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Effects of circuit exercise training on cardiorespiratory indices, body image, and body composition of obese undergraduates at a Nigerian University

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Abstract

Introduction. Obesity is a disease that adversely affects quality of life, mortality and morbidity, and is associated with a sedentary lifestyle. This study evaluated the effect of circuit-exercise training on the cardiorespiratory indices, body image, and body composition of obese undergraduate students.

Methods. Ninety obese undergraduates (69 females and 21 males) were assigned to either a circuit-exercise training group or a non-exercise/control group. The exercise program consisted of 40 minutes of circuit-training (resistance and aerobic) sessions, performed 3 times per week for 6 weeks. The participants rotated between the stations with a 20 second rest in between; as well as warm up and cool down periods. Moderate exercise-intensity was performed at 50%–70% of the age-predicted heart rate reserve. Pre (baseline) and post (6 week) values of cardiovascular parameters, body image, and body composition parameters were evaluated. Demographic data were summarized with descriptive statistics while significant differences within and between the groups were determined using paired and independent sample *t*-tests, respectively. Statistical significance was accepted for all tests at a value of $p < 0.05$.

Results. Findings from the results showed no significant difference in the mean body image, body mass index, and waist-hip ratio between the groups ($p > 0.05$). A significant difference was observed between the groups ($p < 0.05$) in the mean aerobic capacity, systolic and diastolic blood pressure, heart rate, percentage body fat, and muscle mass.

Conclusions. The 6-week circuit training had a favourable but not significant effect on body image. Aerobic capacity, cardiovascular parameters, and some body composition parameters had a significant change.

Key words: circuit training, obesity, cardiorespiratory fitness, body composition, body image

Introduction

Obesity is a medical condition depicted by the accumulation of excess body fat stored to an extent that may negatively affect health [1]. Studies have reported a steady rise in the obese population and have attributed this to a decline in physical activity and excessive intake of food [2]. A lack of exercise / sedentary lifestyle is considered to be one of the most important health concerns associated with modern society [3]. This is implicated in the development of many chronic illnesses and disorders, and increased risk factors for the rise in cardiovascular disease [4]. The emergence of illnesses can greatly be reduced through regular exercise. Hence exercise performance is known to be linked to body weight loss and a reduction in all-cause mortality and chronic diseases, such as cardiovascular disease and diabetes, leading to an increased life expectancy and mitigating the negative health impact of obesity [5]. In addition, it has a positive impact on the psychological well-being and body image of an individual [6].

Body image (BI) is also an individual's psychological and mental experience of the appearance of their body [7]. Beliefs regarding some sort of perfect body image, the tendency for people to compare themselves to others, and a sense of insecurity are some of the major psychological correlates of body image satisfaction. There is strong evidence of a negative perception of body image by most women and girls [8]. Many are not satisfied with their body size and weight since slimness is seen as the fascinating standard and beauty model, especially for young women [9]. Body image may be seen to be the fulcrum of the mutual influences of the physique, dietary and exercise lifestyle on each other. It is a determining factor of self-esteem which includes perceptual, affective, and mental components, which are based partly on the composition of an objective anthropometric representation [9].

Furthermore, body image literature has the most commonly used body mass index (BMI) as an anthropometric measure. While it is inversely associated with body satisfaction [10], BMI has been criticized because it does not discriminate/differentiate between fat mass and fat-free mass. Body composition is the proportion of fat mass and fat-free mass in the body. Body fat is a measurement of body composition that estimates the amount of body weight that is fat, while fat-free mass is the percentage of body weight that is not fat. Body percentage fat is the total weight of body fat divided by body weight, and consists of storage and essential body fat [11]. Excessive body fat or obesity is linked to

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increased metabolic risk, and its measurement is vital in implementing preventive and curative health strategies [11]. Generally, people are considered obese when their BMI (body weight divided by the square of the height) is ≥ 30 kg/m^2. The unceasing epidemic of obesity in adults and children has brought to the fore the implication of body fat in short term and long-term health. Obesity is a preventable but leading cause of death worldwide, with increasing incidences occurring in children and adults [1]. The American Medical Association classified obesity as a disease in 2013 [12].

However, the long-term fitness and health benefits of exercise performance include the reduction of risk factors of most chronic diseases as well as the improvement in muscle strength, endurance, flexibility, body composition, and cardiorespiratory functions [13]. In the past, many guidelines focused on one mode of resistance training or aerobic training to facilitate weight loss or weight maintenance, but recent facts are emerging that circuit exercise training can also be effective for reducing fat mass [14].

Circuit exercise training (CET) is a type of combined-training which includes both multi-joint resistance training and aerobic exercise. Some researchers have suggested that a CET composed of endurance and resistance training may be preferred to one focused only on a single mode of exercise [14]. The training session includes several stations where different exercises are performed for a set time, and after the appointed time the station is changed as quickly as possible. Both resistance training and aerobic training are prescribed for obese individuals, because they promote heart rate and blood pressure regulation, body composition, biochemical markers, as well as muscle strength and aerobic capacity [15, 16]. However, beyond these, another goal may include improving body image, which is associated more with psychological well-being than with physiological well-being. With these findings, indulging in exercise has been proved to be vital for the prevention and treatment of physiological and psychological problems in the obese population. Hence, this study is focused on ascertaining the effects of 6 weeks of circuit exercise training on body image, cardiorespiratory parameters, and body composition of obese undergraduate students.

Subjects and methods

Research design

A pre and post controlled randomized study.

Sample size

The sample size was calculated as 30 using a power analysis that showed that to get a small effect size (d = 0.95) at a power of 0.8 and 0.05 level of significance, a minimum sample size of 30 subjects is needed. Therefore, a minimum of 30 subjects was needed for this study.

Subject selection

The database of the students was accessed from the students' affairs department of the campus where the study was carried out. Text messages and e-mail were sent to students informing them of the study and requesting them to declare an interest. One hundred and seventy students declared an interest and were invited to the study. However, only one hundred and twenty students eventually reported for the study. One hundred and one met the selection criteria for participation in the study. Inclusion criteria were healthy obese undergraduate who were willing and available to participate in the study, BMI ≥ 30 kg/m^2, age 18 years and above. Exclusion criteria were students with BMI < 30 kg/m^2, students who are currently on an exercise program, students who are on dietary restriction, presence of contraindications to exercise testing and training, students with significant cognitive impairment or inability to follow instructions, and students who are pregnant. A total of one hundred and one subjects were recruited for the study (50 subjects in the control group and 51 subjects in the study group). The control group also received dietary counselling once a week for 6-weeks. The subjects were made up of 69 females and 21 males, as eleven subjects did not complete the course. Five dropped out of the control group while four dropped out of the experimental group while the remaining two did not attain the eligibility of 70% attendance during the exercise training. All the subjects were sedentary and were assigned either to the study or control group randomly. The fishbowl simple random sampling method was used to randomize subjects into the study group (51 subjects) or control group (50 subjects). Numbers were written on cards and draws were made.

Instruments

An adapted body image questionnaire from the cosmetic procedures screening questionnaire (COPS) was used to assess the body image of the subjects. This questionnaire was a nine-item self-report measure of body dysmorphic disorder (BDD) symptoms. It generated a total score ranging from 0 to 72. It measured the severity of BDD symptoms and identified people with BDD. A positive and negative affect score was used in assessing the impact of the CET on the body image of the subjects. The COPS had good internal consistency (α = 0.86–0.91), good test-retest reliability, evidence of single-factor structure, and moderate to good corrected item-total correlations (r = 0.41–0.86) [17].

OMRON Body composition monitor (BF511, OMRON HEALTHCARE Co. Ltd, Kyoto Japan) was used to measure body composition. This was the main unit, with a pair of electrodes for the foot and a display unit with a pair of electrodes for the handgrip. The main unit was connected to the display unit via a cord. It used the bioelectrical impedance method to measure the body fat (BF) percentage. Age, height, gender, and weight of the subjects were input, and these parameters were taken into consideration to generate the following body composition parameters: total BF (%), visceral fat (VF) (%), BMI, body weight (BW), muscle mass (MM), and resting metabolic rate. This unit was considered to be a valid assessor of body composition parameters [18].

Tape rule (HD2020, Shanghai Kearing Stationery Co., Ltd., Shanghai, China): The waist circumference (WC) in centimetres was measured with a non-elastic tape measure, which ranged from 0–150 cm.

Stadiometer: A locally constructed stadiometer made of wood and calibrated in centimetres (cm) was used to measure the height of the subjects.

Digital exercise Metronome (JM-06, Superior Medical Equipment Inc, Wilmington, United States of America): A digital metronome provided a rhythmic cadence that produced a steady pulse (or beat) that helped maintain an established tempo during the exercise sessions. Used to achieve uniformity in the movement of subjects during the exercise sessions.

Digital sphygmomanometer (HEM7120, Omron Healthcare Co. Ltd, Kyoto, Japan): Used for checking the systolic and diastolic blood pressure.

Kadio Stopwatch (KD-1063, Takshun electronic Co. Ltd, Fujian, China): Used to track the duration of the exercise sessions.

Exercise mats (Dynamos 18 cm × 60 cm × 15 cm, Decathlon, UK): Used for resistance exercises during the circuit training sessions that require lying down, e.g. crunches.

Procedure for data collection

The subjects were tested at the University indoor sports gym. They were given the aims, procedures, and task requirements for the data collection. They were informed about their roles and benefits, while also assuring them of confidentiality during the study.

The subjects in both groups were placed on a diet plan by a dietician. They were encouraged to eat healthy, properly cooked, balanced diets and to eliminate the intake of "junk foods", which was customary of undergraduates. They were instructed not to skip nor eat between meals. They were given specific times to take each meal of the day and asked not to take more than one proportionate serving per meal.

Cardiorespiratory indices

The vital signs were taken at the beginning and end of each exercise session. The pulse rate was measured in beats per minute (bpm), for a full one minute using a stopwatch. A sphygmomanometer was used together with a stethoscope for measuring the blood pressure in millimetres per mercury (mm Hg). Cardiorespiratory fitness or maximum oxygen consumption (VO_2max) was predicted using the heart rate ratio method [19]. The formula was as follows: VO_2max (ml · min^{-1} · kg^{-1}) = 15.0 × (HRmax / HRrest). HRmax = (220 – age), HRrest = Heartbeats/1 minute. All values were taken at baseline and at 6 weeks.

Body composition

The height of each subject was measured by instructing them to stand in an upright position in front of the stadiometer without wearing any footwear. The reading from the stadiometer was taken with a ruler placed horizontally on the vertex of the head of the subject. The readings were read off to the nearest 0.1 centimetre [20].

OMRON BF511 was used to measure the weight (kg), as the subject stepped on the main unit while barefoot, standing upright with feet placed on the foot electrodes with the weight evenly distributed.

OMRON BF511 measured the following parameters: BMI (kg/m^2), Visceral fat (VF) percentage, body fat (BF) percentage and skeletal muscle mass (MM) using the bio-electric impedance to determine the body composition integrating information of weight, age, height, and gender to generate results based on omron's data of the body composition.

Waist and hip circumference

Subjects stood in an upright position, and measurement was taken between the lower costal border and the iliac crest at the narrowest point at the end of normal expiration. The subject's arm was placed in abduction so that the tape could be passed around the abdomen with ease [20]. Measurement of the hip circumference was taken with the patient in a standing position with the arms folded across the chest, the feet together and the gluteal muscles relaxed [20]. Measurements were taken at the level of the greatest posterior protuberance of the buttocks. The waist-hip ratio was calculated pre (baseline) and post (at 6 weeks).

An adapted body image questionnaire was handed over to all the participants to either complete on-site or take home as they deemed fit. The questionnaire was issued at baseline and at 6 weeks.

Circuit exercise training (CET)

Prior to the initiation of exercise training, the subjects were acquainted with the techniques required for the proper performance of the exercise. The subjects were trained 3 times a week (with at least 1 day of rest between sessions) and 60 minutes per session for 6 weeks under the supervision of a physiotherapist. A physician who was also part of the team was always on standby in case of any emergency during the exercise session. The warm-up and cool-down periods were integrated into each exercise session involving 10 minutes of low-intensity and light stretching activities. The CET included a mixture of 10 types of both resistance and aerobic exercise. The resistance exercises included squats, crunches, push-ups, superman exercises, and side lunge exercises, while the aerobic exercises included light jumping, running on the spot, jumping jacks, foot-stamping, and walking in place. Each exercise in the training program was performed for 60 seconds with a resting time of 20 seconds between stations and 3 minutes between sets. Two to four sets of the exercise were performed per session. The rest period and the number of repetitions were adjusted as the week progressed and the fitness level of the subjects increased. Table 1 shows the progress of the CET. The exercise was performed at a moderate intensity level of 50%–70% of the predicted maximum heart rate. The target heart rate was calculated by the Karvonen formula using the heart rate reserve (HRR) [21].

HRR = (220 – age) – resting heart rate (HRrest)

Target Heart rate = (HRR × % intensity) + HRrest

Data analysis

The data were summarized using descriptive statistics of mean, standard deviation, percentages and frequency. The normality of data distribution was tested and confirmed by the Shapiro–Wilk test. The mean differences in variables

Table 1. Circuit exercise training programme progression

Parameter	Type	Events	Intensity
Warm-up	Dynamic stretching		40%–50% HRmax
Circuit training	Resistance exercise	Push-ups, squats, crunches, lunge and superman exercise	Weeks 1–3, 50%–60% HRmax
	Aerobic exercise	Light jumping, running on the spot, foot stamping, steps, jumping jacks	Weeks 3–6, 60%–70% HRmax
Cool-down	Static stretching		40%–50% HRmax

HRmax – maximum heart rate

between the groups were compared using an independent sample *t*-test while the mean differences of variables within the group were tested with the paired *t*-test with the Alpha level set at $p < 0.05$. A statistical package for the social sciences (SPSS version 21) was used to analyse all the data.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the University of Nigeria Teaching Hospital (approval No.: NHREC/05/01/2008B-FWA00002458-1RB 00002323).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

A total of 90 subjects (45 in the control group and 45 in the study group) in the age range of 18–29 years completed the study. All measurements were taken pre (baseline) and post (at 6-week) and the results were analysed at $p < 0.05$ and a confidence interval of 95%. The sociodemographic characteristics of the subjects are summarized in Table 2 below. There were no significant differences in the baseline parameters between the groups.

The between-group comparison showed a significant difference in all the cardiorespiratory parameters ($p < 0.05$) post-intervention (Table 3). The within-group comparison (Table 4) in the study group also showed a significant difference in cardiorespiratory parameters ($p = 0.01$). Comparison of body composition between the groups (Table 5) post-intervention showed a significant difference only in MM, WC, and % body fat ($p < 0.05$)

Body Image and all the body composition parameters revealed a significant difference ($p < 0.05$) within the study group (Table 6), while only BI, BMI, %BF, and MM showed a significant difference ($p < 0.05$) within the control (Table 6).

Discussion

The results from this study revealed significant differences between the mean scores of body image within the study and control groups, post-intervention. However, there was an improvement in the body image between the study and control groups, although it did not attain a significance level. This finding is in agreement with the results of a similar study which found out that college females who exercised for maintenance of a healthy weight or enhanced tone had lower body satisfaction, and that those who exercised for the purposes of fitness and health had enhanced body satisfaction [22]. On the contrary, another study showed that participation in 6-week strength CET enhanced the body image of Slovakian primary school females [23]. Also, it was revealed that an im-

Table 2. Socio-demographic statistics of participants

Variable		Control group ($n = 45$) (mean ± *SD*)	Study group ($n = 45$) (mean ± *SD*)	*t*-value	*p*-value
Age (years)		21.40 ± 3.12	21.36 ± 4.14	0.218	0.525
Height (m)		1.67 ± 6.35	1.67 ± 5.85	0.039	0.782
		Frequency [n (%)]	Frequency [n (%)]	Total [n (%)]	
Gender	Male	8 (8.9%)	11 (12.2%)	19 (21.1%)	
	Female	37 (41.1%)	34 (37.8%)	71 (78.9%)	
Ratio	Male:Female	1:3	1:3.6	1:3.7	
Total		45 (50%)	44 (50%)	90 (100%)	

Table 3. Comparison of cardiorespiratory parameters between the groups

Variable	Study group ($n = 45$) (mean ± *SD*)	Control group ($n = 45$) (mean ± *SD*)	*t*-value	*p*-value
Pre				
SYS (mm Hg)	133.2 ± 12.13	131.7 ± 14.66	0.312	0.76
DYS (mm Hg)	86.53 ± 10.28	85.8 ± 12.04	0.179	0.86
HR (b/min)	10 6.83 ± 12.43	105.73 ± 12.53	2.423	0.16
VO_{2max} (ml · min^{-1}· kg^{-1})	26.11 ± 3.95	25.27 ± 2.48	0.64	0.53
Post				
SYS (mm Hg)	120.6 ± 7.30	132.00 ± 15.03	2.64	0.01*
DYS (mm Hg)	77.7 ± 5.50	85.60 ± 12.33	2.27	0.03*
HR (b/min)	93.0 ± 6.88	105.00 ± 3.07	24.37	0.03*
VO_{2max} (ml · min^{-1}· kg^{-1})	48.20 ± 3.00	27.73 ± 5.82	9.77	0.01*

SYS – systolic blood pressure, DYS – diastolic blood pressure, HR – heart rate, VO_2max – maximum oxygen consumption in one minute
* statistical significant difference

Table 4. Comparison of cardiorespiratory parameters within the groups

Variable	Pre (mean ± *SD*)	Post (mean ± *SD*)	*t*-test	*p*-value
Study group				
SYS (mm Hg)	133.2 ± 12.13	120.6 ± 7.30	4.065	0.01*
DYS (mm Hg)	86.53 ± 10.28	77.7 ± 5.50	3.355	0.01*
HR (b/min)	10 6.83 ± 12.43	93.0 ± 6.88	4.163	0.01*
VO_{2max} (ml · min^{-1}· kg^{-1})	26.11 ± 3.95	48.20 ± 3.00	4.260	0.01*
Control group				
SYS (mm Hg)	131.7 ± 14.66	132.0 ± 15.03	1.00	0.33
DYS (mm Hg)	85.8 ± 12.04	85.6 ± 12.33	0.218	0.83
HR (b/min)	105.73 ± 12.53	105.00 ± 3.07	0.095	0.93
VO_{2max} (ml · min^{-1}· kg^{-1})	25.27 ± 2.48	27.73 ± 5.82	1.08	0.30

SYS – systolic blood pressure, DYS – diastolic blood pressure, HR – heart rate, VO_2max – maximum oxygen consumption in one minute
* statistical significant difference

Table 5. Between group comparisons of body image and body composition parameters

Variable	Study group (*n* = 45) (mean ± *SD*)	Control group (*n* = 45) (mean ± *SD*)	*t*-value	*p*-value
Pre				
BI	43.53 ± 8.76	41.3 ± 9.04	0.677	0.50
BMI	34.6 ± 3.76	33.2 ± 3.11	1.169	0.25
BF (%)	42.9 ± 6.81	46.4 ± 5.81	1.550	0.13
MM (%)	27.0 ± 4.01	24.1 ± 2.92	2.228	0.34
WC (cm)	100.07 ± 7.29	99.6 ± 12.37	0.444	0.66
HC (cm)	119.7 3 ± 9.33	118.3 ± 7.67	–0.61	0.55
WHR	0.837 ± 0.058	0.87 ± 0.805	1.32	0.20
Post				
BI	34.5 ± 8.76	38.7 ± 10.01	1.14	0.26
BMI	32.5 ± 3.34	32.8 ± 3.02	0.24	0.81
BF (%)	38.4 ± 4.23	44.8 ± 5.45	3.60	0.01*
MM (%)	29.9 ± 2.90	25.1 ± 2.69	4.727	0.01*
WC (cm)	92.0 ± 9.99	97.6 ± 12.42	–3.663	0.002*
HC (cm)	114.2 ± 8.69	112.3 ± 7.47	13.92	0.001*
WHR	0.808 ± 0.088	0.868 ± 0.819	1.94	0.06

BI – body image, BMI – body mass index, BF – body fat, MM – muscle mass, WC – waist circumference, HC – hip circumference, WHR – waist-hip ratio
* statistical significant difference

Table 6. Within group comparison of body image and body composition

Variable	Pre (mean ± *SD*)	Post (mean ± *SD*)	*t*-test	*p*-value
Study group				
BI	43.53 ± 8.76	34.5 ± 8.76	5.397	0.01*
BMI	34.6 ± 3.76	32.5 ± 3.34	6.129	0.01*
BF (%)	42.9 ± 6.81	38.4 ± 4.23	4.265	0.01*
WC (cm)	100.07 ± 7.29	92.0 ± 9.99	6.12	0.001*
HC (cm)	119.73 ± 9.33	114.2 ± 8.69	4.50	0.001*
MM (%)	27.0 ± 4.01	29.9 ± 2.90	–4.64	0.01*
WHR	0.837 ± 0.058	0.808 ± 0.088	2.560	0.002*
Control group				
BI	41.3 ± 9.04	38.7 ± 10.01	2.722	0.02*
BMI	33.2 ± 3.11	32.8 ± 3.02	2.638	0.02*
BF (%)	46.4 ± 5.81	44.8 ± 5.45	4.491	0.00*
WC (cm)	24.1 ± 2.92	25.1 ± 2.69	1.52	0.96
HC (cm)	114.3 ± 7.67	112.3 ± 7.47	0.96	0.09
MM (%)	24.10 ± 2.92	25.10 ± 2.69	–4.81	0.01*
WHR	0.87 ± 0.805	0.868 ± 0.819	0.349	0.73

SD – standard deviation, BI – body image, BMI – body mass index, BF – body fat, MM – muscle mass, WC – waist circumference, HC – hip circumference, WHR – waist-hip ratio
* statistical significant difference

provement in various dimensions of the body image can be achieved by a relatively short duration circuit-weight training for college males and females in the USA [24]. However, it should be noted that the six-week intervention utilized in this study improved the perception of body image but the observed improvement was not statistically significant between the groups. This may be attributed to the fact that the previous studies did not specifically target obese subjects. In addition, some of these studies involved only female subjects. Also, the age difference between the subjects of this study compared to previous studies may have contributed to the disparity in the results. The short duration of the present study may not have provided adequate time for a significant effect to be observed, considering the fact that the control group also received dietary counselling which may also have had an effect on the body image. The positive effect of exercise on the perception of body image maybe due to improvement or raised confidence in self-efficacy, improved fitness level and

ability and enhanced awareness of physical function. Dietary counselling, as well as exercise, resulted in obvious changes in both BMI and BI, as people feel better about their body when they observe positive changes in their body composition. This may explain the no statistical significance in BI when compared between the groups.

The present study reported a mean significant difference in the score of the cardiorespiratory fitness/aerobic capacity (VO_{2max}) between the study and control group post-intervention. This corroborates with the results of a meta-analysis which demonstrated that resistance CET had an overall significant and large effect on VO_{2max} (average of 9.7%) in different populations [25]. Thus, the result of the present study has proven that CET can be a relevant intervention that improves the cardiorespiratory fitness and health status of obese individuals. It appears that adequate training intensity or stimulus and a short rest interval seem to be key in eliciting changes in aerobic capacity.

The mean significant difference in heart rate recorded between the groups post-intervention was in consonance with the results of Mogharnasi et al. [26], which reported that heart rate had a significant change compared to the control group after 8 weeks of CET among obese male students. Also, the results by Miller et al. [27] showed that high-intensity circuit-training in sedentary obese men revealed a significant improvement in resting HR (16% decrease). Therefore, it is most likely that the 6 weeks duration of the exercise in this study was of an appropriate intensity to cause a significant change in resting heart rate. This can buttress the marginal effect of exercise intensity and duration on the resting heart rate. The ability of the heart rate to recover after exercise depends on the extent to which the cardiovascular system functions to reverse the autonomic nervous system stimulants and adjusts the pressure receptors that are involved during exercise. Heart rate initial decrease was due to the reactivation attempts of parasympathetic nerves, with the slowed decrease due to continued activity of the parasympathetic nerves and the decreased impact of sympathetic nerves [28].

There was also a significant difference in the mean blood pressure (SBP and DBP) between the study and control group post-intervention. This is in consonance with Getty et al. [3] who reported a significant reduction in central blood pressure, following a 4-week circuit CET intervention. In their study, it was asserted that though the mechanism was not examined, reduced central blood pressure may be associated with a decreased vascular resistance relating to the enhanced endothelial function (flow-mediated dilatation) and structure (carotid artery intima-media thickness). The reduction in blood pressure in this present study may be further explained by the postulation, which states that a relationship exists between blood pressure and body composition; and that increased blood pressure is often associated with excess body fat, as such exercise for weight loss is often recommended as a strategy for decreasing blood pressure [29]. The lower blood pressure associated with the study group is believed to be caused by a continuous reduction in systemic vascular resistance. Contributing to this effect is the signalling of the production and release of nitric oxide and prostacyclin from the vascular endothelium activated by the action of accumulated metabolites from the skeletal muscle during exercise, which encourages enhanced vasodilation through relaxation of the vascular smooth muscle [30].

The results of this study indicated that CET significantly decreased the percentage of body fat following the 6-week intervention. Previous studies [31, 32] also reported the same findings in their 12-week CET among obese individuals. Hence, these findings indicate that CET improves body fat in the obese population. This study showed a significant difference in the mean muscle mass between the study and control group post-intervention. This was supported by the findings of a similar study which indicated that exercise could significantly increase the lean body mass of obese people [33]. The study of Miller et al. [27] also proved that short-term high-intensity circuit training produced a significant improvement (2% increase) in lean muscle tissue percentage. Contrary to these findings, Kim et al. [31] reported that there were no significant differences in muscle mass between the groups post-intervention. They implied that the difference in the outcomes of their study is likely to be a result of different types of exercise, time, duration, and intensity utilized.

The findings of this study also showed no significant difference in the mean BMI between the study and control group. This was in agreement with the result of a similar study that utilized a 10-week CET with no significant difference in body weight and, invariably, BMI [34]. They suggested it was likely due to the relatively low loads of resistance exercise used in the study. Several research works have reported contradictory findings. A meta-analysis revealed that CET is effective in reducing body weight and BMI in adults, and particularly in those who are overweight or obese [35]. The meta-analysis reported that the extent of weight reduction had a tendency to increase with an increase in the average BMI of the participants. It is imperative to recognize that these studies did not place the participants in the control group on dietary counselling. The short duration of the present study may not have provided adequate time for a significant effect to be observed, considering the fact that the control group was also placed on dietary counselling, which may also have an effect on the BW and invariably on the BMI. However, the present study did not measure the calorie intake of the subjects. The result of this study should be interpreted with caution because this study has a limitation on not monitoring the dietary progression (calorie restriction) of the subjects.

The result of this study indicated no significant difference in the mean waist-hip ratio between the study and control group post-intervention. This was in agreement with the results of Ferreira et al, [36] who reported no significant changes in waist-hip ratio and waist circumference in 14 sedentary females within the age range of 33–45 years, who participated in a 10-week resistant CET. The insignificant difference observed in the variables was in line with the literature that body composition changes take place slowly in human exercise studies and the magnitude of the change is small [37]. However, these results are at variance with the findings of Sperlich et al. [5] who observed a reduction in the waist-hip ratio of participants after high-intensity CET. The difference observed in the study may be due to the different modes of training, duration, intensity, and types of exercises adopted. However, the findings of this study may be a result of the dietary counselling which the control group was placed on. Consequently, it could be assumed that both CET and dietary counselling improves fat loss, and as such the difference in fat loss between the groups as a result of 6-week CET may not be significant. Moreover, further research for a longer period of time should be carried out to determine the combined effect of CET and 10-week only dietary counselling on the WHR of obese individuals. The calculation of calorie intake/loss and its monitoring can authenticate the effectiveness of dietary counselling as an intervention for fat loss among obese individuals.

More importantly, it is worthy of note that all the body composition parameters including visceral fat, recorded a signifi-

cant change post-intervention in the study group. This has far-reaching health implications in the obese population. Chronic inflammation has a strong positive correlation with being overweight and obesity [38]. Considering the implications of inflammation in cardiovascular disease, one of the strategies to reduce the disease is to improve body composition and inflammatory markers by adequate participation in exercise (comprising of aerobic and resistance exercises). Also, excess body fat accumulation, in particular visceral fat, is associated with insulin resistance and the occurrence of Type 2 diabetes (T2D) [39]. However, it has also been shown that adequate intensity and volume of moderate-intensity results in a decline in body fat and visceral fat, consequently reducing the risk of occurrence or incidence of T2D [39].

Conclusions

The 6-week circuit exercise intervention has proven to be an efficient method for the improvement of body image, cardiorespiratory parameters, and body composition of an obese population, specifically young adults. Participation in circuit exercise should be encouraged amongst obese individuals as they are more at risk of developing cardiovascular diseases and prone to battling with body size dissatisfaction. In addition, circuit exercise can be self-administered and as such, the economic/financial burden (in a poor developing nation) of registering in a regular gym setting for weight reduction is reduced. Physiotherapists should be involved in the multi-disciplinary team management of obesity.

Disclosure statement

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Conflict of interest

The authors state no conflict of interest.

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