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Research article

Effects of High-Intensity Interval and Moderate-Intensity Continuous Exercise on Physical Activity and Sedentary Behavior Levels in Inactive Obese Males: A Cross-over Trial

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Abstract
A total of 17 participants (30.2 ± 4.8 years; 35.4 ± 4 kg/m^2; 38.2 ± 3.6 % body fat) were enrolled in this randomized crossover trial to analyze the effects of a single session of high-intensity interval (HIIE) and moderate-intensity continuous exercise (MICE) on the physical activity and sedentary behavior levels in inactive obese males. The participants performed two exercise sessions and one control session (no exercise): i) low-volume HIIE (10 x 60 s at 90% of maximal aerobic velocity [MAV] interspaced by 60 s at 30% of MAV); ii) MICE (20 min at 70% of maximum heart rate); and iii) control (25 min in a seated position). After all sessions, the physical activity and sedentary behavior levels were monitored by accelerometer over seven consecutive days. No differences in the physical activity (activity counts, and time spent at light, moderate, and vigorous intensities) and sedentary behavior (time spent at sedentary behavior, breaks, and bouts) levels were found among the sessions (HIIE, MICE and control) ($p > 0.05$). In summary, a single session of HIIE and MICE does not change the physical activity and sedentary behavior levels in inactive obese males. Therefore, low-volume of both high- and moderate-intensity exercise should be considered for inactive obese males given that it does not reduce the physical activity level or increase the time spent at sedentary behavior.

Key words Aerobic exercise, high-intensity interval training, sedentary lifestyle, obesity, accelerometer.

Introduction

Obesity is a multifactorial condition that increases the risk for several chronic diseases (Hruby and Hu, 2015; Who, 2014). A total of 58% of the worldwide adult population will be overweight in 2030 and 20% will be obese (Kelly et al. 2008). The main causes of obesity are an energy imbalance between calories consumed and calories used, or a lack of physical activity sufficient to compensate for the consumed calories (Hruby and Hu, 2015; WHO, 2010; Casazza et al., 2013). Around 31% of adults aged 15 and over are insufficiently active worldwide (Hallal et al., 2012).

Approaches to prevent and treat obesity include performing physical exercise in addition to habitual physical activity and reducing time spent in sedentary behavior (Innerd et al., 2018). In this context, different physical exercise training protocols have been applied to increase adherence to exercise in obese individuals, including high-intensity interval exercise (HIIE). Systematic reviews and meta-analyses have shown that HIIE improves cardiometabolic risk factors in overweight/obese people (Batacan et al., 2017; Weston et al., 2014). Despite the HIIE protocol being effective to improve health-related fitness in obese/overweight people, it is suggested that the sudden increase in the amount of physical exercise will be compensated by a reduction in habitual physical activity levels and by an increase in time spent in sedentary behavior in order to preserve an individual's set point (Thivel et al., 2014; Fedewa et al., 2017). Thus, this compensatory effect could result in negative health-related outcomes, since a single physical exercise training session does not seem to eliminate the impairment of prolonged and excessive sedentary behavior (i.e. ≥ 13 h) on cardiometabolic health (Duvivier et al., 2013).

Although there are guidelines in the literature about the exercise prescription for obese individuals according to the FITT (Frequency, Intensity, Time, Type) principle, the intensity that should be recommended for weight loss remains unclear, as well as the compensatory effect promoted by different exercise intensities (e.g. light, moderate, and vigorous). In overweight adolescent boys, a single session of HIIE and MICE increases sedentary behavior and decreases habitual physical activity compared to a control condition, without a difference between HIIE and MICE (Paravidino et al., 2017). In adults, Alahmadi et al. (2011) found no compensatory effect on the habitual physical activity after a HIIE and MICE session in overweight and obese males three days pre- and post-session, while Nugent et al. (2018) demonstrated a decrease in sedentary behavior time and an increase in physical activity level for three days after HIIE and MICE intervention (two weeks of) in adults with pre-diabetes, without difference between sessions. Despite these interesting results, to the best of our knowledge there is no data about the effect of a single low-volume HIIE and MICE sessions on habitual physical activity and sedentary behavior levels throughout 7 days after these exercise sessions in inactive obese males. This amount of time is necessary for better describing the habitual physical

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activity and sedentary behavior levels after a traditional exercise prescription (MICE) and an alternative exercise prescription approach (HIIE) for obese individuals.

Previously, we have demonstrated that both MICE and HIIE elicits a mild muscle damage and delayed onset muscle soreness and no acute phase inflammation in inactive overweight/obese individuals (Farias-Junior et al., 2019a; 2019b; Souza et al., 2018) up to 48 hours post-exercise. This, in turn, could generate a similar impact of MICE and HIIE on the habitual physical activity and sedentary behavior levels in this population. Therefore, the aim of this study was to analyze the effects of a single low-volume HIIE and MICE session on the habitual physical activity and sedentary behavior levels in inactive obese males. It was hypothesized that the inactive obese males would decrease their habitual physical activity levels and increase their sedentary behavior levels similarly following a single low-volume HIIE and MICE sessions compared to a day without exercise.

Methods

Trial design

This is a randomized controlled crossover trial conducted to analyze the effects of a single low-volume HIIE and MICE session on the habitual physical activity and sedentary behavior levels in obese males. The CONSORT guideline was followed (Boutron et al., 2017). The study was conducted from September 2016 to August 2017 in the Department of Physical Education, Federal University of Rio Grande do Norte, Natal, Brazil. The protocol of this study was in accordance with the Declaration of Helsinki and was approved by the Institutional Ethics Committee (Protocol: 976.389/2015) and registered as clinical trials (ReBEC: RBR-62kr6f).

Sample size

An a priori statistical power was conducted considering an increase in time spent in sedentary behavior following both exercise sessions compared to the control session, an estimated effect size of 16.5% for a time by condition interaction effect (Paravidino et al., 2017), a statistical power 1–β of 80% and an alpha of 5%. The minimum sample size required for the study was 16 participants. Considering a dropout rate of 25%, we recruited a total of 20 participants (G*Power software, version 3.1.9.2).

Participants

Thirty-two obese males were initially recruited from the invitation disclosed in university settings, e-mails and online social networks in the city of Natal, Brazil, however only 20 met the inclusion criteria. A total of 17 individuals completed the study (Figure 1). Inclusion criteria were: i) men aged 18 to 35 years; ii) body mass index (BMI) above of 30 m/kg² and body fat above of 25%, with stability of body mass in the last six months; iii) being physically inactive (perform < 150 min/wk of moderate physical activity or < 75 min/wk of vigorous physical activity) (Garber et al., 2011); iv) being apparently healthy according to the Physical Activity Readiness Questionnaire. BMI was calculated as weight (kg) divided by the square height in meters (m^2) and nutritional status was classified according to World Health Organization criteria (1995). Body fat (%) and fat free-mass (kg) were measured using double-energy X-ray absorptiometry (GE, Medical Systems, USA).

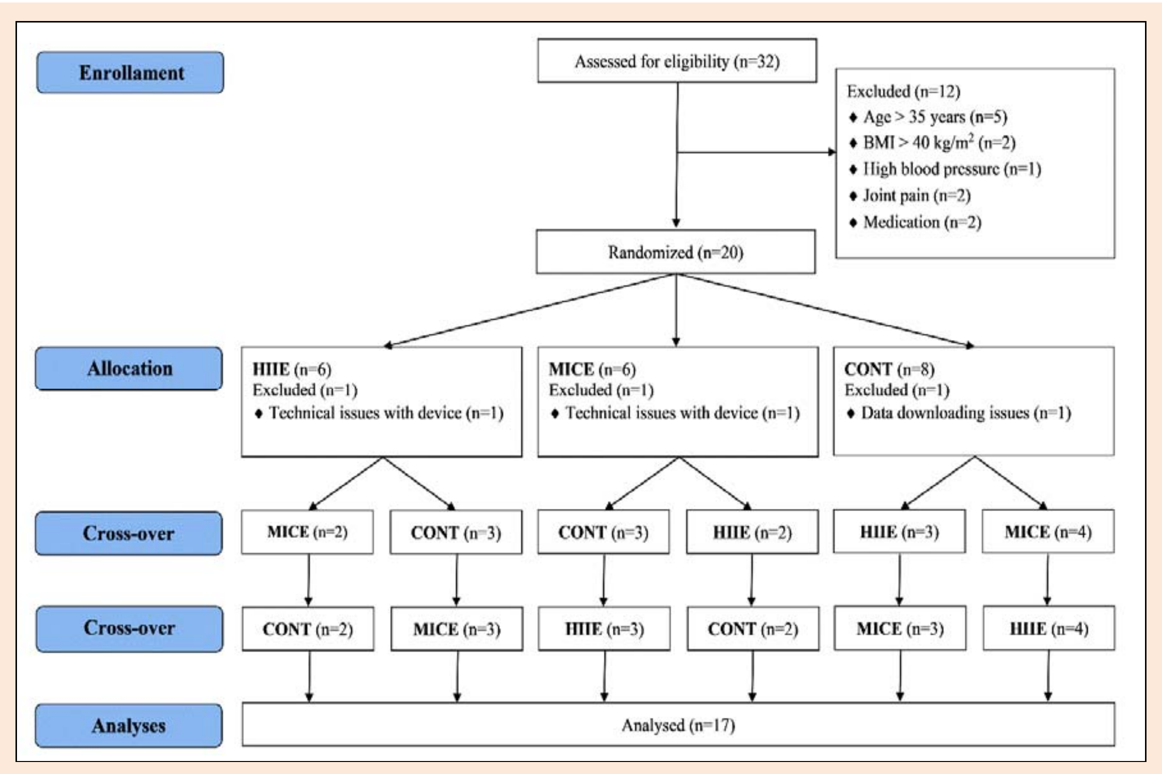

Figure 1. Study flow diagram.

Exclusion criteria used were: i) smokers; ii) patients with overt hypothyroidism, diabetes mellitus, hypertensive, anemic, active infection, cancer or any contraindications to exercise; and iii) participants who began the study but did not complete any one of the experimental sessions or did not remain with the accelerometer for at least 10 hours per day during at least 4 days per week, including 1 day on the weekend were excluded from the study.

Procedures

The participants were initially screened using the Physical Activity Readiness Questionnaire and then completed the short-version International Physical Activity Questionnaire to assess their physical activity level (Matsudo et al., 2012). The participants subsequently performed a maximal graded exercise test on a treadmill. At the end of the maximal graded exercise test, the exercise and control sessions were randomly scheduled with a one-week interval between each one. A computer-based simple randomization (www.graphpad.com) was used to determine the order of the exercise and control sessions. Due to logistics, only the participants were blinded for the order of the sessions. Participants were asked to avoid moderate-vigorous physical activity, caffeinated products, and alcohol consumption, as well as to maintain a good sleeping pattern 24 h before the maximal graded exercise test and experimental sessions. All procedures were performed in the morning (between 8:00-11:00 a.m.) in a quiet and temperature controlled room (23-25°C). Physical activity and sedentary behaviors were monitored during seven consecutive days after the end of the exercise and control sessions.

Maximal graded exercise test

Participants performed a warm-up on a treadmill (RT250, Movement®, Brazil) at 2.0 km/h during three minutes and then they started the protocol maximal graded exercise test at 3.0 km/h and increments of 1.0 km/h every minute until voluntary exhaustion. The MAV was considered as the highest velocity sustained by a full stage of one minute (Frazão et al., 2016). Heart rate (HR) was monitored during the test using a HR monitor (Polar®, RS800CX, Finland). The highest HR value observed during the test was considered as the maximum HR (HR_{max}). Rating of perceived exertion (RPE) was also monitored during the test and recorded at the end of each minute using the Borg scale 6-20 (20). The end of the test was determined by the presence of at least one of the following criteria: i) HR_{max} > 95% of estimated for age (i.e. 220 - age); ii) RPE > 17 or; iii) when participants voluntarily stopped. After the maximal test, the participants rested for 10 min and then they performed a supramaximal verification test to confirm the previously reached HR_{max}. Participants performed 2 min at 50% of MAV, 1 min at 70% of MAV, and afterward exercised until volitional exhaustion at a standard supramaximal velocity (i.e. MAV + 1 km/h) (Midgley and Carroll 2009). HR_{max} was considered to have been reached when the difference between HR achieved during the maximal exercise test and the supramaximal verification test was less or equal to 4 beats/min (Midgley and Carroll, 2009).

Exercise and control sessions

The HIIE session consisted of 10 work bouts of 1 min at 90% of MAV reached in the maximal graded exercise test interspersed by 1 min of active recovery at 30% of MAV (i.e. slow walking), according to previous studies (Frazão et al., 2016; Fayh et al. 2018; Souza et al., 2018) and considered as low volume HIIE (Gibala et al. 2012). The MICE session consisted of 20 min at 65-75% of HR_{max}. Both exercise sessions lasted 25 min, including a warm-up at 4 km/h for three minutes and a cool-down at 4 km/h for two minutes. HR was continuously recorded throughout the exercise sessions (Polar®, RS800CX, Finland). In addition, whole-body RPE was assessed using the RPE 6-20 Borg scale (Borg, 1998) during the last 10 s of each minute during both exercise sessions. In order to describe the exercise intensity, approximately 25 µL of blood from the tip of the individual's finger was collected immediately after both exercise sessions and analyzed in a portable monitor for determining blood lactate (Accutrend Plus®, Roche, Switzerland). In the control session, participants remained in a seated position for 25 min and they were allowed to read and use electronic devices such as a tablet, computer or smartphone.

Physical activity and sedentary behavior level measurements

Physical activity and sedentary behavior levels were evaluated by wearing a tri-axial accelerometry device (Actigraph GT9X Link, Pensecalo, USA). The device was fixed on the volunteer's body immediately after each experimental session. The epoch interval for the ActiGraph monitor was set at 1 min, and the output was expressed as activity counts/min, as recommended by Martins et al. (2016). The participants were advised to use the accelerometer attached to an elastic belt positioned on their right hip (anterior iliac crest) which was placed on the same day of the week and time of day for all sessions; the device was not removed during this period, except while bathing and during water activities. The participants used a diary to register the procedures of wearing and taking off the device. The following criteria were adopted for data analysis (Martins et al., 2016; Trost et al., 2011): (i) Average accumulated from at least 10 hours of use per day during at least 4 days per week, including 1 day on the weekend was considered; (ii) The data were considered valid from the time it was placed after the sessions until the seven days following; (iii) The criteria used to define the non-wearing time was 60 consecutive minutes of zero counts. The following cut-off points were adopted to determine the physical activity scores of activity counts/min (Tudor-Locke et al., 2010): 100-2,019 (light intensity); 2,020-5,999 (moderate intensity); and > 5,999 (vigorous intensity). A pragmatic cut-off of <100 counts/min was used to define sedentary behavior (Matthews et al., 2008), which typically includes activities such as sitting or working quietly (e.g., reading, typing). Each minute that the accelerometer counts were <100 was considered sedentary time; total sedentary time was the sum of sedentary minutes while the accelerometer was worn. A break was considered as an interruption in sedentary time (minimum 1 min) in which the accelerometer count rose up to or above 100 counts/min. Although the activities that produce accelerometer counts per minute of at least 100 are likely to be different for each individual, they may include activities as light in intensity as standing from a sitting position or walking a step. Mean intensity (reported as accelerometer counts/min) and duration of the breaks were also reported (Healy et al., 2008). The following variables were considered to analyze physical activity level: activity counts, steps, and time spent at light, moderate and vigorous intensities; while the following variables were considered for sedentary behavior analysis: time, breaks and sedentary bouts. Wear time was considered for data analyses. The data were analyzed using ActiLife software version 6.13.3.2.

Statistical analysis

Intention-to-treat analysis was followed in this study. Data normality was verified using the Shapiro-Wilk test. Paired t-test was used to compare the $\%HR_{max}$, RPE and blood lactate between exercise sessions. A generalized linear model was used to assess the effect of condition on the weighted average values of seven days for the variables of physical activity and sedentary behavior. A generalized estimating equation model was used to assess the interaction effects of time by condition, effect of time and effect of condition on the variables of physical activity and sedentary behavior. The normality of the model residuals was verified by normal Q-Q plot. The probability distribution for each model was based on the goodness of fit. Cohen's d_z was used to determine the effect size (ES) of the mean difference. Hopkins's criteria were implemented to interpret the magnitude of the ES, as follows: <0.2 is trivial, 0.2-0.5 is small, 0.6-1.1 is moderate, 1.2-1.9 is large, and 2.0-4.0 is very large. The adopted significance level was $p < 0.05$. Data are expressed as mean ± standard deviation (SD). All analyses were performed using the SPSS for Windows/v.25.0 (Statistical Package for Social Sciences Chicago, IL, USA).

Results

Table 1 shows the characteristics of the participants. Participants showed very low moderate and vigorous physical activity levels, and a high amount of time spent in a sitting position.

As expected, mean intensity of the HIIE session was higher than the MICE session (83.7 ± 6 vs. 70.5 ± 2 % HR_{max}, $p < 0.001$). In the HIIE, the intensity during the intervals was 89.1 ± 3.2 % HR_{max}, while it was 78.1 ± 4.6 % HR_{max} during the recovery periods. The mean RPE was also higher in the HIIE session compared to the MICE session (12.4 ± 1.8 vs. 11.2 ± 1.2, $p = 0.001$). In the HIIE, RPE during the intervals and recovery periods were 13.7 ± 1.7 and 11.2 ± 2.3, respectively. The blood lactate level was higher post-HIIE compared to post-MICE (11.7 ± 2.6 vs. 4.5 ± 1.1 mmol/L, $p < 0.001$).

The mean time of non-wear of the control session was 9.6 h, the HIIE session was 10.6 h, and the MICE session was 10.8 h, without significant differences between sessions ($p > 0.05$). Table 2 shows the results of the physical activity level in minutes over seven days following control and exercise sessions. There was an interaction effect of time by condition for activity counts and vigorous physical activity ($p < 0.05$). However, post hoc analysis demonstrated only between-condition difference on the activity counts in the first day after the sessions (HIIE: vs. control, 348.2 ± 106.5 vs. 246.9 ± 138.5 counts/day, $p = 0.017$; ES = 2.05, large ES). Moreover, there was no interaction effect of time by condition for light and moderate physical activity ($p > 0.05$).

Table 3 shows the results of the sedentary behavior level level over seven days following control and exercise sessions. There was an interaction effect of time by condition for sedentary time ($p < 0.05$), but post hoc analysis found only a trend for significance in the difference between HIIE and control session in the first day (HIIE vs. control, 500.5 ± 92.6 vs. 551.8 ± 71.3 min/day, $p = 0.070$; ES = 0.41, small ES). There was no interaction effect of time by condition for breaks and bouts ($p > 0.05$).

Table 4 and Figure 2 shows the results of percentage of time spent in sedentary behavior and physical activity over seven days following control and exercise sessions. There was an interaction effect of time by condition for light, moderate and vigorous physical activity ($p < 0.05$), and a trend for significance in the sedentary behavior ($p = 0.073$). Post hoc analysis found no between-condition differences ($p > 0.05$).

Table 1. Characteristics of the participants (n = 17).

Variables	Mean ± SD	(Minimum – Maximum)
Age, years	30.2 ± 4.8	(25 – 41)
Weight, kg	109.4 ± 14.7	(86.6 – 137.4)
Height, m	1.75 ± 0.1	(1.65 – 1.93)
Body mass index, kg/m^2	35.4 ± 4	(30.6 – 45.9)
Body fat, %	38.2 ± 3.6	(30.1 – 43.4)
Resting heart rate, bpm	74.9 ± 7.3	(65 – 90)
Maximal heart rate, bpm	193 ± 11.7	(179 – 213)
Maximal treadmill velocity, km/h	12 ± 1.3	(10 – 14)
Physical activity level		
Moderate, min/wk	12.2 ± 14.2	(0 – 40)
Vigorous, min/wk	0	0
Time sitting week, h/day	10.3 ± 3.2	(1 – 15)
Time sitting weekend, h/day	10.8 ± 2.6	(6 – 16)

Values are expressed in mean ± standard deviation (SD).

Table 2. Physical activity level over seven days following control and exercise sessions in inactive obese males (n = 17).

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	P[1]	P[2]	P[3]
					Counts, min					
Control	246.9 ± 138.5	215.1 ± 118.3	215 ± 150.5	187 ± 126.6	241.9 ± 154.2	176.7 ± 96.5	245.1 ± 133.9	0.002	<0.001	0.876
MICE	316.7 ± 116.4	258.2 ± 179.4	171.1 ± 52	227.9 ± 92.5	232.2 ± 104.7	201.6 ± 95	229.5 ± 126.8			
HIIE	348.2 ± 106.5[a]	217.3 ± 123.3	193.5 ± 91.9	202.5 ± 116.9	209.3 ± 68.9	225.7 ± 95.6	183.6 ± 90.7			
					Light, min					
Control	241.9 ± 71.4	304.8 ± 118.1	274.4 ± 117.8	249.9 ± 72.1	294.3 ± 90.7	251.9 ± 109.6	273.8 ± 102.6	0.227	<0.001	0.727
MICE	235.6 ± 77.5	315.8 ± 90.9	292.2 ± 68.2	307.6 ± 113.8	296 ± 134.4	290.8 ± 116.5	287.4 ± 93.8			
HIIE	250.6 ± 80.1	300.8 ± 127.2	256.2 ± 69.4	296.7 ± 98.4	293.2 ± 117.9	219.3 ± 120.1	258.1 ± 121			
					Moderate, min					
Control	20.3 ± 20.9	20.2 ± 18.4	20.6 ± 24.8	14.8 ± 22.4	21.4 ± 19	16 ± 17.8	27.5 ± 20.9	0.076	0.043	0.928
MICE	27.3 ± 16.2	19.6 ± 22.3	13.4 ± 10	18.9 ± 16.6	26.8 ± 27.5	19.1 ± 18.6	16.2 ± 14.6			
HIIE	28.6 ± 14.9	18.4 ± 22.8	13.5 ± 14.8	15.1 ± 13.8	16.3 ± 13.5	20.9 ± 18.2	19.2 ± 18.7			
					Vigorous, min					
Control	1.1 ± 4.5	0.3 ± 0.8	0.2 ± 0.8	0.3 ± 1	1.4 ± 5.2	0.1 ± 0.5	0.2 ± 0.4	<0.001	<0.001	0.562
MICE	1.3 ± 4.5	0 ± 0	0.1 ± 0.5	1.4 ± 3.3	0.5 ± 1.9	0.4 ± 0.8	0.6 ± 1.9			
HIIE	3.8 ± 5.4	0.6 ± 2.1	0 ± 0	0.1 ± 0.5	0 ± 0	0 ± 0	0.1 ± 0.3			

Values are expressed in mean ± standard deviation. HIIE, high-intensity interval exercise; MICE, moderate-intensity continuous exercise. (a) Significantly different from control session at same time point ($p < 0.05$). [1] Results of generalized estimating equation model used to assess the interaction effect of time by condition. [2] Results of generalized estimating equation model used to assess the effect of time. [3] Results of generalized estimating equation model used to assess the effect of condition.

Table 3. Sedentary behavior level over seven days following control and exercise sessions in inactive obese males (n = 17).

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	P[1]	P[2]	P[3]
					Time, min					
Control	551.8 ± 71.3	765.9 ± 227.5	748.4 ± 293	772.6 ± 300.6	747.4 ± 249.8	785.9 ± 212.6	792.2 ± 304	0.016	<0.001	0.791
MICE	513.3 ± 81.5	705.4 ± 266.6	813.1 ± 277.9	698.1 ± 293.8	737.1 ± 319.8	722.3 ± 216.7	728.2 ± 323.4			
HIIE	500.5 ± 92.6	837.5 ± 282.6	785.6 ± 317.1	822.3 ± 296	702.1 ± 292.4	758.4 ± 245.2	889.1 ± 246.7			
					Breaks, transitions					
Control	16.1 ± 4.2	21.5 ± 7.7	20 ± 7.7	21.3 ± 9.3	20.3 ± 6.4	22.1 ± 7.5	21 ± 10.2	0.497	<0.001	0.616
MICE	14.4 ± 4.1	20.3 ± 8.3	22.2 ± 6.2	20.6 ± 11.2	19.7 ± 9.2	19.9 ± 7.6	18.1 ± 8			
HIIE	15.1 ± 4.1	22 ± 7.3	22 ± 7.4	23.6 ± 9.5	19.2 ± 8.1	23.2 ± 8.3	24.5 ± 9			
					Bouts, unit					
Control	16.6 ± 4.3	21.4 ± 8.2	19.8 ± 8.3	20.9 ± 9.7	19.9 ± 6.8	22.1 ± 7.6	21.3 ± 10.3	0.455	<0.001	0.575
MICE	14.8 ± 4.2	19.9 ± 8.6	21.9 ± 6.5	20.1 ± 11.6	19.1 ± 9.3	19.5 ± 7.7	18.2 ± 8.2			
HIIE	15.5 ± 4.3	21.9 ± 7.4	21.8 ± 8.1	23.6 ± 9.9	18.9 ± 8.5	23 ± 8.7	25 ± 9.3			

Values are expressed in mean ± standard deviation. HIIE, high-intensity interval exercise; MICE, moderate-intensity continuous exercise. [1] Results of generalized estimating equation model used to assess the interaction effect of time by condition. [2] Results of generalized estimating equation model used to assess the effect of time. [3] Results of generalized estimating equation model used to assess the effect of condition.

Table 4. Percentage of time spent in sedentary behavior and physical activity over seven days following control and exercise sessions in inactive obese males (n = 17).

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	P[1]	P[2]	P[3]
					Sedentary, % time					
Control	68 ± 8.4	69.6 ± 11.8	70.7 ± 11	72.9 ± 10.4	69.2 ± 8.2	74.2 ± 10.9	70.7 ± 12.2	0.073	0.001	0.524
MICE	65.4 ± 9.3	66.3 ± 13.4	71.4 ± 7.7	66.1 ± 12.8	67.8 ± 12	69.7 ± 9.2	67.7 ± 15			
HIIE	63.9 ± 8.6	71.1 ± 12.6	72.2 ± 9.8	70.8 ± 13.5	68 ± 11.8	68.5 ± 9.8	76 ± 8.2			
					Light, % time					
Control	29.4 ± 7.6	28.4 ± 10.7	27.1 ± 9.3	25.5 ± 8.5	28.2 ± 6.4	24.3 ± 9.8	26.4 ± 10.7	0.038	0.025	0.535
MICE	29.8 ± 9.6	31.6 ± 11.6	27.3 ± 7.4	31.7 ± 12.9	29.4 ± 11.5	28.3 ± 9.3	30.5 ± 14.5			
HIIE	32 ± 9.4	27.1 ± 12.3	26.3 ± 9.1	27.9 ± 12.5	30.4 ± 11.7	29.5 ± 9.3	22 ± 7.8			
					Moderate, % time					
Control	2.5 ± 2.5	2 ± 2	2.2 ± 3	1.6 ± 2.5	2.5 ± 2.6	1.5 ± 1.6	2.9 ± 2.3	0.006	<0.001	0.884
MICE	3.5 ± 2.3	2.2 ± 2.6	1.3 ± 0.9	2 ± 2.1	2.7 ± 2.6	2 ± 2.1	1.7 ± 1.7			
HIIE	3.7 ± 2	1.8 ± 2.4	1.5 ± 2	1.4 ± 1.3	1.6 ± 1.2	2 ± 1.9	2 ± 2.3			
					Vigorous, % time					
Control	0.1 ± 0.5	0 ± 0.1	0 ± 0.1	0 ± 0.1	0.2 ± 0.7	0 ± 0.1	0 ± 0	<0.001	<0.001	0.677
MICE	0.1 ± 0.5	0 ± 0	0 ± 0.1	0.1 ± 0.2	0.1 ± 0.2	0 ± 0.1	0.1 ± 0.2			
HIIE	0.5 ± 0.7	0.1 ± 0.2	0 ± 0	0 ± 0.1	0 ± 0	0 ± 0	0 ± 0			

Values are expressed in mean ± standard deviation. HIIE, high-intensity interval exercise; MICE, moderate-intensity continuous exercise. (a) Significantly different from control session at same time point ($p < 0.05$). [1] Results of generalized estimating equation model used to assess the interaction effect of time by condition. [2] Results of generalized estimating equation model used to assess the effect of time. [3] Results of generalized estimating equation model used to assess the effect of condition.

Table 5. Weighted average of physical activity and sedentary behavior levels over seven days following control and exercise sessions in obese males (n = 17).

	Control	MICE	HIIE	P[1]
		Physical activity		
Counts, min	4068 ± 944.7	4539.2 ± 926.7	4257.9 ± 1057.6	0.347
Light, min	267 ± 71.9	284.1 ± 65.4	275 ± 86.3	0.784
Moderate, min	19.9 ± 12.6	23 ± 17	19.3 ± 12.2	0.713
Vigorous, min	0.5 ± 1.6	0.7 ± 1.5	0.7 ± 1	0.797
		Sedentary behavior		
Time, min	716.6 ± 216.3	690.3 ± 228.4	755.5 ± 218	0.669
Breaks, transitions	19.9 ± 6.2	19 ± 6	21.2 ± 5.5	0.508
Bouts, unit	19.8 ± 6.6	18.8 ± 6.2	21.2 ± 5.7	0.469
		% time		
Sedentary	69.8 ± 7.5	67.9 ± 8.6	70.4 ± 8.4	0.851
Light	27.1 ± 6.8	29.5 ± 8.9	27.5 ± 8.3	0.657
Moderate	2.1 ± 1.5	2.5 ± 2	2.1 ± 1.5	0.660
Vigorous	0.1 ± 0.2	0.1 ± 0.1	0.1 ± 0.1	0.806

HIIE, high-intensity interval exercise; MICE, moderate-intensity continuous exercise.[1]Results of generalized linear model used to assess the effect of condition.

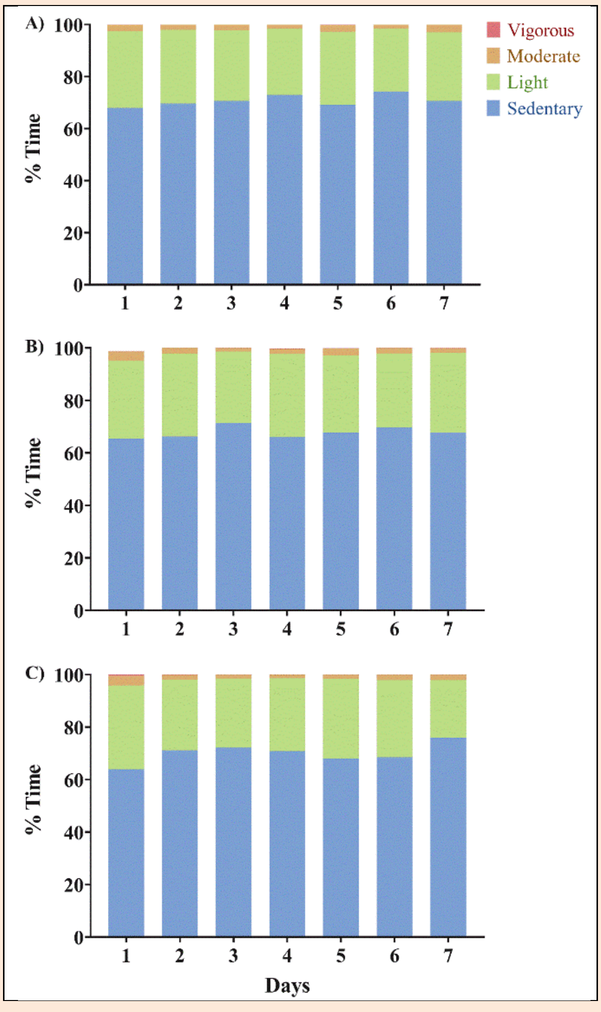

Figure 2. **Percentage of time spent in habitual physical activity and sedentary behavior over seven days following control (panel A), moderate-intensity continuous exercise (panel B) and high-intensity interval exercise (panel C) sessions in inactive obese males (n = 17).**

Table 5 shows the results of weighted average of physical activity and sedentary behavior over seven days following control and exercise sessions. There was no effect of condition for physical activity and sedentary behavior levels ($p > 0.05$).

Discussion

The main finding of this study was that there were no differences in the physical activity and sedentary behavior levels over seven days following a single low-volume HIIE and MICE sessions in obese males. Thus, our initial hypothesis that the HIIE and MICE sessions would elicit a similar negative compensatory effect reducing the physical activity level and increasing the sedentary behavior level from 24 h post-exercise compared to the control session was not confirmed.

A systematic review showed that the duration of the exercise session and intervention length were significantly associated with change in physical activity level during exercise training, indicating that longer exercise sessions led to a decrease in physical activity level (Fedewa et al., 2017). Thus, we believe that the low-volume of the exercise protocols used in the present study may explain the non-decrease in habitual physical activity after both exercise sessions. The possible explanation is that the short duration of the exercise sessions minimizes the onset of muscle damage and soreness in obese individuals (Farias-Junior et al., 2019b) or they occur in a mild magnitude, thereby enabling them to maintain their lifestyle without altering their physical activity level. Another possible explanation refers to the type of HIIE protocol proposed in the present study. It is possible that the low-volume protocol may not have been able to modulate high-grade chronic inflammation, thereby producing important implications for generating anti-inflammatory effects and avoiding immunosuppression (Dorneles et al., 2016). In fact, a recent publication by our group showed that a single HIIE session is able to decrease the inflammatory marker levels, indicating an anti-inflammatory response without alterations in the function of the mucosal immune system and lipoperoxidation in obese males (Souza et al., 2018). With low gradient inflammation, it is possible that obese males did not feel post-exercise muscle damage and soreness and, therefore, they did not increase their sedentary behavior level. Further clarification is needed regarding the clinical relevance of the relation between inflammatory parameters, habitual physical activity and sedentary behavior levels.

Some studies have examined the acute effects of aerobic exercise on physical activity level in different populations using an accelerometer (Melanson, 2017). The worldwide trends of increasing obesity prevalence have increased the focus on understanding how different exercise intensities impact the physical activity and sedentary behavior levels in these individuals. For example, Paravidino et al. (2017) demonstrated that a single HIIE (4 x 10 min at 77-95% of HR_{max} with 5 min of light walking at < 64% of HR_{max}) and MICE (4 x 10 min at 64-76% of HR_{max} with 5 min of light walking at < 64% of HRmax) sessions increase sedentary behavior level and decreases habitual physical activity level compared to a control condition in overweight adolescent boys, without a difference between HIIE and MICE. In the same population, Paravidino et al. (2016) demonstrated that there is no influence of exercise intensity on total energy expenditure related to habitual physical activity in overweight adolescent boys. Additionally, Alahmadi et al. (2011) found no compensatory effect post-HIIE (6 x 5 min intervals at 6 km/h at 0% and 10% grade with 5 min recovery at 0% grade) and post-MICE (60 min at 6 km/h at 0% grade) in overweight and obese adult males. Specifically, habitual physical activity on the day of an exercise session is similar to pre- and post-exercise (i.e. 3 days pre- and post-session). Controversially, habitual physical activity trends increase to 16% and 25% after MICE and HIIE after 48 h, respectively. It is important to highlight that the exercise modalities of these studies are different from the present study, and future research is necessary to elucidate how different exercise modes and intensities can acutely influence sedentary behavior level following a HIIE session.

Regarding the time spent in sedentary behavior, the results of the present study showed that the different exercise intensities did not significantly alter this variable when compared to the control. Evidence on the detrimental health effects of prolonged sedentary behavior is well established in the literature (van Nassau et al., 2015; Tremblay et al., 2017; Yates et al., 2015; Phillips et al., 2017). Thus, our results may have practical importance given that following both exercise protocols the individuals did not increase their time in sedentary behavior. It seems that the low exercise volume may not have been a sufficient stimulus to change the sedentary commitment at both intensities (i.e. moderate- and high-intensity). However, other studies with a higher exercise volume also did not verify differences in the sedentary behavior of obese individuals after an exercise session with different intensities (Martins et al. 2016; Paravidino et al. 2017). Another interesting finding was that there was no difference in sedentary behavior breaks among the sessions. One reason that may be associated to this finding is the high sedentary behavior of the participants, which differs from Healy et al. (2008) who evaluated the sedentary behavior of 168 overweight participants without exercise intervention, and presented an average of 601 breaks and 56 hours of sedentary behavior for seven days.

The present study has some limitations that must be mentioned. The Actigraph does not have precision to distinguish sitting from standing when worn on the hip and when only the vertical axis with traditional activity cut-off points are used (van Nassau et al. 2015). Thus, the data assessment method only uses the vertical axis and neither sitting nor standing are characterized by strong vertical accelerations, which makes it difficult to distinguish between these two behaviors (Kumahara et al. 2004). We also cannot disregard the fact that participants were research volunteers, and may have a very specific or motivational life profile for participation in the protocol, which would lead to a lower probability of change in physical activity and sedentary behavior levels during the study. Regarding the strengths of present study, the following points are highlighted: (i) the seven-day assessment after exercise sessions; (ii) a homogeneous sample, minimizing the effects of heterogeneity; and (iii) the inclusion of a control session (no exercise).

Conclusion

A single session of low-volume HIIE or MICE does not change the physical activity and sedentary behavior levels in inactive obese males. Therefore, low-volume of both high- and moderate-intensity exercise should be considered for inactive obese males given that it does not reduce the physical activity level or increase the time spent at sedentary behavior. Longitudinal analyses could offer additional insights about the independent changes (or not) of the habitual physical activity and sedentary behavior levels during a MICE and HIIE intervention and its effects on health- and fitness-related outcomes in obese population.

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The authors declare they have no competing interest. The study complied with the laws of the country of the authors' affiliation.

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Key points

- Low-volume HIIE and MICE does not decrease the habitual physical activity level over one week in inactive obese males.
- Low-volume HIIE and MICE does not increase the sedentary behavior level over one week in inactive obese males.
- Low-volume of both high- and moderate-intensity exercise should be considered to improve health- and fitness-related outcomes in inactive obese males.

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