Section: Physical Education and Sport

Original Research Article

EFFECTS OF INTENSIVE AND EXTENSIVE CIRCUIT TRAINING PROGRAMS ON BODY COMPOSITION, METABOLIC PROFILE AND PHYSICAL POTENTIAL IN OBESE ADOLESCENTS: COMPARATIVE STUDY

Simplice Innocent Moussouami [1,2], Florent Nsompi[1], Brahima Ouedraogo[3], Yvon Rock Ghislain Alongo[1], Misère Emmanuel Rodrigue Loubota[2], Bio Nigan Issiako[1], François MBemba[1]

[1]Laboratory of Physiology of Effort and Biomechanics (LPB). Higher Institute of Physical Education and Sport (ISEPS), University Marien Ngouabi (Congo). BP: 69
[2]Sport, Health and Evaluation Research Unit (UR/SSE). National Institute for Youth, Physical Education and Sport (INJEPS), University of Abomey-Calavi (UAC). 01 BP: 169. Porto-Novo (Benin).
[2]Laboratory of Physiology of Effort. National Institute for Youth, Physical Education and Sport (INJEPS), University of Abomey-Calavi (UAC). 01 BP: 169. Porto-Novo (Benin).

Received *: 01/07/2024*
Received in revised form *: 14/08/2024*
Accepted *: 30/08/2024*

Corresponding Author:
Dr. Simplice Innocent Moussouami,
Laboratory of Physiology of Effort and Biomechanics (LPB). Higher Institute of Physical Education and Sport (ISEPS), University Marien Ngouabi (Congo). BP: 69
Email: simplicemoussouami@gmail.com

DOI: 10.70034/ijmedph.2024.3.115

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2024; 14 (3); 640-645

ABSTRACT

Background: The aim of this study was to compare the changes in body composition, métabolic variables and aerobic capacity induced after intensive versus extensive circuit training in obese adolescents.
Materials and Methods : This was an intervention study involving 26 overweight adolescents (15.60 ± 1.43 years old). The study participants were randomly divided into two groups : 13 of them performed the intensive circuit training (ICT) program, while the other 13 underwent the extensive circuit training (ECT) program for 12 weeks and 3 times/week. Body composition, biological markers and aerobic capacity were measured at baseline and 12 weeks after the intervention.
Results: Significant improvements in body fat mass (3.87%), body mass index (8.43%), body fat percentage (2.11%), waist circumference (3.79%) and hip circumference (3.29%) were achieved in the post-intervention ICT group. In the same group, a reduction in TC, TG and LDL-C and an increase in HDL-C were observed compared with the ECT group. Maximum oxygen consumption was improved by around 10.69% in the ICT group.
Conclusion : extensive circuit training may be particularly useful for improving the body composition, lipid profile and aerobic capacity of obese adolescents. This program may be considered as one of the therapeutic methods for the management of overweight/obese adolescents.
Keywords: Intensive circuit training, extensive circuit training, adolescents, obesity, Brazzaville.

INTRODUCTION

Obesity is known as a complex disease involving an accumulation of fat that can damage health.[1] Over the last few decades, the prevalence of obesity has risen steadily throughout the world and varies from country to country. This variability is greater in developing countries. which are undergoing a nutritional transition. This diseease has become a major health problem affecting all age groups in the world's population, including children and adolescents. However, these health problems are more common in children and adolescents.[2] Obesity is strongly linked to the development of chronic diseases, to a lack of health-related quality of life and to increased healthcare costs.[3]

Lifestyle changes aimed at increasing physical activity and reducing sedentary behaviour are recommended to reduce and treat obesity. Concomitant endurance and resistance training is often used as part of an intervention programme. To date, one of the most common methods of simultaneous training is circuit training.[4] This method promotes aerobic conditioning, muscular endurance, neuromuscular adaptations and strength in a single training session.[5] In effect, it consists of one or more series of different exercises performed in quick and effective succession, with a short rest period between exercises.[6] Intensive or high-intensity circuit training can be performed in a short time (around 7 minutes for 12 exercises). However, extensive circuit training is carried out over a much longer period and is characterised by recovery times that are longer than the physical training.

A number of studies have shown the importance of an intervention program based on circuit training in obese subjects: an 8-week circuit training program improves biological markers, body composition, isometric strength and physiological parameters in obese people.[7]

In terms of types of exercise, most studies involved high-intensity intermittent (or interval) training (HIIT) for the management of obese people, and the results are not consistent.[8] Given this literature, the results on the effect of a type of exercise on obesity remain controversial. Consequently, this study aimed to detremine the effets of extensive and intensive circuit training on body compsition, metabolic profile and physical capacity in obese adolescents.

MATERIAL AND METHODS

Participants

A total of 26 obese adolescents aged 15.60 ± 1.43 years (82,5 kg weight; 1.65 ± 1.63 m height; 32.77 ± 2.33 kg/m2 body mass index) with a BMI body index ≥25kg/m2 participated in this study. The sample size was estimated using G*Power sofware (version 3.1.9.7; Universitat Kiel, dusseldorf, Germany) using an apriori test with, an effect size of 0.25 and 0.85 statistical power reavolve round a two-tailed independent t-test. These adolescents were randomly assigned to the intensive circuit training (ICT) group (n = 13) and the extensive circuit training (ECT) group (n = 13). The two groups were homogenous regarding age, height, weight and athletic career lenght. All parents of the participants were informed of the experimental protocol of the study before signing a written informed consent form. The study was conducted in accordance with the Declaration of Helsinki and was approved by the scientific committee of Higher Institute of Physical Education and Sport (ISEPS), in Brazzaville, Congo (N°413/UMNG/ISEPS/CS). The adolescents selected for this study were all in good health and had no injuries throughout the intervention. Any participant who had engaged in regular physical activity during the previous 4 months and had shown symptoms of cardiovascular pathology was excluded from the study. In order to minimise diet-related changes in anthropometric parameters, participants were asked to follow a habitual diet and hydration state based on their drinking behaviour.

Experimental Design

Two researchers were employed to evaluate the participants. Each participant completed assimilation exercises once before the actual study. Each group followed the training program 3 times a week for 12 weeks and variables relating to body composition, biological and cardiovascular markers were measured and blood samples were taken at two points: at the start (T1) and just after (T2) of each training programme.

Anthropometric Measurements

These measurements were taken at the time of day and assessed with light clothing, without socks or shoes. An electronic scale (Omron BF 511. Kyoto. Japan) was used to measure body mass, fat mass, fat percentage and body mass index. Standing height was measured using a Seca 202 stadiometer (Seca Hamburg, Germany). Waist circumference was measured at the distance from the lowest rib to the iliac crest and hip circumference at the symphysis with a tape measure. The waist-to-hip ratio (WHR) was calculated using the equation WHR = waist circumference/hip circumference.

Measurement of heart rate and aerobic capacity

Heart rate and other study parameters were measured at the begiming and the end of each exercise. It was measured at rest (Fco) in a seated position after 10 minutes' rest using a pulsometer watch (Polar V800. Finland). To define training intensity, maximum Fc (Fcmax) was predicted using the formula 208 - (0.7 x age).

Aerobic capacity was measured within the 6-minute run test (6MWT). Participants walked for as long as possible in a 30 m indoor corridor with markers every 3 m along its length. The turnaround point was marked by a cone and the start line was drawn on the ground with tape to mark the beginning and end of each lap. Peak VO2 was calculated with the American College of Sports Medicine (ACSM) peak VO2 formula = (0.02*distance [m] - (0.191*age [year]) - 0.07*weight [kg]) + (0.09*height [cm]) + (0.02*pressure rate product [*10-3]) + 2.45 based on the total number of metres covered by the participants.

Measurement of Biochemical Markers

Blood samples were taken systematically after 8 hours of nocturnal sleep, in a standardised semi-recumbent position, by the same nurse, from the antecubital vein. Those blood samples were immediately placed on ice and centrifuged for 10 minutes at 1500g (4°C). The decanted plasma was aligotated and then frozen at -80°C until assayed, total cholesterol (TC), triglycerides (TG), high-intensity lipoprotein cholesterol (HDL) and low-intensity lipoprotein cholesterol (LDL) were analysed by enzymatic calorific assay.

Training programs (Table 1)

A familiarisation session was carried out by the participants at the start of each program. The intervention was organized over 12 consecutive weeks with 3 weekly sessions. Each training session was preceded by a standardised 15-minute warm-up.

The warm-up consisted of low-intensity running (50% of HRmax), acceleration over a distance of 15 m and dynamic stretching. The circuit training consisted of 12 exercises, focusing mainly on the lower limbs, core and trunk muscles, and upper limbs for each group. The repetitions in each group lasted from 30 to 75 minutes, but were spaced 5 minutes apart for the RCI group and 20 minutes apart for the RCE group. The following exercises were performed frequently during each circuit : 1) Bouncing strides and sprints, 2) Squats, 3) Sheathing, 4) Abs, 5) Jumping with feet together over blocks, 6) Sheathing, 7) Squat with ball, 8) Cruch, 9) Sheathing, 10) Knee flexion and extension, 11) Hip rotation exercise, 12) Jumps.

Table 1: Training programs

	Weeks (1-2-3)	Weeks (4-5-6)	Weeks (6-7-8)	Weeks (9-10-11)
Intensive circuit training	3x (2x5min) (2:1) HR : <80 bpm R=5min	3x(3x6min) (2:1) HR :80-89 bpm R=5min	3x(3x6min) (2:1) HR : 90-100 bpm R=5min	3x(4x6min) (2:1) HR : >100 bpm R=5min
Extensive Circuit training	3x (2x5min) (1:2) HR : <80 bpm R=5min	3x(3x6min) (1:2) HR : 80-89 bpm R=5min	3x(3x6min) (1:2) HR : 90-100 bpm R=5min	3x(4x6min) (1:2) HR : >100 bpm R=5min

Example: 3× (2× 5 min) (2:1) means that each subject must complete the circuit in 5 min, with each training session consisting of three sets of two repetitions each. (2:1): represents the ratio between the exercise period and the recovery period, indicating that the work period is twice as long as the active recovery period. HR: <80 bpm represents the exercise heart rate; R : recovery between sets.

Statistical analysis

The Statistical Package for Social Sciences SPSS version 25 (SPSS Ic. Chicago. IL) was used for all analyses. The Levene and Shapiro-Wilk tests were used to assess the equality of variance and normality of the data, respectively. A repeated-masures ANOVA was applied to confirm the main effect. If there was a significant interaction effect, an unpaired t-test was used to compare values between two groups (ICT and ECT) or a paired t-test between times. All values were expressed as mean standard deviation. The significance level was set at $p < 0.05$. Effect sizes for the group x time interaction were calculated using eta squared (η 2) with the magnitude of the sizes determined as follows: small ≤ 0.001. mean ≥ 0.06 and large ≥ 0.14 for η 2. A sample size of 14 individuals per group was sufficient using a mixed model ANOVA to detect a moderate (Cohens d = 0.57) group interaction effect VO2max time with a significance level and power of 0.8.

RESULTS

The participants were 15.60 ± 1.43 years old and measured 82.4 ± 5.21 kg in body weight with 161,50 ± 6.43 cm of height, 33.6 ± 1.98 kg/m2 of BMI, 36.8 ± 5.74% of body fat percentage, 88.6 ± 6.52 cm in hip circumference and had a mean hip circumference of 97.3 ± 4.66 cm. [Table 2]

Changes in body mass, body mass index (BMI), pourcentage of body fat (%BF), waist circumference (WC) and hip circumference (Hip) were observed in obese adolescents following the circuit training programmes (table 3). Body mass decreased at about 2.9 and 0.3 respectively in the ICT and ECT groups after the intervention, with only the ICT group showing a significant decrease (F = 9.68, P = 0.006). The percentage of body fat was reduced at about 0.1 in the ECT group, although without significance, and 0.8 in the ICT group with significance (F = 13.32, P = 0.001). after the intervention. A reduction in waist circumference of 3.4 and 0.3 was observed respectively in the ICT and ECT groups after 12 weeks of intervention, with statistical significance in the ICT group. Hip circumference was reduced by 3.2 and 1.3 respectively in the ICT and ECT groups after 12 weeks of intervention with statistical significance in both groups. [Table 3]

The 12-week circuit training intervention induced significant changes in resting heart rate and VO2peak in obese adolescents. Heart rate decreased by 3.5 and 0.1 respectively in the ICT and ECT groups after the 12-week intervention with statistical significance in the ICT group (F = 23.45, P = 0.002) and showed an interaction effect between the two groups. The ICT group showed a significant increase in VO2max of 1.7 (F = 15.32, P = 0.001) compared with the ECT group (of 0.4) with no significant difference. [Table 4]

Analysis of variance showed a significant interaction for total cholesterol levels (p = 0.005: $\eta 2 = 0.001$) total cholesterol; triglycerides (p = 0.001; $\eta 2$ = 0.004), ligth- intensity lipoprotein cholesterol (p = 0.001 $\eta 2$ = 0.002), high- intensity lipoprotein cholesterol (p = 0.005 $\eta 2 = 0.003$). The difference in total cholesterol was 1.03% for the ICT group compared with 0.4% for the ECT group. Similarly, the % differences were for triglycerides 5.7% and 0.6%, LDL 3.2% and 1.6% and HDL 12.1% and 0.8% for the ICT and ECT groups respectively. [Table 5]

Table 2: Change in body composition after 12 weeks of training

Variable	All group	ICT	ECT	*P-value*
Age (years)	15.60 ± 1.43	15,49 ± 1,14	15,74 ± 1,21	0.53
Height (m)	161,50 ± 6.43	161,77 ± 5.61	161,89 ± 7.12	0.06
Weitgh (kg)	82.4 ± 5.21	82.5 ± 5.55	82.4 ± 5.12	0.78

BMI (kg/m²)	33.6 ± 1.98	33.2 ± 1.94	32.3 ± 2.47	0.06
BF%	36.8 ± 5.74	37.9 ± 6.48	36.4 ± 5.85	0.01
WC (cm)	88.6 ± 6.52	89.7 ± 7.26	88.6 ± 4.21	0.56
Hip (cm)	97.3 ± 4.66	97.1 ± 4.71	97.7 ± 4.57	0.02

The values in the tables are presented as the mean ± standard deviation: BW: body weight; BMI: body mass index; BF%: percentage of body fat; WC: waist circumference; Hip: hip circumference; ICT: intensive circuit training group; ECT: extensive circuit training group.

Table 3: Change in body composition after 12 weeks of training

Variable	Group	Baseline	After		*F*	*P-value*
Weitgh (kg)	ICT	82.5 ± 5.55	79.3 ± 6.00	Time	75.71	0.001
	ECT	82.4 ± 5.12	82.1 ± 4.94	Group	6.00	0.28
	t	*0.07*	*0.25*	Time x group	9.68	0.006
	p	*0.78*	*0.62*			
BMI (kg/m²)	ICT	33.2 ± 1.94	30.4 ± 1.88	Time	31.71	0.00
	ECT	32.3 ± 2.47	32.1 ± 2.49	Group	5.81	0.30
	t	*0.01*	*0.33*	Time x group	15.32	0.001
	p	*0.99*	*0.51*			
BF%	ICT	37.9 ± 6.48	37.1 ± 6.86	Time	39.86	0.001
	ECT	36.4 ± 5.85	36.3 ± 5.77	Group	0.03	0.86
	t	*0.01*	*0.42*	Time x group	13.32	0.001
	p	*0.99*	*0.52*			
WC (cm)	ICT	89.7 ± 7.26	86.3 ± 6.32	Time	45.45	0.00
	ECT	88.6 ± 4.21	88.3 ± 4.25	Group	0.09	0.96
	t	*0.56*	*9.96*	Time x group	16.11	0.001
	p	*0.41*	*0.09*			
Hip (cm)	ICT	97.1 ± 4.71	93.9 ± 4.51	Time	8.13	0.013
	ECT	97.7 ± 4.57	96.4 ± 4.43	Group	6.13	0.027
	t	*0.02*	*5.02*	Time x group	8.59	0.004
	p	*0.88*	*0.01*			

The values in the tables are presented as the mean ± standard deviation: BW: body weight; BMI: body mass index; BF%: percentage of body fat; WC: waist circumference; Hip: hip circumference; ICT: intensive circuit training group; ECT: extensive circuit training group.

Table 4: Variation in cardiorespiratory parameters after 12 weeks of training

Variable	Group	Baseline	After		*F*	*P-value*
HR (bpm)	ICT	75.2 ± 4.69	71.7 ± 3.71	Time	23.45	0.002
	ECT	76.3 ± 4.16	76.2 ± 4.12	Group	0.06	0.81
	t	*0.05*	*0.06*	Time x group	14.22	0.001
	p	*0.81*	*0.80*			
VO2peak (mLO$_2$/kg/min)	ICT	15.9 ± 0.77	17.6 ± 0.96	Time	80.81	0.001
	ECT	16.2 ± 0.84	16.6 ± 0.96	Group	0.05	0.92
	t	*0.38*	*0.17*	Time x group	11.67	0.002
	p	*0.54*	*0.68*			

The values in the tables are presented as the mean ± standard deviation: HR: Heart rate; VO2peak: maximun oxygen volume.

Table 5: Variation in biochemical markers after 12 weeks of training

Variable	Group	Baseline	After		*F*	*P-value*
TC (mg/dL)	ICT	154.4 ± 1.17	152.8 ± 1.61	Time	13.66	0.002
	ECT	154.5 ± 1.44	153.7 ± 1.14	Group	4.89	0.044
	t	*2.25*	*4.70*	Time x group	8.82	0.005
	p	*0.09*	*0.03*			
TG (mg/dL)	ICT	91.7 ± 4.21	86.4 ± 4.10	Time	51.67	0.001
	ECT	93.4 ± 3.19	92.8 ± 3.43	Group	3.45	0.08
	t	*0.91*	*0.01*	Time x group	10.54	0.001
	p	*0.34*	*0.96*			
LDL (mg/dL)	ICT	89.3 ± 4.28	86.4 ± 4.10	Time	65.16	0.001
	ECT	89.4 ± 3.86	87.9 ± 4.39	Group	0.06	0.81
	t	*0.01*	*0.02*	Time x group	14.36	0.001
	p	*1.01*	*0.88*			
HDL (mg/dL)	ICT	47.7 ± 5.25	53.5 ± 4.03	Time	57.32	0.001
	ECT	47.01 ± 4.54	46.6 ± 4.51	Group	6.05	0.28
	t	*0.44*	*1.08*	Time x group	9.18	0.005
	p	*0.51*	*0.31*			

The values in the tables are presented as mean standard deviation: TC: total cholesterol; TG: triglycerides; LDL-C: ligth- intensity lipoprotein cholesterol. HDL: high-intensity lipoprotein cholesterol (HDL); ICT: intensive circuit training group; ECT: extensive circuit training group.

DISCUSSION

The present study was conducted, to observe changes in body composition, cardiorespiratory parameters and biochemical biomarkers, in obese adolescents after 12 weeks of intensive circuit training and extensive circuit training. The main results of this study revealed a reduction in body mass, resting heart rate and an improvement in VO2max max in the ICT group compared with the ECT group.

An improvement in body composition variables is considered to be a strong marker of reduction of cardiovascular risk and metabolic syndromes. The results of the present study showed a significant reduction in body composition parameters in subjects in the ICT group compared with those in the ECT group. The reduction in body mass, fat percentage and waist circumference could be attributed to several factors, such as the duration and intensity of the training and the motivation of the participants. This finding is consistent with some previous studies, upholding this physical activity leading to stabilisation and/or loss of weight and therefore of body mass index, a reduction in the percentage of fat mass with maintenance or reduction of waist circumference.[9,10] Similar results are described in the study by Safarzade et al,[11] in which an improvement in body mass, BMI and WHR in obese subjects was observed after 8 weeks of training using 12 exercises per circuit and 8 to 10 repetitions for each of them. Another study reports a significant improvement in body composition in obese children after a 12-week resistance training program.[12] In the present study, the difference observed between the two groups suggests that the proposed training programs were effective in improving the various components of body composition, either through motor skills or the duration of the intervention, in line with recommendations on physical exercise.

After 12 weeks of intervention, VO2max was greater in the ICT group than in the ECT group. This difference can be attributed to the increase in the slow component of VO2 due to the great fatigue of the motor units during eccentric concentration, forcing the recruitment of additional motor units to achieve the same work rate.[13] During intensive circuit training, this increase in mechanical demands was accompanied by an increase in heart rate. Another plausible explanation for this difference is the characteristics of interval training, which reduces lactic acid production and improves phosphocreatine utilisation during exercise.[14] VO2max has been shown to be highly sensitive to high-intensity training. As suggested by meta-regression and meta-analysis, high-intensity exercise is ideal for improving VO2max.[15] due to acute parasympathetic regulation.[16] These results are consistent with the available literature, which suggests that circuit training improves VO2max and that this improvement is greater than the intensity of the exercises.[15,17] In the same context, a recent study showed that combined circuit training for 12 weeks significantly improved maximal oxygen consumption in obese people.[18]

In addition to body composition and maximal oxygen consumption, intensive circuit training had a greater effect than extensive circuit training on plasma concentrations of TC, TG, HDL-C and LDL-C. Previous studies have suggested that, taking into account intensity, frequency and time, regular exercise reduces the blood concentration of TC, TG and HDL-C that lead to arteriosclerosis and increases the level of HDL-C for vascular improvement (19,20). These results are consistent with those of a study which reported significant improvements in the lipid profile of obese subjects after progressive resistance circuit training.[21] In the lipid profile literature, a recent study also showed significant differences in the lipid profile of a group of obese people after 12 weeks of exercise compared with baseline.[22] However, other authors reported no significant differences in lipid parameters after 8 weeks of exercise.[23,24]

There are a number of limitations to this study which should be noted when interpreting the results observed. Firstly, the sample was small, which means that the results cannot be generalised more widely. Secondly the population only included young people with moderate obesity. This makes the results unsuitable for all obese children. Future research should take into account the effect of an intensive circuit training programme in all categories of obesity. In addition, the proposed intervention programs did not include any calorie restriction, despite the fact that low-calorie diets are known to improve body composition and metabolic markers. An additional limitation of this study is that, visceral fat was not measured to determine its effect on improving inflammatory parameters. Another potential limitation of the analyses, in this study, is the use of inflammatory markers that were only measured once.

Innovation and applications

This study has shown that intensive circuit training is an effective means of improving anthropometric, cardiorespiratory and lipid parameters in obese adolescents, compared with an extensive circuit training exercise program.

Indeed, although the literature has always emphasized the benefits of exercise in obese people, this work proposes a non-drug, less expensive but promising therapeutic method for the management of this population.

CONCLUSION

These results suggest that 12 weeks of circuit training can improve body composition, cardiorespiratory fitness and lipid profile in obese adolescents. Intensive circuit training can be considered as an effective intervention approach to improve exercise engagement in obese adolescents, in the context of weight control and lipid profile. However, additional multidisciplinary interventions involving nutritional education are needed to accelerate the effects of weight loss in this population.

Acknowledgment

The authors wish to acknowledge the participants for their voluntary participation in the study.

Funding

This research was supported by the Research Program of Marien Ngouabi University through the Laboratory of Physiology of and Biomecchanics (LPB), the Higher Institue of Physical Education and Sport, which provided the funding.

Conflict of Interest

The authors state no conflict to interests.

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