other medications (insulin and glimepiride). No participants reported changing their medication dose during intervention.

All participants received approval by their physician to practice moderate intensity exercise and signed an informed consent. Study was conducted in accordance with Helsinki Declaration regarding research involving human subjects and was approved by local Ethics Committee on Human Research (Reference No.041/2010).

Anthropometry and body composition assessment

Anthropometric measurements were obtained at laboratory by a trained examiner. Weight, height and waist circumference were measures by calibrated equipment according to Lohman and colleagues [13]. Body mass index (BMI) and waist circumference were calculated and analyzed in accordance with World Health Organization guidelines [14]. Body composition was assessed by Body Composition Analyser (BIA 310 bio impedance analyzer, Biodynamics Corp) [15].

Sedentary behavior and moderate-vigorous physical activity

SB and MVPA level were measured using a physical activity monitor (GT3X, ActiGraph TM, Pensacola, FL, USA) [16-18]. The monitor was fixed with an elastic belt around the hip on the right side of each participant for three consecutive days (two weekdays and one weekend day) [19], except during water-based activities or during sleep (at night) [20].

Data was recorded at 60-second intervals and analyzed using ActiLife 5.10.0 and Firmware 4.2.0 software (ActiGraph TM, Pensacola, FL, USA). Wear time validation was defined according to previous work [21, 22]. A day was considered as valid with at least 600 min (10h) of wear without excessive counts (>20,000 counts). At least one valid day (pre- and post-intervention) was required to be included in current analyses [22]. Time spent in activity ≤ 100 counts per minute (counts.min-1) was considered SB and time spent in 10-min bouts or more ≥ 760 counts.min-1 was considered MVPA [21,22]. Average daily duration (min.d-1) spent on SB and MVPA was estimated by averaged across valid days [22]. Data were adjusted based on 16 waking hours (6am-10pm). For intervention period, participants did not wear accelerometer on same days that they practiced exercise at Laboratory.

Cardio respiratory fitness

Cardiorespiratory fitness was measured using metabolic gas analyzer (VO2000, Medical Graphics Corporation) and analyzed using software Aerograph 4.3 (Medical Graphics Corporation). Metabolic gas analyzer was automatically calibrated before each test. Cardiorespiratory fitness tests were performed on a cycle ergometer (ISO1000, SCIFIT® Corporate Headquarters). All necessary precautions for performing cardiorespiratory fitness tests in diabetic patients (e.g. blood pressure measurement at rest and during testing, blood glucose) were taken pre- and post-testing.

Prior to cardio respiratory fitness tests, participants became acclimatized to cycle ergometer through a 5-minute warm-up (40% of VO2 peak). Participants underwent an individualized ramp protocol with increments by minute according to criteria established [23], until reaching 85% of maximal heart rate (HR) estimated by HR max = 208 – (age x 0.7) [24]. As no physician was present during the test, for safety reasons, we interrupted the cardiorespiratory fitness test when participants reached 85% of maximal HR, and started the recovery stage. Test data (HR and VO2) were used as basis for development of individual equations to estimate peak oxygen consumption (VO2 peak) by linear regression [25] (Sigma Plot® Version 11.0; Systat Software, Inc., Chicago, IL, USA).

Protocol

Exercise intervention was performed 3 days per week (d.wk-1) over 8 week at the laboratory using cycle ergometers (Cycle 167, 2001, ERGO-FIT®). Each exercise bout ranged from 30-60 minutes and intensity gradually increased from 50-60% of VO2 peak [26]. Each training bout was divided into three phases: 1) warm-up, 2) exercise bout and 3) cool-down. Warm-up and cool-down always lasted 5 minutes each.

Exercise intensity was based on VO2 peak (as per determined from the cardiorespiratory fitness test) and controlled by heart rate (HR) monitor (Polar® RS800CX, Finland). Participants were asked to maintain an average speed 20 km.h-1 during the exercise bout. Load (watts) on cycle ergometer was increased to achieve target HR during each exercise bout. If a participant showed peripheral fatigue (as determined by difficulty maintaining the required speed), cycle ergometer load was reduced and exercise speed was increased in order to maintain the required physiological load (HR).

We did not control participants' food intake, but they were asked to maintain their usual diet during exercise intervention. SB and MVPA were measured before and after exercise intervention.

Cardiorespiratory fitness, anthropometric assessment and body composition were measured pre- and post-exercise intervention.

Statistics

All variables passed the normality test (Shapiro–Wilk). Data was tested with parametric statistics. Data presented as means ± standard error of the mean (SEM). Results were analyzed using Paired t-test to compare all variables (SB; MVPA; Anthropometry and body composition and cardiorespiratory fitness) pre- and post-exercise intervention. Significance was accepted at $p<0.05$. Analyses were performed by software Sigma Plot® Version 11.0 (Systat Software, Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Average monitor wear time was of 1102 min.d-1 and 1067 min.d-1 pre- and post-exercise intervention, respectively. Therefore, all data showed were adjusted based on a 960 min.d-1 (16 hours) waking time.

We found no statistically significant differences on SB and MVPA in patients with type 2 diabetes undergoing aerobic exercise program (Figure 1), although there is a tendency to increase SB and decrease MVPA. We also did not find statistical differences between weekdays compared with weekend days for SB and MVPA (Figure 2), albeit there is a tendency to increase SB and decrease MVPA on weekend days. However, the intensity used during aerobic exercise program was adequate to promote improvements in cardiorespiratory fitness (p = 0.04) (Table 1).

Before intervention, the time spent on SB was 55% (154 min.d^{-1}) higher than time spent on MVPA. After intervention those differences increased to 76% (199 min.d-1) (Figure 1). Although these differences were not statistically significant, they may indicate a behavioral compensatory response to the exercise program [4,5]since after 8 weeks of exercise program patients showed a decrease in physical activity levels (21 min.d-1) and an increase in the SB (24 min.d-1).

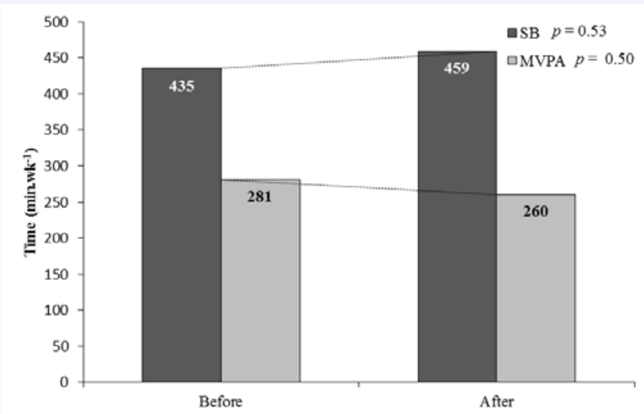

Figure 1 Sedentary behavior (SB) and moderate-vigorous physical activity (MVPA) of diabetic patients, before and after intervention. Dark gray bars represent time spent on SB per day (min.wk^{-1}). Light gray bars represent time spent on MVPA per day (min.wk^{-1}). Dashed line represents variation before and after intervention. Data are showed as mean ($\bar{x}$). Paired t-test, SB (p=0.53) and MVPA (p=0.50).

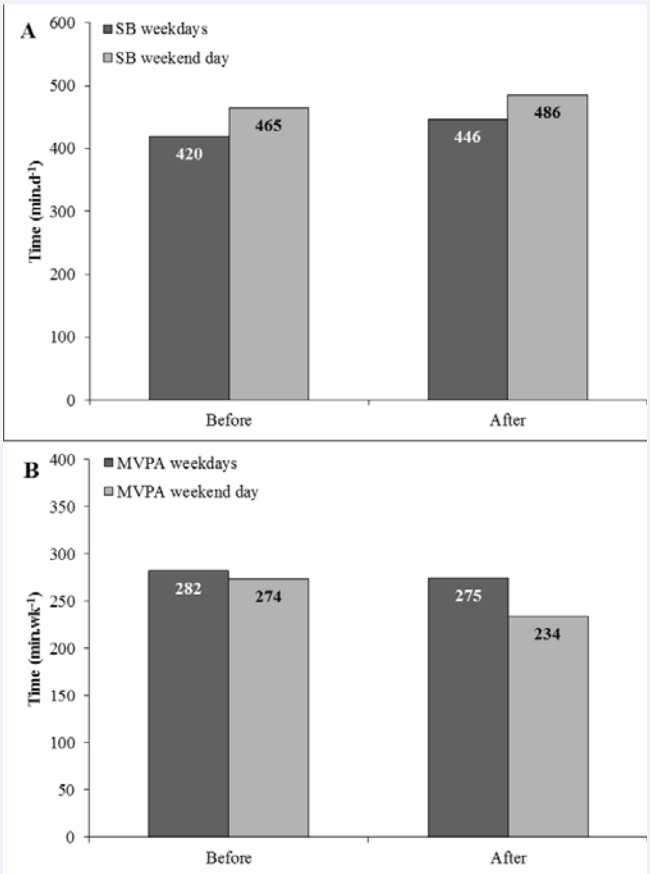

Figure 2 Sedentary behavior (SB) and moderate-vigorous physical activity (MVPA) of diabetic patients on weekdays vs. weekend days, before and after intervention.
Figure 2 shows comparison of time spent on SB (A) and MVPA (B) on the weekdays vs. weekend day before and after intervention. A) Dark gray bars represent time spent on SB per day on weekdays (min.d^{-1}) and light gray bars represent time spent on SB per day on weekend day (min.d^{-1}). B) Dark gray bars represent time spent on MVPA per day on weekdays (min.wk^{-1}) and light gray bars represent time spent on MVPA per day on weekend day (min.wk^{-1}). Data are showed as mean ($\bar{x}$).

Anthropometric measures, body composition did not differ significantly before and after intervention. Participants were classified as having obesity level-I by BMI and high body fat percentage (Table 1).

This study is the first to investigate whether an aerobic exercise program can influence SB and MVPA in type 2 diabetics. We found that the exercise program used in this study did not cause statistically significant changes on SB and MVPA in patients. However, our results show a trend towards an increase on SB and reduction on MVPA (Figure 1 and 2), as indicated by previous studies by King et al [4,5].

Recent studies investigated whether subjects undergoing an exercise program could present changes in physical activity levels, concluded that there was no statistically significant change [9, 27]; despite a tendency to increase SB and decreasing physical activity [27].

Our results demonstrate that diabetic patients present MVPA

Table 1: Anthropometric measures, body composition and VO_2 peak of subjects before (n = 8) and after (n = 8) intervention.

	Before	**After**	
Variables	$\bar{x}$ ±SEM	$\bar{x}$ ± SEM	p-values
Weight (kg)	83.7 ± 6.0	83.2 ± 6.2	0.19
BMI (kg.m^{-2})	30.2 ± 2.2	29.8 ± 2.2	0.06
WC (cm)	102.6 ± 4.3	97.5 ± 7.1	0.31
% Fat	33.4 ± 2.2	32.4 ± 2.0	0.24
VO2 Peak (ml.kg.min^{-1})	25.7 ± 1.8	29.5 ± 2.3	0.04

Abbreviations: BMI = Body Mass Index; WC = Waist circumference; % Fat = Body fat percentage. Data are showed as mean ($\bar{x}$) ± Standard error of the means (SEM).

almost two times higher than the recommendations of 150 min. wk^{-1} for exercise [28]. They spent 280 and 260 min.wk-1 on MVPA before and after intervention, respectively. Our results are similar to those reported by Gennuso et al [22] in older active adults showing MPVA levels of 322 min.wk-1. Noteworthy, for additional health benefits it is recommended the increase of 300 minutes per week of moderate-intensity aerobic physical activity [29].

Despite these recommendations diabetic patients in our study continued to show high rates of SB in their wake time both before and after the intervention. Our data highlights that people with type 2 diabetes need to incorporate more activities into their daily routine. This will not only boost physical activity levels but enhance muscle contraction and increase daily energy expenditure, which may improve glycaemic control and assist in weight loss [1,26].

Exercise efficacy is well established [1], but can also induce behavioural changes [4,5]. Our results allow us to speculate that it is not enough to just exercise in order to decrease SB time. Instead it should be recommended that incorporating more physical activities into a person's daily routine in addition to routine exercise may present a greater potential public health message. Overall this will allow for a greater positive change in behaviour and may cause further reductions in SB levels. Further studies investigating whether MVPA almost twice the weekly recommendations (ie ~300 min.wk^{-1} for exercise) would be protective against SB are warranted. These studies may provide important clues about the effect of MVPA on SB levels and whether the current recommendations should be increased in order to protect against SB and associated cardio metabolic diseases like type 2 diabetes.

In the meantime, both SB and MVPA may have been influenced by patients' work, since they had the following professions: Housemaid, Technical Administrative and University Professor. Recent studies [30, 31] have shown the employment type strongly influences SB.

Thus, the necessity for adopting a physically active lifestyle (eg, daily activities, leisure, work, domestic work and activities related to transport) combined with a reduction in SB in patients with type 2 diabetes is evident. Especially given high SB levels are directly related to increased risk of developing cardio metabolic diseases, including diabetes [6-8].

Our study has several limitations. Extrapolation of results and statistical power of the data were limited by the sample size. This problem arose due to inherent difficulties finding volunteers with type 2 diabetes without microvascular diseases, or other complications, who were able to participate in a controlled exercise program for 8 weeks. In addition, we also agree that the presence of a control group could increase the study internal validity. Participants' food intake was not controlled and we are aware that this can have great impact on glucose control. Nonetheless, we did ask participants to maintain their usual diet during exercise intervention. We believe this aspect of the study did not affect our main objectives, which was to study behaviors in people with type 2 diabetes following an exercise program.

CONCLUSION

We conclude that aerobic exercise program used in this introductory study, despite adequate to induce increases in cardiorespiratory fitness, has not caused statistically significant compensatory responses on SB and MVPA in patients with type 2 diabetes. However, there is a trend towards an increase on SB and reduction on MVPA.

Further studies performed with a larger sample size and inclusion of a control group is warranted. These studies will provide a better understanding on the compensatory responses of an exercise program on SB and MVPA in diabetic patients.

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