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Research article

The effects of intermittent exercise on physiological outcomes in an obese population: Continuous versus interval walking

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Abstract
This study compared the effects of 12 weeks of caloric restriction and interval exercise (INT) and caloric restriction and continuous aerobic exercise (CON) on physiological outcomes in an obese population. Forty-four individuals (BMI ≥ 30 $kg \cdot m^{-2}$) were randomised into the INT or CON group. Participant withdrawal resulted in 12 and 14 participants in the INT and CON groups, respectively. All participants were on a strict monitored diet. Exercise involved two 15-min bouts of walking performed on five days per week. Interval exercise consisted of a 2:1 min ratio of low-intensity (40–45% VO_{2peak}) and high-intensity (70–75% VO_{2peak}) exercise, while the CON group exercised between 50–55% VO_{2peak}. Exercise duration and average intensity (%VO_{2peak}) were similar between groups. There were no significant differences ($p > 0.05$) between the two groups for any variable assessed apart from very low density lipoprotein (VLDL-C), which significantly decreased over time in the INT group only ($p < 0.05$, $d = 1.03$). Caloric restriction and interval exercise compared to caloric restriction and continuous aerobic exercise resulted in similar outcome measures apart from VLDL-C levels, which significantly improved in the INT group only.

Key words: Interval training, body fat, fitness, metabolism.

Introduction

Obesity is a pandemic issue that has been reported to affect at least 400 million adults worldwide, with this figure predicted to reach approximately 700 million by 2015 (World Health Organization, 2005). Of major concern is that obesity is associated with numerous co-morbidities such as hypertension, diabetes and hypercholesterolemia, which can result in cardiovascular morbidity and mortality (Stein and Colditz, 2004).

Whilst caloric restriction is a common strategy used for weight-loss, a combination of caloric restriction and exercise has been shown to be a more effective non-surgical intervention (Curioni and Lourenco, 2005). This combination has been shown to reduce the loss of fat-free mass (Marks et al., 1995), promote fat loss (King et al., 2001), maintain or minimise a fall in resting metabolic rate (RMR: Lennon et al., 1985), reduce visceral adipose tissue depots (Ross, 1997) and improve blood lipids (Dattilo and Kris-Etherton, 1992). Importantly, exercise can improve aerobic fitness, which can directly reduce the risk of co-morbidities associated with obesity (Mann, 1974). The exercise regime commonly employed in obese populations involves continuous aerobic exercise performed at a constant low to moderate intensity (Jacobsen et al., 2003). However, this mode of exercise may not be the most effective modality for fat-loss or health improvement. High-intensity exercise burns more calories when compared to lower intensity exercise performed over the same time period and can also result in greater energy expenditure and fat oxidation post exercise (Kaminsky and Whaley, 1993; King, et al., 2002; Tremblay et al., 1994). In addition, O'Donovan et al. (2005) reported greater improvements in total cholesterol, low density lipoprotein (LDL-C) and high density lipoprotein (HDL-C) after 24 weeks of high-intensity exercise (80% VO_{2peak}), compared to moderate-intensity exercise (60% VO_{2peak}). However, continuous high-intensity exercise places a greater physiological load on the cardiovascular system and may be difficult for sedentary, obese individuals to undertake. This conjecture is supported by Jakicic et al. (2004) and Ballor et al. (1990) who reported the need for obese participants to split their exercise sessions into series of shorter bouts due to their inability to perform a single continuous session of moderate to high-intensity exercise.

Of relevance, interval training involves bouts of high-intensity exercise interspersed with periods of rest or lower intensity exercise that allow for partial recovery (McArdle et al., 2001). The intensity and duration of the interval bouts can be manipulated in order to match an individual's fitness level, thereby making this form of training a suitable option for most individuals. To date, the few studies that have compared interval training to continuous aerobic exercise in an obese population have reported that interval training resulted in higher VO_{2peak} and RMR (King et al., 2002), greater fat loss (King et al., 2001; Trapp et al., 2008) and an excess post oxygen consumption (EPOC) that was longer and of greater magnitude (Kaminsky and Whaley, 1993). However, none of these studies included a caloric restriction component, while Trapp et al. (2008) did not match work or exercise intensities between groups. Further, Kaminsky and Whaley (1993) assessed the effects of interval exercise on EPOC only. Therefore, the aim of this study was to compare a 12-week home-based, intermittent, interval exercise programme and caloric restriction (defined as 'diet' throughout this manuscript hereon) to an intermittent continuous aerobic exercise programme and diet on cardiovascular fitness, body composition, resting metabolic rate and blood lipids in an obese population.

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Methods

Forty-four sedentary, obese individuals (body mass index: BMI ≥ 30 kg·m^{-2}), aged between 18 and 65 years, who had just joined a weight loss agency, volunteered for the study. Potential participants were excluded if they participated in more than 30 min of exercise on 3 occasions per week over the previous 6 months. Participants were also excluded if they were pregnant, taking certain medications (i.e. beta blockers, blood pressure or thyroid medication), were diabetic, had a blood pressure (BP) greater than 160/90, had lost more than five kg in the last three months, or had musculoskeletal problems that prevented them from walking. A power analysis was performed based primarily on results from King et al. (2001; effect size 0.82) and it was calculated that 13 participants were needed per group in order to detect an effect at an alpha of 0.05 with an 80% confidence level (Cohen, 1988). Participants were matched according to age, gender and BMI and then randomly stratified into either an interval (INT) exercise and diet group or a continuous (CON) aerobic exercise and diet group using a computer generated programme. The matching process resulted in the exclusion of 4 participants who could not be found a suitable match, while a further 14 participants withdrew from the study for reasons due to time constraints (n = 7), work commitments (n = 3), sickness (n = 1), holiday (n = 1), could not be contacted (n = 1) and pregnancy (n = 1). This left 12 participants in the INT group (9 females, 3 males) and 14 in the CON group (11 females, 3 males). Participants in both groups were on a similar strict caloric diet during the intervention period which was monitored by the weight loss agency. Participants were not blinded to their treatment due to the nature of the intervention. The study was approved by the University of Western Australian (UWA) Human Ethics committee and all participants signed an informed consent form.

Physiological measures

Prior to the commencement of the intervention, participants were required to attend the human performance laboratory between 06.00 and 09.00 hr where BMI was confirmed by measuring height (stadiometer) and body mass (August Sauter GmbH D-7470 Albstadt 1 Ebingen, West Germany), while blood pressure (BP) was also assessed after a 5 min rest. As resting metabolic rate (RMR) is affected by the menstrual cycle (Donahoo et al., 2004), all pre-menopausal females were required to make their appointment during their luteal phase of their menstrual cycles (Kaminsky and Whaley, 1993). Participants were required to avoid exercise, as well as to have fasted in the 12-hr period prior to the RMR test. During the RMR test, participants were required to lie quietly on a bed for 30 min. Expired air was then collected over the final 20 min period in a Tissot gasometer tank (Collins Inc, Braintree, Massachusetts, USA). A gas analysis system consisting of an oxygen gas analyser (Servomex Basic O2 Analyser, 500A, Susses, England) and a carbon dioxide gas analyser (Datax Normocap CO2 moniotr, CD102, Helsink, Finland) was used to measure samples of expired air. The gas analysis system was calibrated prior to testing using three certified gravimetric gas mixtures of known concentrations.

Body composition was then determined from a total body scan using a GE Lunar Prodigy Vision Dual Energy X-ray Absorptiometry (DEXA) machine (GE Medical Systems, Madison, WI) and accompanying software (enCORE 2004, GE Medical Systems, Lunar, Madison, WI). This software defines android fat mass region by the area of the abdomen from the top of the pelvis (lower boundary) to a proximal upper boundary that is 20% of the distance between the top of the pelvis and the base of the neck. Arms are excluded from this analysis. The upper boundary of the gynoid fat mass region is defined by the top of the pelvis, with lateral boundaries being the pelvis and outer thighs. The lower boundary for this region is defined as a line distal to the upper boundary that is twice the height of the android region. Calibration procedures were performed each day prior to scanning while quality control was performed periodically on the DEXA scanner during data collection. Test-retest analysis for body composition using this particular machine has demonstrated high reliability (r = 0.97).

Participants returned to the laboratory the following day where VO_{2peak} was determined using a graded exercise test (GXT) that employed the Balke protocol (McArdle et al., 2001). Walking speed was set at 5 kph, and the grade increased incrementally every 3 min until the participant could no longer continue. During the GXT, ratings of perceived exertion (RPE: Borg, 1982), BP and heart rate (HR) were recorded at the end of every stage, while a 12-lead ECG (Cardiofax V Ecaps 12 8370K, Nihon Kohden Corp, Japan) assessment was performed by a clinical exercise physiologist. During the GXT, oxygen uptake was calculated from minute ventilation, which was measured using mass flow ventilometry and mixing chamber analyses of expired gas fractions (Vmax, Sensormedics, Yorba Linda, CA). The gas analysers were calibrated prior to each test using alpha (α) standard reference gases, while the flow sensors were calibrated using a one litre syringe, as per manufacturer specifications. Individual VO_{2peak} was determined by averaging the two highest consecutive VO_2 values recorded over a 20-s period during the 2 min period prior to volitional exhaustion.

Finally, participants were required to provide a fasted blood sample at a commercial pathology clinic that assessed total cholesterol (TC), triglycerides, HDL-C, LDL-C, very low density lipoprotein (VLDL-C) and coronary risk ratio (CRC: divides TC by HDL-C; McArdle et al., 2001). All baseline measurements were repeated in the week following the completion of the intervention.

Diet control

All participants participated in a strict diet programme developed and monitored by a commercial weight loss organisation. The diet consisted of a low carbohydrate (CHO; low glycemic) and moderate fat diet, with the macronutrient breakdown being approximately 50% CHO, 30% fat (mostly monosaturated) and 20% protein. Caloric intake was individually restricted for all participants based on height and body mass, with restrictions approximating 1200 kcals for women and 1400 kcals for men per day. Participants attended weekly weigh-ins at the weight loss organisation. In order to sample dietary intake, all participants were required to record their daily energy intake in a diary during weeks 1 and 12 of the intervention. While this procedure indicates dietary adherence for the time period monitored only, it can be considered suggestive of overall dietary intake during the intervention period. Instructions were given to all participants on how to record their food intake in this diary. Information from this diary was subsequently analysed using a computer software programme (FoodWorks Professional Edition, Version 4, Xyris Software, Australia 2005).

Exercise interventions

Exercise in both groups consisted of home-based walking which was performed on five days of the week over a 12-week period. Each exercise session was divided into two 15 min bouts, with at least 3 h separating each exercise bout. Walking intensity in the CON group was initially set at HR values that equated to 50% of individual VO_{2peak} determined during the GXT. After 6 weeks, the exercise intensity was increased to 55% of individual VO_{2peak} in order to account for any improvement in aerobic capacity. Walking in the INT group was performed using a 2:1 min ratio of low-intensity (40% VO_{2peak}) to moderate-intensity (70% VO_{2peak}) exercise, with these intensities increased to 45% and 75% VO_{2peak} after 6 weeks. These intensities were equated to individual HR values determined during the GXT. Duration of exercise and average relative exercise intensity (individual % VO_{2peak} equated to individual HR; bpm) were the same between groups for each exercise session. All participants were given a HR monitor (Polar F3 Electro Oy, Kempele, Finland) in order to monitor and maintain the correct exercise (walking) intensity, while all exercise sessions were recorded in an activity diary throughout the 12-week intervention. Fortnightly phone calls were made to all participants over the course of the intervention in order to check on progress and adherence to exercise sessions. All participants were asked not to perform any additional exercise than that prescribed for each intervention.

Daily activity data for a week (number of steps per day) was assessed during weeks 1 and 12 of the intervention using a pedometer (Yamax, Digi-walker, SW-700, Tokyo, Japan). The Yamax Digi-walker pedometer has been reported to accurately and reliably measure steps during walking and running in overweight and obese individuals (Swartz et al., 2003).

Statistical analysis

Statistical analysis was performed using Statistical Packages for Social Science, version 14.0 (Chicago, IL) for Windows with the alpha set at $p < 0.05$. Independent t-tests were initially performed in order to compare groups at baseline. All data was assessed using the Levene's test for equality of variance. Baseline and post-intervention scores for all variables were analysed using a 2 (group) by 2 (time) mixed design, repeated measures ANOVA. Post hoc t-tests were performed if an interaction effect was significant ($p \leq 0.05$). The magnitude of the treatment effect was also assessed using Cohen's d effect sizes (ES) and thresholds (< 0.5 = small; 0.5 - 0.79 = moderate; ≥ 0.8 = large; Cohen, 1988). Only moderate to large ES are reported.

Results

All results are reported as mean ± standard deviation. There were no significant differences ($p > 0.05$) between groups at baseline for age, body-mass, height and BMI (Table 1).

Table 1. **Baseline physical characteristics for the CON group (n=14) and the INT group (n=12). Data are means (±SD).**

	CON	INT
Age (yr)	44.4 (10.4)	43.8 (10.4)
Body mass (kg)	93.1 (17.7)	87.6 (10.7)
Height (m)	1.65 (.09)	1.65 (.08)
Body mass index ($kg \cdot m^{-2}$)	33.9 (5.0)	32.5 (3.8)

Aerobic fitness

Prior to the intervention, there were no significant differences ($p > 0.05$) between the two groups for VO_{2peak} ($ml \cdot kg^{-1} \cdot min^{-1}$) or time to exhaustion on a GXT (Table 2). While there were no significant interaction effects for these variables upon completion of the intervention ($p > 0.05$), there were significant main effects for time for VO_{2peak} ($p < 0.001$, d = 0.77 and 0.98 for the INT and CON groups, respectively), as well for time to exhaustion ($p < 0.001$; d = 1.10 and 1.30 for the INT group and CON groups, respectively). Details for resting HR (bpm), systolic blood pressure (SBP), diastolic blood pressure (DBP) and final RPE values are shown in Table 2. There were no significant differences between groups for any of these variables at baseline, upon completion of the intervention, or over time ($p > 0.05$).

Lipid Results and Coronary Risk Ratio

There were no significant differences between groups at baseline for any of the blood lipid measures assessed ($p > 0.05$; Table 3). Significant main effects for time ($p < 0.05$) were found for TC, triglycerides, LDL and VLDL-C, with differences in values over time resulting in moderate and

Table 2. **Baseline and post-intervention physiological results for the CON (n=14) and the INT groups (n=12). Data are means (±SD).**

	CON Group		INT Group	
	Baseline	Post Intervention	Baseline	Post Intervention
VO_{2peak} ($ml \cdot kg^{-1} \cdot min^{-1}$)	25.5 (3.6)	29.3 (3.7)	27.3 (5.2)	31.5 (6.5)
Time to exhaustion (min)	14.9 (3.4)	19.5 (3.2)	14.9 (4.0)	19.6 (4.0)
Resting heart rate (bpm)	75 (13)	77 (12)	76 (11)	77 (9)
Systolic blood pressure (mmHg)	114.0 (13.6)	114.8 (15.6)	123.3 (17.9)	118.4 (14.6)
Diastolic blood pressure (mmHg)	77.4 (7.4)	79.2 (6.4)	80.6 (11.4)	77.0 (8.3)
Final rating of perceived exertion	17.6 (1.9)	17.9 (1.7)	17.9 (1.9)	17.8 (1.9)

Table 3. Baseline and post-intervention lipid results for the CON (n = 13) and the INT groups (n = 12). Data are means (±SD).

	CON Group		INT Group	
	Baseline	Post Intervention	Baseline	Post Intervention
Total cholesterol (mM/L)	5.06 (1.10)	4.59 (.93)	6.46 (2.07)	5.66 (1.9)
Triglycerides (mM/L)	1.31 (.62)	1.15 (.98)	1.67 (.83)	1.09 (.39)
High density lipoprotein (mM/L)	1.45 (.33)	1.46 (.35)	1.51 (.28)	1.52 (.53)
Low density lipoprotein (mM/L)	2.96 (1.04)	2.60 (.97)	4.13 (1.90)	3.50 (1.84)
Very low density lipoprotein (mM/L)	.62 (.53)	.57 (.54)	.95 (.34)	.54 (.12) *
Coronary Risk Ratio	3.69 (1.12)	3.25 (.93)	4.50 (1.44)	3.66 (1.69)

* $p < 0.05$ significant difference between baseline and post-intervention results.

large ES for triglycerides and VLDL-C in the INT group only ($d = 0.64$ and $d = 1.03$, respectively). A significant interaction effect was found for VLDL-C ($p < 0.05$), with *post hoc* analysis showing a significant decrease in this measure in the INT group only ($p < 0.05$; ES = 1.03; 39.1% vs 18.7% decline in the INT vs CON group).

There was no significant difference in CRC between groups at baseline, nor was there a significant interaction effect upon completion of the intervention ($p > 0.05$; Table 3). There was however, a significant main effect for time ($p < 0.05$), with the decrease in CRC over the course of the intervention reflected by a moderate ES ($d = 0.58$) in the INT group only.

Body composition

There were no significant differences between groups for body mass, fat mass or lean mass at baseline ($p > 0.05$, Table 4). While there were no significant interaction effects for any of these variables upon completion of the intervention ($p > 0.05$; Table 4), there were significant main effects for time for body mass ($p < 0.001$) and fat mass ($p < 0.001$). Large ES were found for the decline in fat mass over the course of the intervention in both groups ($d = 1.10$ and 0.92 in the INT and CON groups, respectively), while a moderate ES was recorded for the decline in body mass over the course of the intervention in the INT group only ($d = 0.79$). Further, while there were no significant differences between groups for gynoid and android fat mass at baseline or upon completion of the intervention ($p > 0.05$; Table 4), a significant main effect for time was found for gynoid fat mass ($p < 0.001$), with decreases in this measure being reflected by large ES in both groups ($d = 0.94$ and 0.84 in the INT and CON groups, respectively).

Resting metabolic rate

Resting metabolic rate values ($kcal\cdot d^{-1}$) were similar between the INT and CON groups prior to the intervention (1488 ± 256 and 1452 ± 312 $kcal\cdot d^{-1}$, respectively; $p > 0.05$). Additionally there were no significant differences in RMR between groups post-intervention or over time (1434 ± 239 and 1406 ± 192 $kcal\cdot d^{-1}$ for the INT and CON groups, respectively; $p > 0.05$). Further, there were no significant differences in resting respiratory quotient (RQ) between the INT and CON groups at baseline (0.81 ± 0.07 and 0.78 ± 0.05, respectively; $p > 0.05$), upon completion of the intervention (0.83 ± 0.05 and 0.80 ± 0.05, respectively; $p > 0.05$) or over time ($p > 0.05$).

Adherence and diaries

Based on exercise diaries, adherence to exercise was 88% and 93% for the INT and CON groups, respectively, with there being no significant difference between these values ($p > 0.05$). All participants were still enrolled in the diet programme at the weight-loss agency upon completion of the intervention. Further, there was no significant difference in the average total number of steps taken per day (including exercise and incidental steps), as assessed by a pedometer, between the INT and the CON groups during week 1 (10954 ± 4150 steps and 9522 ± 2245 steps, respectively; $p > 0.05$), and week 12 (11659 ± 4182 steps and 10567 ± 4476 steps, respectively, $p > 0.05$), or over time ($p > 0.05$). Further, assessment of a self-report food diary revealed no significant differences in energy intake ($kcal\ d^{-1}$) between the INT and the CON groups during week 1 (1195 ± 83 and 1173 ± 97 $kcal\ d^{-1}$, respectively) or week 12 (1255 ± 289 and 1193 ± 62 $kcal\ d^{-1}$, respectively), or over time ($p > 0.05$).

Discussion

The aim of this study was to compare a 12-week home-based, diet and interval exercise programme to a diet and continuous aerobic exercise programme in order to determine which protocol resulted in greater benefits in aerobic fitness, blood lipids, body composition and metabolism. In general terms, while results demonstrated beneficial effects associated with both interventions, only the combination of interval training and caloric restriction resulted in significant improvement in VLDL-C.

Results from this study showed that while there were improvements in aerobic fitness in both groups over

Table 4. Baseline and post-intervention results for body composition for the CON (n=14) and the INT groups (n=12). Data are means (±SD).

	CON Group		INT Group	
	Baseline	Post Intervention	Baseline	Post Intervention
Body mass (kg)	93.1 (17.7)	85.4 (18.0)	87.6 (10.7)	79.1 (9.2)
Fat mass (g)	41660 (7915)	34382 (8133)	37681 (7729)	29181 (8082)
Lean mass (g)	47070 (11567)	46905 (11452)	46781 (7986)	46755 (8250)
Android fat mass (g)	3951 (1109)	3194 (1176)	3642 (857)	2600 (742)
Gynoid fat mass (g)	7643 (1488)	6373 (1525)	6799 (1513)	5429 (1395)

* $p < 0.05$ significant difference between baseline and post-intervention results.

time, there were no significant differences in these measures between groups post-intervention. This outcome was surprising due to the number of studies that have reported a higher VO_{2peak} after high-intensity exercise compared to lower intensity exercise (Adeniran and Toriola, 1988; King et al., 2001; O'Donovon et al., 2005; Sokmen et al., 2002), even when total energy was equal between interventions (King et al., 2001; O'Donovan et al., 2005). Use of higher intensity exercise (80% VO_{2peak}, Kraus et al., 2002; 80% VO_{2peak}, O'Donovon et al., 2005; 90% HR_{max}, Adeniran and Toriola, 1988; 95% VO_{2peak}, King et al., 2001; 120–150% VO_{2max}, Sokmen et al., 2002) than that used in the current study (intervals of 70–75% VO_{2peak}) may account for this discrepancy in results, as higher intensity exercise places a greater overload on the cardiopulmonary system, which in turn should result in greater improvements in fitness. Further, while the need for adherence to exercise (frequency, intensity and duration) and accurate reporting was stressed to participants, it is possible that these requirements may not have been met, which in turn may have contributed to the insignificant differences in aerobic fitness between groups. Nonetheless, benefits observed in both groups, demonstrated by increased time to exhaustion (NS) on the GXT of 5 min 33 s (INT group) and 5 min 20 s (CON group), translate to potential improvement in cardiovascular outcomes, as a 1 min increase in treadmill exercise time during a GXT has been associated with a reduction in mortality (Blair et al., 1995).

Another health measure that is typically problematic in obese individuals relates to a blood lipid profile that does not support healthy function (O'Donovan et al., 2005). Normal values for blood lipids are as follows: TC < 5.5 mM/L, triglycerides < 1.8 mM/L, HDL-C = 1.1 – 3.5 mM/L, LDL-C < 3.5 mM/L and VLDL-C < 1.04 mM/L (Safeer and Ugalat, 2002). Of relevance, results from this study demonstrated that 12 weeks of diet and interval exercise resulted in TC and LDL-C values approaching normal levels in the INT group. Further, a significant improvement in VLDL-C over time was demonstrated in the INT group only. These results may be due to baseline values that were in the upper range for these measures in the INT group, whereas these measures were well within normal range for the CON group. Further, the significant decrease in VLDL-C over time in the INT group may explain the lower CRC (NS; ES = 0.58; 18.7% vs 11.9% decline in INT vs CON group) that occurred over the course of the intervention in this group. Results from this study support other studies that have reported improvement in blood lipids either after an exercise programme (Weintraub et al., 1989; Sugiura et al., 2002) or following a diet intervention (Dattilo and Kris-Etherton, 1992). Weintraub et al. (1989) suggested that improvement in blood lipids as a result of exercise may be due to greater lipoprotein lipase activity and a consequent reduction in triglyceride levels. Lack of significant differences in blood lipids between the two groups post-intervention may have been due to the short intervention period used, as well as the use of exercise intensities in the INT group that were not high enough to elicit change. For example, O'Donovan et al. (2005) reported significant improvement in TC, LDL-C and HDL-C after 24 weeks of exercise performed at 80% VO_{2peak}.

Declines in total fat and gynoid fat mass were reflected by significant main effects for time, as well as moderate and large ES in both groups. In addition, the decrease in body mass over time (significant main effect only) was reflected by a moderate ES in the INT group only. This result for body mass in the INT group most likely reflects the greater total fat and android fat mass loss in this group (~22.5% and 28.5%) compared to the CON group (~17% and 19.2%), combined with minimal changes over time between groups for lean mass and gynoid fat mass. These results support other similar studies that reported body mass loss (Schmidt et al., 2001; Volek et al., 2005) and fat mass loss (King et al., 2001) after exercise interventions (King et al., 2001; Schmidt et al., 2001) and a diet and exercise intervention (Volek et al., 2005).

It was expected that the INT group would lose more fat mass (including gynoid and android fat mass) compared to the CON group due to reports of greater fat burning associated with higher intensity exercise compared to lower intensity exercise (Tremblay et al., 1994; King et al., 2001: King et al., 2002). While changes in body composition were not significantly different between groups in the current study, the percentage change experienced for total fat mass and android and gynoid fat loss were higher in the INT group. As noted earlier, higher exercise intensities, which may have resulted in greater improvement in aerobic fitness and hence greater fat oxidation, may have been needed in order to elicit significant changes in body composition in the INT group compared to the CON group.

While caloric restriction has been reported to decrease lean mass (Pritchard et al., 1997), resulting in a decline in RMR (Jakicic, 2002), the addition of an exercise component to a diet intervention has been shown to maintain (Tremblay et al., 1994) or attenuate this decline in lean mass (Pritchard et al., 1997). This in turn can preserve RMR (Treuth et al., 1996). The current study found that even though it appeared that participants maintained their strict diet (as suggested by similar kcal intake values recorded during weeks 1 and 12 and the need to undertake regular weigh-ins at a weight loss agency), lean mass and RMR were not significantly altered over the course of the intervention. An explanation for the lack of significant increase in lean mass, and consequently RMR in the INT group compared to the CON group, may have been due to the mode of exercise undertaken in that walking is not likely to induce significant increases in muscle mass. Lack of significant change in fat-free mass in obese women following an 8-week walking programme was also reported by King et al. (2001). Further, as high-intensity exercise (85% - 95% VO_{2peak}) has been shown to increase RMR, compared to lower intensity exercise (King et al., 2002; Poehlman and Danforth, 1991), the use of higher intensity exercise (>75% VO_{2peak}) may have been needed in the current study in order to elicit a significant increase in RMR in the INT group.

Exercise interventions in an overweight or obese population are often associated with high attrition and poor adherence rates (Dishman, 2001; Jakicic and Gallaher, 2003), with a 53% attrition rate being reported for an 8-week study where exercise was performed in a laboratory by obese participants (King et al., 2001). This compares to a 35% attrition rate (30% for the CON group and 40% for the INT group) in the current 12-week study, with adherence to exercise being 87.7% and 92.9% (NS) for the INT and the CON group, respectively. While these adherence rates are comparable to those reported in a similar 12-week exercise study by Murphy et al., (2002; 88.2 % and 91.3 for high and low intensity exercise, respectively), the lower attrition rates may have been due to the home-based nature of the intervention and /or the use of split exercise sessions, which afforded participants flexibility in performing their exercise. This greater freedom in performing exercise is important, as lack of time has been reported to be the most common reason given for discontinuing an exercise programme (Dishman, 2001). Nonetheless, we acknowledge that exercise compliance (intensity, frequency and duration) in a home-based programme is totally dependant upon the accurate reporting of these details by the participant, with this being a limitation to the current study.

Conclusion

This study was novel in that it assessed diet and exercise (interval versus continuous aerobic exercise) in an obese population using a home-based exercise protocol that required participants to perform their exercise in two separate 15-min bouts. Results showed that when compared to diet and continuous aerobic exercise, a combination of diet and interval exercise resulted in significant improvement in VLDL-C levels. Results also suggested that a home-based exercise programme that allowed participants to split their exercise sessions over two bouts in a day resulted in lower attrition rates than laboratory based programmes. Future studies should include a control group, a larger cohort, a longer intervention period, as well as assess the use of higher intensity exercise during interval exercise.

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Key points

- Twelve weeks of interval exercise and caloric restriction resulted in significant improvement in very low density lipoprotein cholesterol in an obese population, as compared to continuous aerobic exercise and caloric restriction.
- Twelve weeks of either interval exercise or continuous exercise resulted in similar improvements in aerobic fitness in an obese population.

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