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CLINICAL TRAIL

Retrospective Comparison of Two Circuit Training Programs with Different Intensities in Obese and Overweight Individuals

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Abstract

Aim: The aim of this study was to retrospectively compare two Circuit Training (CT) programs, one with moderate and one with high intensity, on the body composition, Cardiorespiratory Fitness (CRF), biochemical and physiological markers and isometric strength in apparently healthy obese and overweight individuals.

Methods: This is a retrospective comparison of two groups of apparently healthy obese and overweight individuals that participated in two different trials examining the effect of two intermittent CT programs. The experimental groups in both trials were originally compared to a control (no exercise) group. One trial examined the effect of high intensity CT (HCT group) and the other the effect of moderate intensity CT (MCT group, n = 30). Participants on both trials were randomly assigned to the exercise or the control group. Both groups performed two exercise sessions per week for 8 weeks. MCT group performed 2 circuits of 8 exercise stations with 12 repetitions per station, performed for 1min at 50-60% of Heart Rate Reserve (HRR) alternated with 30s active recovery stations at 40-50% of HRR for the whole duration of the 8 weeks. HCT group performed 2 circuits of 6 exercise stations with 10-12 repetitions per station, performed for 1min at 50-60% of HRR alternated with 1min stations of 40-50% of HRR for the first 2 weeks and then progressed to an intensity of 70-85% of HRR, alternated with stations performed at 50-60% of HRR. Body composition, Cardiorespiratory Fitness (CRF), biochemical and physiological markers and isometric strength were measured in both groups using the same methodology.

Results: Both programs had a 100% completion rate without any adverse effects. After 8 weeks, HCT group had greater but not significantly different reductions in body weight (BW) (HCT: -3.6%, MCT: -2.5%), body mass index (BMI) (HCT: -3.5%, MCT: -2.7%), in percentage (%) (HCT: -4.5%, MCT: -3.7%), and in kilograms (Kg) (HCT: -7.9%, MCT: -5.9%) of body fat, percentage (%) (HCT: 5%, MCT: 3.3%) and in kilograms (Kg) of lean body mass (LBM) (HCT: 1.9%, MCT: 0.3%), in waist circumference (WC) (HCT: -2.7%, MCT: -1.4%), in hip circumference (HCT: -1.3%, MCT: -0.5%), waist-hip ratio (WHR) (HCT: -1.2%, MCT: -1.1%), heart rate at rest (HR-rest) (HCT: -5%, MCT: -4.3%), mean arterial pressure (MAP) (HCT: -4.8%, MCT: -4.5%) and greater improvement in maximal oxygen uptake (HCT: 16.7%, MCT: 11.1%) (VO_2peak). Blood lipids did not improve significantly in either group, but reductions in some variables were greater in the HCT group. On the other hand, MCT group appeared to induce greater improvements in Systolic Blood Pressure (SBP) (HCT: -3%, MCT: -5.3%), Diastolic Blood Pressure (DBP) (HCT: -4.6%, MCT: -5.6%), Double Product (RPP) (HCT: -7.2%, MCT: -10 %) and isometric strength of the lower extremity.

Conclusion: Short duration CT programs with moderate intensity produce comparable changes in body weight, body composition and other health variables in obese and overweight individuals without comorbidities. This can possibly increase compliance with the program as the duration is short and the intensity more suitable for obese and overweight participants. Exercise intensity is important mainly for cardiorespiratory fitness as higher intensities improve VO_2peak more and the effect lasts longer which should be considered when prescribing CT exercise programs.

Keywords

Circuit training, Cardiovascular health, Obese, Overweight, Moderate-intensity intermittent training, High-intensity intermittent training

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Introduction

Obesity is one of the main risk factors for several chronic diseases, including diabetes and cardiovascular diseases [1]. Moreover, average life expectancy is reduced by 1 year if there is an increase of 2% points in the Body Mass Index (BMI) in a society level [2].

Numerous interventions can be offered to obese and overweight individuals, such as nutrition and behavioural modifications, surgical and pharmacological treatments and increase of physical activity levels [3]. Physical activity and exercise seem to have a positive effect on health parameters [4], however research suggests that 50% of the individuals starting an exercise program in order to increase their physical activity level, will drop out within the first 6-months [5]. A variety of factors that prevent individuals from exercising were identified, including lack of motivation and time, access to facilities or equipment, lack of energy or workout partner and self-efficacy [6,7].

Moderate Intensity Continuous Training (MICT) is the most studied form of exercise regime in obesity management [8]. However, MICT requires higher volume to induce a reduction In Body Weight (BW), therefore High Intensity Interval Training (HIIT) was introduced as a time saving alternative for weight control [9]. Several studies comparing MICT to HIIT in several health parameters [4] demonstrate that both regimes are beneficial, but the effects on Body Fat (BF) vary [10-15]. However, neither MICT nor HIIT protocols used in these meta-analyses seem to be in agreement with the public physical activity recommendations [16-19]. Existing trials used mostly aerobic exercise protocols; however public guidelines recommend to include strengthening activities on 2 or more days a week, in addition to aerobic activity (150min of moderate or 75min of vigorous activity), in order to maximize health benefits [20].

Circuit Training (CT) is a multi-modal exercise regime which combines aerobic and resistance exercise stations and has been shown to be similar or more effective than aerobic exercise alone in improving maximal oxygen consumption (VO2peak), muscle strength [21], biochemical markers [22], Body Fat (BF) and body weight (BW) [22,23]. In particular Circuit Training (CT) with high intensity (HCT) provides numerous health benefits by utilizing comparatively brief duration and restricted exercise effort [24,25].

There are a few studies which investigated the effects of CT in obese and overweight population using both moderate and high intensity. Specifically, 2 studies investigated the effects of CT in a small sample of obese men [22] or overweight women [26] without involving any control group. Male participants showed improvements in physiological variables, biochemical markers and body composition following HCT for 4-weeks [22]. Females in the other study did not demonstrate significant changes in body composition and isokinetic strength parameters after 12-weeks [26].

Another 2 studies published by the same group, compared a HCT protocol to MCT in middle aged obese women and reported that HCT had higher upper limb strength [27] but both groups led to significant increases in VO2max [28]. Moreover, 5 studies in obese and overweight women, compared HCT or MCT to a control-group [21,29-32] and reported some conflicting results depended on the outcome variable. The 2 studies by [29,30] reported beneficial effects in several variables such as BF, BW, psychological distress, VO2max and muscle strength after a 10-month implementation [29,30]. Similar results were reported by Kim, et al. for MCT [32]. A third study by the same group, reported improvements in muscular strength and flexibility which were maintained during the detraining period [31]. The only study which included a control-group reported no significant difference in body composition and physiological parameters and biochemical markers between the groups, however VO2max improved more in the HCT-group after 12-weeks [21].

Other studies used circuit resistance/weight training in obese individuals, mostly in women [33-38] and reported varying results regarding body composition, muscular strength, and biochemical markers. Some other studies compared different CT protocols [25,39-41] in this population with varying results, but most of them highlighted the superiority of higher intensities, in the changes of body composition.

Despite the findings of the previous studies there are still significant gaps regarding CT. For instance, the optimal parameters of the program are far from being conclusive. The minimum effective dose of CT is largely unknown. Despite results showing a positive result of HCT, higher intensity induces greater perception of physical pain [25] which might affect compliance. The time commitment and the frequency can be an exercise barrier [42] and the balance between intensity and duration is crucial and the optimal combination is yet to be determined.

Moreover, there is a lack of studies comparing functional CT protocols with different intensities, which include aerobic and strength training and are of short duration. Therefore, two clinical trials (refs) were designed to assess the effects of functional MCT or HCT in various health parameters compared to a control group. Both trials showed several significant positive effects compared to the control group. This paper includes a retrospective comparison of the experimental groups (MCT and HCT) of the two trials. The comparison is possible as the outcome measures and the methodology between the two trials are the same.

Methods

A detailed description of the methodology has been presented elsewhere (ref). In short thirty (n = 30) participants for each trial were recruited from the local area of Nicosia, Cyprus via a poster advertisement displayed around the campus of University of Nicosia. The inclusion criteria consistent of: Overweight or obese (BMI: 25-39 kg/m^2), men and women aged 18-55 years, not participating in regular structured exercise training (< 30 min) with low levels of physical activity as measured with International Physical Activity Questionnaire (IPAQ). Participants were excluded if they had an exercise-limiting cardiovascular, respiratory, musculoskeletal or metabolic diagnosis. All participants were fully informed about the benefits and possible complications of the study and procedures and signed a written consent form for their participation, before study involvement. Following that, participants were first screened for meeting the criteria during an initial session and then again underwent a comprehensive medical examination by a consultant cardiologist, before conducting the baseline measurements. Those who met the criteria were randomized by the lead researcher using a software (SealedEnvelope.com, Clerkenwell Workshops) into two groups (HCT or MCT and control) of 15 participants. Both trials were part of a common project approved by the Cyprus National Bioethics Committee (EEBK/EΠ/2017/38). This paper includes a retrospective comparison of the exercise groups of the two trials.

Participants were assessed 3 times at: (T1) baseline, (T2) post-training (post 8-weeks), (T3) detraining period (post 2-months), with each assessment conducted under laboratory conditions in the morning between 8:00-9:00 am. Baseline assessment took place 1-week prior the beginning of intervention, post-training and detraining assessments took place at least 2-days following the last day of the corresponding period. All the below described variables were assessed at T1 and T2, except VO2peak which was assessed at all 3-time points. Participants attended assessment sessions following an over-night fast and were asked to abstain from caffeine, alcohol and vigorous activity 24-hours prior to the assessment.

Cardiorespiratory fitness was assessed using the Six-Minute Walk Test (6MWT) at T1, T2 and T3 in a 30-meter marked indoor corridor in the laboratory of University of Nicosia according to the instructions of American Thoracic society [43]. The formula of American College of Sports Medicine (ACSM), VO2peak = (0.02*distance[m]) - (0.191*age[yr]) - (0.07*weight [kg]) + (0.09*height [cm]) + (0.26*rate pressure product [*10-3]) + 2.45 was used to calculate VO2peak based on the total walked meters [44].

Height was measured (T1) in a standing position using a portable stadiometer (Seca 202, Hamburg, Germany). Body composition variables were measured (T1 and T2) via an electronic scale (Omron BF511, Kyoto, Japan) and measurements included: BW, BMI, lean body mass in percentage (LBM%) and in kilos (LBM-Kg), percentage of BF (BF%) and BF in kilos (BF-Kg). In addition, waist circumference (WC) was measured with a tape, midway between the lowest rib and the iliac crest and the hip circumference at the level of the symphysis. Following this measurement, the Waist-to-Hip Ratio (WHR) was calculated based on the equation WHR = waist circumference/hip circumference [44].

Blood samples were taken from the antecubital vein, after 12-hours overnight fasting (T1 and T2). The samples for glucose measurement, were collected in fluoride oxalate tubes and centrifuged at 3500 rpm (plasma collection) for 10 min and analysed using an automated analyser with an enzymatic assay (Hitachi Automatic Analyzer 7600, Tokyo, Japan). Moreover, the blood samples for lipid profile markers were collected in serum separating tubes and once again centrifuged at 3500 rpm (serum collection) for 10 min and were analysed by a fully auto-analyser Integra 400 Plus (Roche Diagnostics GmbH), by enzymatic, colorimetric method.

Testing of maximal isometric strength of quadriceps and hamstrings was assessed (T1 and T2) using the Micro FET 2 dynamometer (Hoggan Health Industries Inc. West Draper, UT, USA). The test was performed first on the dominant and then on the non-dominant limb and consisted of 3-maximal isometric contractions (3s) separated by 1-minute rest. The test was performed in a sitting position, with hands placed sideways and with hips and knees fixed at 90° of flexion (with a goniometer). The "break technique" was used in order to record the maximum strength [45].

An automated blood pressure monitor (Omron M3, Kyoto, Japan) and a pulse meter watch (Polar V800, Finland) were used (T1, T2, before and after each session) to record Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and resting HR (HRrest) respectively, while participants were seated for at least 10-minutes. The measurements were recorded 3 times in order to take the average for each time point (T1 and T2). The maximum HR of each participant was initially predicted from the maximum HR [HRmax] formula: 208-(0.7 x age) [46] and thereafter, the intensity of exercise training was set as percentage of the heart rate reserve (%HRR). The formula target HR (THR) = [(HRmax/peak – HRrest) × % intensity desired] + HRrest was used to determine the applied exercise intensity [44].

Resting mean arterial pressure (MAP): MAP = [(DBP X 2) + SBP]/3], and rate pressure product (RPP): RPP= HR X SBP were calculated as in previous publications at T1 and T2 [47-50]. Perceived exertion was assessed using the OMNI (0 = extremely easy to 10 = extremely hard) point scale [51].

Participants were asked to complete the IPAQ (T1 and T2), in order to estimate the amount of time spend physically active over the past 7-days (outside of the physical activity of the study) and classified as: 1) Low, 2) Moderate and 3) High level of physical activity category [52].

Training program

Participants were asked to visit the laboratory, 1-week before the beginning of the training intervention, for a single familiarization session. Both training groups exercised twice a week for 8-weeks in total and followed a program consisting of a warm-up, main CT exercises and a cool-down. All sessions were performed on non-consecutive days throughout each week and were supervised by one of the researchers. Both exercise groups started each session with a 3-min warm-up: Toe taps, heel taps, marching on the spot, step jack, split squat jack, skier jack and ended it with a 3-min cool-down toe taps, heel taps, quadriceps stretching, hamstrings stretching, triceps stretching, pectoralis stretching) at 40-50% of HRR. Exercise HR was recorded continuously during the sessions through the Polar V800.

Moderate intensity Circuit Training (MCT)

This group had to perform: a) A warm-up (3-min) and b) A cool-down (3-min), c) 2 circuits of 8 exercise stations (6 cardiovascular [CV] stations and 2 Active Recoveries [AR]) per circuit and 12 repetitions per station. The exercises sequence per cycle was: 3 CV exercise stations following 1 AR exercise station. Each CV exercise station lasted for 1-min, whereas each AR exercise station lasted for 30s and were performed at 50-60% of HRR and 40-50% of HRR respectively. The included exercises performed were (1) Medicine ball squat overhead throw, (2) High knees, (3) Squat jumps, (4) Wall push-ups or standing bicep curl, (5) Marching on the spot, (6) Bend over double triceps kickback, (7) Split squat medicine ball slams, (8) Two-handed dumbbell lateral step-up or squats.

High intensity Circuit Training (HCT)

This group had to perform: a) A warm-up (3-min) and b) A cool-down (3-min), c) 2 circuits of 6 exercise stations (4 CV stations and 2 AR) per circuit and 10-12 repetitions per station, each lasting for 1-min. The exercises sequence per cycle was: 2 CV exercise stations following 1 AR exercise station; where CV stations performed at 50-60% of HRR and AR stations at 40-50% of HRR for the first 2-weeks and at 70-85% and 50-60% of HRR respectively for the rest of the remaining sessions. The included exercises per session performed were (1) Squat jumps, (2) Medicine ball squat overhead throw, (3) Wall push-ups or standing bicep curl, (4) Two-handed dumbbell high step-up, (5) Running, (6) Dumbbell walking lunges. In both groups external load was added in order to maintain the intensity and repetitions in the desired level when the initial load became easy.

Statistical analysis

In order to assess the effects of exercise training on VO2peak (primary outcome) assuming a moderate (Cohens d = 0.57) group by time interaction, a sample size of 14 participants per group were needed, to allow for power of 80% and a level of significance of 5% in the original trials. Statistical analysis was performed using SPSS 25 software (IBM, Armonk, NY). Normality of distribution was tested using Kolmogorov-Smirnov test. Baseline comparisons were performed using a chi-squared test for categorical variables and an independent sample t test for continuous variables.

Repeated measures ANOVA (2 × 2) was used to compare changes over time (T1, T2) and between groups (HCT, MCT) for all variables. Repeated measures ANOVA (2 × 3) was also used to assess VO2peak at 3 time points (T1, T2, T3). The corresponding non parametric tests were used for the non-normally distributed variables. Data are presented as mean ± SD for normally-distributed data and median (interquartile range) for non-normally distributed data. The level of significance was set to 5%. Effect sizes for main effects and interaction were calculated by partial eta-squared (η^2_p) with the magnitude of effect sizes determined as: small $\eta^2_p \leq 0.01$, medium $\eta^2_p \geq 0.06$, and large $\eta^2_p \geq 0.14$ [53].

Results

No injuries or adverse events were recorded; thus all 30 participants were able to complete the exercise program and finish all the measurements (T1, T2, T3). Baseline descriptive statistics are reported in Table 1. The two groups had a significant difference in age and LDL, with no other significant differences at baseline.

Body composition

No group effect or group x time interaction was found in any body composition variable. As shown a significant time effect was demonstrated in BW ($p = 0.001$, $\eta^2_p = 0.54$), BMI ($p = 0.001$, $\eta^2_p = 0.55$), BF% ($p = 0.001$, $\eta^2_p = 0.47$), hip circumference ($p = 0.005$, $\eta^2_p = 0.25$), WC ($p = 0.001$, $\eta^2_p = 0.31$) and WHR ($p = 0.021$, $\eta^2_p = 0.18$). Significant changes over time were found in BF-Kg ($p = 0.001$), LBM% ($p = 0.005$) but not in LBM-Kg ($p = 0.615$). The % difference in body composition variables are summarized in Table 2 for each group.

Cardiorespiratory fitness

Similar to body composition, cardiorespiratory fitness showed no group effect or group by time interaction. However, a significant time effect was found in VO2peak ($p = 0.001$, $\eta^2_p = 0.48$) (Table 3). The % difference between the time points were: T1-T2 was 16.7% (± 11.74) ($p = 0.001$), T1-T3 was 11.6% (± 11.87) ($p = 0.001$), and T2-T3 was -4.4% (± 4.05) ($p = 0.001$), for HCT-group. On the other hand, the % difference for MCT-group for T1-T2 was 11.1% (± 8.45) ($p = 0.001$), for

Table 1: Participant's characteristics at baseline. Data are presented as Mean ± Standard Deviation or Median (Interquartile Range).

Variable	HCT-group	MCT-group	p-values
Gender	M = 5; F = 10	M = 5; F = 10	p = 1.000
Age (Years)	32.9 (29.0)	26.2 (27.0)	p = 0.029
Height (cm)	167.2 (164.0)	167.3 (163.0)	p = 0.588
Weight (Kg)	89.8 ± 18.96	89.3 ± 16.32	p = 0.946
BMI (kg/m²)	31.9 ± 4.90	32.0 ± 5.21	p = 0.957
BF%	40.7 ± 9.10	43.2 ± 9.75	p = 0.481
BF (Kg)	36.6 ± 11.5	38.8 ± 12.1	p = 0.615
LBM%	29.0 (25.0)	25.0 (23.8)	p = 0.263
LBM (Kg)	26.6 (22.5)	22.2 (20.3)	p = 0.455
WC (cm)	92.4 ± 10.88	93.1 ± 9.94	p = 0.842
Hip Circumference (cm)	110.1 ± 9.22	110.9 ± 11.95	p = 0.839
WHR	0.8 ± 0.06	0.8 ± 0.08	p = 0.959
SBP (mm Hg)	120.0 ± 16.31	118.1 ± 13.30	p = 0.725
DBP (mm Hg)	82.3 ± 7.68	83.6 ± 10.02	p = 0.700
MAP (mm Hg)	96.2 ± 13.01	93.5 ± 7.15	p= 0.492
RPP (mmHg*bpm)	9547.2 ± 1870.04	9881.9 ± 1714.53	p = 0.613
HRrest (bpm)	79.7 ± 8.71	83.2 ± 11.65	p = 0.355
VO_2peak (ml O_2/kg/min)	16.2 ± 2.40	15.6 ± 1.82	p = 0.452
LDL (mg/dL)	90.5 ± 21.03	113.3 ± 6.54	p = 0.014
HDL (mg/dL)	48.2 ± 12.29	46.6 (9.06)	p = 0.688
TC (mg/dL)	160.6 ± 28.17	179.3 ± 29.46	p = 0.087
Glucose (mg/dL)	92.3 ± 8.39	89.7 ± 12.01	p = 0.497
Triglycerides (mg/dL)	109.7 (87.0)	95.9 (85.0)	p = 0.917
Right QUADS (N)	158.5 ± 25.14	171.5 ± 36.00	p = 0.262
Left QUADS (N)	155.6 ± 25.25	178.3 ± 50.04	p = 0.128
Right HAMS (N)	160.8 ± 24.40	150.1 ± 52.46	p = 0.481
Left HAMS (N)	158.8 ± 22.26	162.9 ± 33.51	p = 0.692
OMNI Scale	8.7 (8.0)	8.7 (9.0)	p = 0.786

BMI: Body Mass Index, BF%: Percentage of Body Fat, LBM%: Percentage of Lean Body Mass, LBM-Kg: Lean Body Mass in kilograms, WC: Waist Circumference, WHR: Waist to Hip Ratio, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, MAP: Mean Arterial Pressure; RPP: Rate Pressure Product, HRrest: Resting Heart Rate, VO2peak: Maximal Oxygen Consumption, LDL: Low Density Lipoprotein, HDL: High Density Lipoprotein, TC: Total Cholesterol, QUADS: Quadriceps, HAMS: Hamstrings, N: Newton, mg/dl: Milligrams per decilitre, mm Hg: Millimetre of Mercury, cm: Centimetre, F: Females, M: Males

Table 2: Percentage of change.

Variable	HCT-group	MCT-group
BW	-3.6% (± 1.96)	-2.5 (± 3.33)
BMI	-3.5% (± 1.91)	-2.7% (± 3.19)
BF%	-4.5% (± 3.88)	-3.7% (± 5.39)
BF-Kg	-7.9% (± 4.81)	-5.9% (± 7.60)
LBM%	5% (± 9.14)	3.3% (± 6.72)
LBM-Kg	1.9% (± 10.79)	0.1% (± 5.07)
WC	-2.7% (± 2.67)	-1.4% (± 3.64)
Hip circumference	-1.3% (± 1.95)	-0.5% (± 0.92)
WHR	-1.2% (± 1.57)	-1.1% (± 3.47)
VO_2peak (T1-T2)	16.7% (± 11.74)	11.1% (± 8.45)
VO_2peak (T2-T3)	-4.4% (± 4.05)	-3.2% (± 4.41)
VO_2peak (T1-T3)	11.6% (± 11.87)	7.5% (± 8.86)

Exertion	13.4% (± 10.62)	11.9% (± 10.85)
LDL	-4% (± 14.79)	-0.4% (± 24.17)
HDL	-0.3% (± 8.83)	0.5% (± 15.71)
Glucose	-1.1% (± 6.44)	9.7% (± 17.35)
Triglycerides	2.6% (± 44.53)	9.9% (± 47.84)
TC	-3.2% (± 8.46)	-0.7% (± 19.12)
HRresting	-5% (± 4.40)	4.3% (± 6.50)
SBP	-3% (± 4.11)	-5.3% (± 5.46)
DBP	-4.6% (± 3.89)	-5.6% (± 10.17)
MAP	-4.8% (± 4.17)	-4.5% (± 4.25)
RPP	-7.2% (± 5.97)	-10% (± 6.99)
Right QUADS	2.1% (± 2.41)	2.6% (± 5.88)
Left QUADS	3.2% (± 1.90)	3.3% (± 5.94)
Right HAMS	2.4% (± 3.07)	4.7% (± 5.26)
Left HAMS	2.9% (± 2.18)	4.2% (± 4.26)

BMI: Body Mass Index, BF%: Percentage of Body Fat, BF-Kg: Body Fat in kilos, LBM%: Percentage of Lean Body Mass, LBM-Kg: Lean Body Mass in kilos, WC: Waist circumference, cm: centimetres, WHR: Waist to hip ratio, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, HR: Heart Rate, MAP: Mean Arterial Pressure, RPP: Rate Pressure Product, bpm: beats per minute, mmHg: millimetres of Mercury, LDL: Low Density Lipoprotein, HDL: High Density Lipoprotein, TC: Total Cholesterol, HAMS: Hamstrings, QUADS: Quadriceps, VO2peak: Maximal Oxygen Consumption

T1-T3 was 7.5% (± 8.86) (p = 0.008) and for T2-T3 was -3.2% (± 4.41) (p = 0.014). Comparisons demonstrated non-significant differences between the groups at T1 (p = 0.45), at T2 (p = 0.11) and at T3 (p = 0.13).

Perceived exertion

Participants in both groups perceived a significant lower exertion at the end of the intervention (HCT p = 0.003, MCT p = 0.004) (Table 3). The average % improvement in perceived exertion for MCT-group was 11.9% (± 10.85) and for HCT-group was 13.4% (± 10.62) (Table 2).

Biochemical markers

A significant time × group interaction was demonstrated in glucose (p = 0.044, η^2_p = 0.14), but no other interaction or group/time effect was found in any other biochemical marker (Table 3). The % differences for all biochemical variables are shown on Table 2.

Physiological markers

All physiological variables demonstrated significant time effect but no group effect or group by time interaction. Effect sizes for time differences were large for all variables specifically SBP (p = 0.001, η^2_p = 0.43), DBP (p = 0.005, η^2_p = 0.25), HR-resting (p = 0.001, η^2_p = 0.38), MAP (p = 0.001, η^2_p = 0.52) and RPP (p = 0.001, η^2_p = 0.62) (Table 3). Percentage changes for each group and variable are reported in Table 2.

Isometric strength

A significant time effect was found in the left hamstrings (p = 0.001, η^2_p = 0.59), right hamstrings (p = 0.001, η^2_p = 0.49), left quadriceps (p = 0.001, η^2_p = 0.50) and right quadriceps (p = 0.001, η^2_p = 0.32).

Discussion

The present study is a retrospective comparison of two different functional CT programmes, in apparently healthy obese and overweight individuals. This study showed that a functional CT with moderate intensity was able to elicit similar improvements in CRF, physiological and biochemical parameters, isometric strength and body composition compared to a CT with high intensity.

Body composition

Both CT protocols induced significant positive effects over time, with large effect sizes (η^2_p between 0.14 and 0.55) on most body composition variables, but there were no differences between the groups. Higher intensities in aerobic exercise have been found to have differential effects in body composition variables. Higher intensities seem to improve body weight, body fat, WC and WHR, whereas lower intensities reduce body weight and body fat [54]. The results of the current analysis show that intensity is not critical to body composition as long as it is above moderate. Moreover, waist circumference reductions were similar (~-3%) to that following HIIT and MICT protocols for 10-weeks [55].

The weekly training volume in the HCT-group was 36min and 40min in the MCT-group. This exercise volume is much lower compared to that used in previous CT studies [25,27,32,36,40]. Nevertheless, this study demonstrates that apparently healthy obese and overweight individuals can improve their body composition with quite lower exercise volume and no restrictions in their diet; therefore, a CT protocol with moderate or high intensity can be a practical alternative for individuals with time constrains.

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Table 3: Outcome variables pre-intervention and post-intervention at 8-weeks.

	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Time	Time X Group	Group
Weight (kg)	89.8 ± 18.96	86.6 ± 18.41	89.3 ± 16.32	87.2 ± 16.46	**p = 0.001**	p = 0.263	p = 0.988
BMI (kg/m²)	31.9 ± 4.90	30.8 ± 4.89	32.0 ± 5.21	31.1 ± 5.14	**p = 0.001**	p = 0.470	p = 0.905
BF%	40.7 ± 9.10	39.1 ± 9.41	43.2 ± 9.74	41.8 ± 10.18	**p = 0.001**	p = 0.683	p = 0.466
BF-kg (kg)	36.6 ± 11.50	34.0 ± 11.39	38.8 ± 12.05	36.7 ± 11.85	**p = 0.001**	p = 0.527	p = 0.567
LBM%	29.0 (25.00)	30.4 (26.20)	25.0 ± (23.80)	25.9 ± (24.20)	†HCT: **p = 0.005**, MCT: p = 0.060	¶p = 418	‡p = 0.217
LBM-kg (kg)	25.4 (28.02)	24.5 (26.96)	22.2 (20.32)	22.3 (20.50)	†HCT: p = 0.530, MCT: p = 0.824	¶p = 519	‡p = 0.455
WC (cm)	92.4 ± 10.88	89.9 ± 10.78	93.1 ± 9.94	91.8 ± 10.35	**p = 0.001**	p = 0.290	p = 0.725
Hip (cm)	110.1 ± 9.22	108.7 ± 9.86	110.9 ± 11.95	110.3 ± 11.29	**p = 0.005**	p = 0.253	p = 0.765
WHR	0.8 (0.85)	0.8 (0.84)	0.8 ± 0.78	0.8 ± 0.85	**p = 0.021**	p = 0.871	p = 0.940
SBP (mmHg)	120.0 ± 16.31	116.3 ± 15.22	118.1 ± 13.30	111.6 ± 11.43	**p = 0.001**	p = 0.215	p = 0.516
DBP (mmHg)	82.3 ± 7.68	78.5 ± 7.43	83.6 ± 10.02	78.2 ± 6.93	**p = 0.005**	p = 0.616	p = 0.846
HR (bpm)	79.7 ± 8.71	75.5 ± 6.78	83.2 ± 11.65	79.3 ± 9.35	**p = 0.001**	p = 0.919	p = 0.273
MAP (mmHg)	96.2 ± 13.01	91.2 ± 8.95	93.5 ± 7.15	89.3 ± 7.54	**p = 0.001**	p = 0.639	p = 0.504
RPP (mmHg*bpm)	9547.2 ± 1870.04	8833.9 ± 1733.50	9881.9 ± 1714.53	8863.9 ± 1468.54	**p = 0.001**	p = 0.245	p = 0.767
LDL (mg/dL)	90.5 ± 21.03	86.5 ± 22.83	113.3 ± 26.54	108.5 ± 18.80	p = 0.308	p = 0.927	**p = 0.003**
HDL (mg/dL)	48.2 ± 12.29	47.5 ± 10.88	46.6 ± 9.06	46.7 ± 11.13	p = 0.807	p = 0.715	p = 0.757
Triglycerides (mg/dL)	109.7 (87.00)	99.7 (84.00)	95.9 (85.00)	95.6 (103.00)	†HCT: p = 0.268, MCT: p = 0.733	¶p = 418	‡p = 0.633
TC (mg/dL)	160.6 ± 28.17	154.2 ± 21.90	179.3 ± 29.46	174.3 ± 23.80	p = 0.284	p = 0.889	**p = 0.021**
Glucose (mg/dL)	92.3 ± 8.39	91.0 ± 6.23	89.7 ± 12.01	96.8 ± 8.69	p = 0.160	**p = 0.044**	p = 0.551
LHAMS (N)	158.8 ± 22.26	163.4 ± 23.23	162.9 ± 33.51	169.1 ± 32.87	**p = 0.001**	p = 0.365	p = 0.637
RHAMS (N)	160.8 ± 24.40	164.6 ± 24.34	160.4 ± 32.78	166.6 ± 32.18	**p = 0.001**	p = 0.224	p = 0.939
LQUADS (N)	155.6 ± 25.25	160.3 ± 24.91	178.3 ± 50.04	182.7 ± 46.98	**p = 0.001**	p = 0.821	p = 0.121
RQUADS (N)	158.5 ± 25.14	161.6 ± 24.29	171.5 ± 36.00	175.1 ± 34.41	**p = 0.001**	p = 0.808	p = 0.243
VO_2peak (ml O_2/kg/min)	16.2 ± 2.40	18.8 ± 2.48	15.6 ± 1.88	17.3 ± 2.44	**p = 0.001**	p = 0.296	p = 0.170

Data are means ± SD for normally-distributed variables and median (interquartile range) for non-normally distributed variables; p-values in bold indicate significant differences; Abbreviations: BMI: Body Mass Index, BF%: Percentage of Body Fat, BF-Kg: Body Fat in kilos, LBM%: Percentage of Lean Body Mass, LBM-Kg: Lean Body Mass in kilos, WC: Waist circumference, cm: centimetres, WHR: Waist to hip ratio, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, HR: Heart Rate, MAP: Mean Arterial Pressure, RPP: Rate Pressure Product, bpm: beats per minute, mmHg: millimetres of Mercury, LDL: Low Density Lipoprotein, HDL: High Density Lipoprotein, TC: Total Cholesterol, mg/dL: Milligrams per decilitre, N: Newton, HAMS: Hamstrings, QUADS: Quadriceps, VO_2peak: Maximal Oxygen Consumption. †Wilcoxon Rank Test before vs. after on each group, ‡ Mann-Whitney Test on post values HIIT vs. MCT, ¶Mann-Whitney Test on pre/post difference HIIT vs. MCT

Cardiorespiratory fitness

It is generally well known that aerobic capacity and muscle strength are important elements for sufficient CRF. CRF is considered a reflection of total body health and a low level of CRF is associated with higher risk for cardiovascular diseases and all-cause mortality [56]. Following the exercise program, HCT-group and MCT-group demonstrated ~17% and 11.1% improvement in VO2peak, without any statistically significant differences between them. It is known that there is a reduction of 10% per decate in VO2peak [57]. The 6% difference between groups means individuals in HCT-group delayed the effects of ageing by 6 years compared to the MCT participants although they were on average 7 years older and with higher VO2peak baseline values. This finding suggests that although improvements between groups are not statistically significant they are likely to be clinically significant and therefore higher intensities should be favoured if CRF is the desired adaptation as long as they are well tolerated.

Several studies that have presented the effects of High Itensity Training [HIT] protocols, demonstrate a wide range of observed VO2max responses following modified CT interventions. Similar, peak oxygen uptake improved from 2,070 ± 206 to 2,110 ± 141 following 3 weekly HCT sessions for 9-weeks in total (2-6 circuits of functional exercises) [25]. Others reported changes in VO2max from 26.1 ± 5.63 to 29.50 ± 5.75, following 2 weekly sessions of HCT for 18-weeks in total [28]. Moreover, participants improved their VO2max from 23.00 ± 3.80 to 26.16 ± 3.71 following 3 weekly HCT sessions for 12-weeks (3 circuits of 12 exercise stations alternating work/rest intervals: 60s/60s and an intensity of 75% of HRmax) [21]. In addittion, improvements from 26.1 ± 4.4 to 33.1 ± 4.8 were found following a HCT program with 3 weekly sessions (10-12 exerices per session, performed as many repetitions as possible at each station, with work/rest intervals: 20-40s and an intenity of ≥ 65% of HRR) lasting for 40-weeks in total [29]. This is the first study that shows clinically relevant improvements with significantly lower volume (frequency × duration) irrespective of high or moderate intensity.

Isometric strength

Skeletal muscles make-up up to 40% of the adult BW and are crucial in performing activities of daily life without any difficulty [58]. Obesity is associated with restrictions in functional performance as it contributes to strength and balance impairments [59].

Strength training can be performed either unilaterally by training one side of the body at the time or bilaterally by training both sides of the body at the same time [60]. Different exercises and joint angles have an affect on the length and movement of the limb muscles and their ability to produce force and velocity, therefore the choice between multy or single-joint exercises is probaly going to impact the induced adaptation. Multi-joint exercises are more effective and practical than single-joint exercises for increasing maximal muscle strength of the kinetic chain and for mimicing functional movement patterns therefore increasing transferability to everyday tasks. On the other hand, single-joint exercises are more effective in targeting specific muscles and correcting imbalances between muscle groups compared to multi-joint exercises [60].

Similar improvements in strength, power and hypertrophy following unilateral and bilateral training were demonstrated in previous publication for trained [61] and untrained individuals [62,63].

CT studies evaluated the handgrip, lower limbs and back strength in this population and reported improvements after 12-weeks of training [26,32,64]. Participants in this study showed improvements in isometric strength of both muscle groups of the lower limbs, using mostly baliteral both single-joint and multi-joint exercises for upper and lower limbs. These improvements in strength can be explained by neuromuscular adaptations which can be grouped as morphological and neural [65]. Resistance training produce hyperteophy and some changes whithn the nervous system such as an improvement in synchronization of motor unit firing and improved ability to recruit motor units to enchance the ability to recruit motor units that along, improve muscle strength [66].

Biochemical markers

Blood lipids are associated with the development of cardiovascular diseases [67]. In this study, no meaningful changes were found in biochemical markers in either group. Previous studies have reported mixed results regarding the effect of CT in lipoproteins. One study with similar duration and frequency as the present study, with more exercise stations and moderate intensity found no effect in biochemical markers in obese and overweight patients with type II diabetes [68]. Similar results were reported by another study after 12-weeks of CT with very high intensity (≥ 75% of HRmax) in obese and overweight females [21]. In addition, studies demonstrated no changes in fasting glucose levels following an 8-week resistance CT (3 times per week, 50-85% of 1-RM) in obese men [38], or following HCT protocol of only 4 weeks [22]. On the other hand, 2 studies which used only resistance CT demonstrated reductions in blood lipid markers in obese men (3 weekly sessions, 65-85% of 1RM) [36] and in obese overweight women (3-4 weekly sessions of 15 resistance exercise stations, 10-12 repetitions per station performed at 70-80% of HRR) after 8 weeks [33]. The interpetation of these results and the results of the current study suggest that higher volume is a significant factor when it comes to biochemical adaptations.

The results of the current study can also be explained by the normal baseline values of the participants and by the lack of an adittional caloric restriction in compination with the exercise (participants were asked to continue their normal diet). Despite the lack of significant difference between groups the higher intensity is probably more effect way to induce this kind of adaptation as lipid profile reductions were higher in the HCT group.

Physiological markers

Significant reductions in SBP and DBP occurred after 8-weeks in both exercise groups. While previous studies also reported significant improvements in BP following CT with high intensity for 12-weeks and 18-weeks [28,41], others reported non significant reductions in DBP after a 4 week HCT [22] or no improvements in BP follwoing CT protocols for 8 and 12-weeks [21,33]. The reductions in BP after the CT protocol, can be explained by a decrease in peripheral vascular resistance, which arises from neuro-hormonal and structural responses, along with reductions in the sympathetic activity which results in an increase in arterial lumen diameter, folowing reduced vasoconstriction [69-71]. Considering the results of the studies quoted, there seems to be a cut off duration of > 12 weeks for clinically meaningful changes in BP.

The improvement over time in BP was accompanied with significant improvements in MAP and RPP, which provide additional evidence of improved cardiac effieciency in both exercise groups. In adittion both groups reduced significantly their HR rest which is related to mortality [72]. Therefore, a short duration CT program of moderate or high intensity is able to improve important cardiovascular health parameters in obese and overweight individuals but further study is required as the results are not universal.

Limitations

This study has some limitations that should be pointed out. First of all, this is a retrospective comparison and although the methodology was the same, systematic differences in outcome measurement cannot be excluded. Second, the sample size of the original studies was small and participants were healthy overweight and obese, without any comorbidities, thus the results should be interpreted with caution. In addition, participants' daily diet and physical activity was not continuously monitor, which may contribute to changes in the examined variables. Finally, the age difference between the two groups also may have influenced the results, as groups were not balanced in terms of age.

Conclusion

In this study, apparently healthy obese and overweight individuals seem to respond positively to a CT protocol with significant improvements overtime in several health variables. The results show that 8-weeks of a short duration (< 40 min/week) CT program of either moderate or high intensity is able to improve body composition, lower limb isometric strength, CRF, physiological parameters, but not biochemical markers. Higher intensities seem to be able to improve CRF more. Therefore, CT with high or moderate intensity is a time-efficient intervention, for healthy obese and overweight individuals, which can reduce cardiovascular risk factors and prevent the development of various chronic diseases. Moderate intensities can potentially increase compliance in unfit individuals with similar overall benefits compared to higher intensities. Higher intensities should be considered when CRF is the main goal of the program.

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