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Pulmonary functions and anthropometric parameters of young male and female adults participating in moderate aerobic exercise

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ABSTRACT

Respiratory disorders may be one of the adverse effects of sedentary lifestyle. This study investigated respiratory functions (FEV_1, FVC and PEFR) and anthropometric parameters (body weight and body mass index) of healthy young males and females participating in moderate aerobic exercise. Forty young healthy untrained non-athletes, twenty males and twenty females (age, 25 ± 5.6 years; body weight, 65 ± 4.0 kg; body height, 176.9 ± 2.5 cm) volunteered to participate in this study. The exercise regimen was of moderate intensity lasting for 20 min daily on a treadmill consistently at the speed of 13 km/h for 14 days. The weight and height of participants were measured using medical scale and wall-mounted stadiometer respectively. The forced expiratory volume in 1 s (FEV_1), forced vital capacity (FVC) and peak expiratory flow rate (PEFR) were assessed using digital spirometer. The results showed a significant ($p < 0.05$) decrease in body weight and body mass index of female participants after 14 days of exercise regimen. The FEV_1, FVC and PEFR were significantly increased ($p < 0.05$) in both male and female subjects after exercise. The Pearson correlation showed a significant ($p < 0.05$) positive correlation between BMI with FEV_1/FVC% in female participants. There was an increase in calories burnt from day 4 of the study in both male and female participants. It is concluded that moderate aerobic exercise improved respiratory functions (FEV_1, FVC and PEFR) in both male and female subjects with greater improvement in females while reducing body weight and body mass index in females.

1. Introduction

Sedentary lifestyle is one of the major causes of cardiovascular related diseases such as hypertension, stroke, diabetes mellitus and myocardial infarction (Kumar and Sinha, 2020). Increase in adipose tissue due to inactivity with a resultant increase in body weight and body mass index is also associated with respiratory disorders (Li et al., 2022). There is increase mortality rate in apparently healthy individuals due to sedentary lifestyle with unknown underlined cardiopulmonary diseases (European Guidelines on cardiovascular disease prevention in clinical practice, 2012). To mitigate these anomalies, a change in sedentary behaviour towards an active lifestyle has been on the forefront of advocacy in both developed and developing countries (Dempsey et al., 2020). It is globally perceived that regular aerobic exercise can be beneficial in reducing the burden of respiratory diseases, but the immediate effects of exercise in reducing mortality rate and the burden of these diseases are uncertain.

Exercise is a subset of physical activity that is deliberate, repetitive, planned, and aimed at enhancing or maintaining physical fitness (Cheval and Boisgontier, 2021). It is any skeletal muscle-driven action of the body that requires net energy expenditure (Dasso, 2019). Aerobic exercise involves activities with lower intensity, which is performed for longer period. This type of exercise requires large amount of oxygen to obtain the energy needed (Izquierdo et al., 2021). The energy is obtained by utilizing nutrients in the presence of oxygen and hence it is called aerobic exercise (Poole et al., 2021). Examples of aerobic exercise are fast walking, jogging, running, bicycling, skiing, skating, hockey, soccer, tennis, badminton, swimming and rowing, they exert more effects on the cardiovascular and respiratory systems (Godbout and Nadeau, 2021). Exercise performed on a treadmill, ergometer, or other similar equipment are also classified as aerobic exercise (Aguiar et al., 2022).

The respiratory system is made up of the lungs and other respiratory apparatus. In the lungs exercise enhanced pulmonary ventilation and oxygen diffusion capacity accompanied by increase depth of breathing,

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thus matching ventilation with perfusion (Dhont et al., 2020). During exercise, there is increase metabolic rate due to energy demand from active muscles (Hargreaves and Spriet, 2020). The muscles require more oxygen during this process and thus the cardiovascular system and the respiratory system must work together to supply the required oxygen. In non-athletes, exercise has also been reported to induce significant modification in most of the respiratory parameters such as peak expiratory flow rate (PEFR), forced expiratory volume in 1 s (FEV_1), forced vital capacity (FVC) and FEV_1/FVC% (Sadiq et al., 2022).

Our understanding of the contribution of these parameters immediately after exercise in healthy individuals remains unclear. It is hypothesised that acute moderate exercise will increase the anthropometric parameters and improve the respiratory parameters in young adult non-athletes. This research was carried out to investigate the immediate effects of exercise and the correlation between anthropometric parameters and pulmonary functions in healthy young adults participating in moderate aerobic exercise and provide the underlying mechanism of these functions before and after exercise.

2. Materials and methods

2.1. Materials

A motorized treadmill (model: INCLINE-MTM-ST-200-1700 with DC Motor: 2.0 HP Motor Blue LCD Display) with speed, time, heart rate, distance, calory, speed range 1–14 km/h) automatic display was used for the study. Alpha touch digital spirometer (Model: Vitalograph SP10Wcontec, UK) was also used for the measurement of lung parameters. Wall-mounted stadiometer (Model 222, range 6 cm–230 cm) and beam balance medical scale (Healthometer 402 KL).

2.2. Informed consent and ethical approval

A sample of participants informed consent form was obtained from Human Research Ethical Committee of the University of Calabar Teaching Hospital (UCTH) and was shared to all intended participants. All participants gave their consent to participate in the exercise. Ethical approval for the study was obtained from the Human Research Ethical Committee of the University of Calabar Teaching Hospital (UCTH) with approval number UCTH/HREC/33/696.

2.3. Experimental subjects

Forty (40) young healthy non-athletes male and female of mean age 25 ± 5.6 years body weight 65 ± 4.0 kg, body height 176.9 ± 2.5 cm were selected for the study. Questionnaires/data sheet for physical activity evaluation was given. Items in the questionnaires included the bio data and health history of the volunteers such as smoking status, cardiovascular, respiratory or musculoskeletal disorders. Sixty young male and female subjects (30 each) showed keen interest to participate in the study and were called over for a preliminary testing/screening. From this number of volunteers, forty healthy young adults (20 males and 20 females) were carefully selected to participate in the study after meeting the study criteria. All participants were undergraduate students of University of Calabar, Calabar Nigeria.

2.4. Pre-screening of subjects

A day prior to the commencement of the exercise experiment all eligible participants were invited for a sensitization and screening exercise. The procedures for the experiments were duly explained and their expectations as volunteers were noted. Their affirmations were reascertained and afterwards blood samples were collected for screening. The study participants were screen to check their body mass indices, history of exercise routine for the past three months, use of drugs that affect the heart and respiratory system, physical fitness and underlying respiratory and cardiovascular disease. At the end of the screening, inclusion and exclusion criteria were used to select the subjects that were fit for the study.

2.5. Inclusion criteria

Participants were apparently healthy who ranged in age between 18 and 30 years and who gave written consent to participate in the study. The participants had no history of high blood pressure or any other cardiovascular, respiratory and haematological diseases such as myocardial infarction, asthma and sickle cell anaemia respectively.

2.6. Exclusion criteria

Exclusion criteria included participants who had shown current or previous cardiovascular disease or exercise intolerance risk. This was ascertained by excluding interested volunteers whose resting electrocardiogram (ECG) showed questionable waves. Also, self-reported data collected from the questionnaire together with their anthropometric measurement during the screening were used to exclude subjects that did not meet the inclusion criteria. Smokers, pregnant women, asthmatic patients and individuals with health-related history such as diabetes mellitus, peripheral vascular diseases or bone/skeletal problems were excluded from the study. Those on antihypertensive, analgesic or other cardiovascular/respiratory therapy were also excluded from the study.

2.7. Exercise experiment procedure

The aerobic exercise experiment consisted of a moderate intensity similar to the method employed by Davies et al. (2009) and was performed between 07 and 10h GMT in a room that was well ventilated. After a warm up exercise of 2 min, each participant was made to run for 20 min on the treadmill consistently for 14 days once each day at the speed of 13 km/h. Each participant covered the distance at a stretch with the speed unchanged. No resting interval was observed as the experiment was conducted for 20 min daily until the selected duration elapsed. The participants were advised not to engage in any vigorous activity during the 14 days period of the exercise. The participants were also advised to maintain normal diet and abstain from other physical activity and alcohol or other adverse dietary habits that may influence the outcome of the experiment.

2.8. Measurement of anthropometric parameters

The heights of participants were measured using a wall-mounted stadiometer (Model 222) minutes before the commencement of the exercise and immediately after exercise on the last day of the study. The body weight of participants was measured before commencement of the exercise and after the exercise using a beam balance medical scale (Healthometer 402 KL) to the nearest 0.1 kg with light clothing without shoes. The measurement of height and body weight was done 6 min before the commencement of the exercise on the first day and 6 min after the exercise on the last day of the study. The body mass index (BMI) was calculated by dividing the weight of each participant in kilogram by the square of their height in meters.

2.9. Measurement of lung parameters

Lung function indices (PEFR, FVC, and FEV_1) were measured using Vitalograph SP10Wcontec. The lung function test was done following the method of Rauf et al. (2021). The spirometer was calibrated before each measurement. Following proper insertion of the mouthpiece and nasal clip, a forceful, rapid, forced expiration challenge was performed immediately following maximum forced inhalation. This was repeated three times, the greatest value served as the baseline value. The pulmonary function tests were performed on each participant before the start of the exercise (0 min before warm-up) on the first day and immediately after the exercise (0 min) on the last day following the method of Daga et al. (2007) with the assistance of an experienced technician.

2.10. Determination of calories burnt

The calories burnt per individual on each day of the exercise were recorded. The recordings were taken from the calculated calories burnt from the treadmill machine for both male and female participants.

2.11. Statistical analysis

The results were expressed as mean ± standard error of mean. Analysis of data was done using the GraphPad Prisms software version 7. The two-tailed paired Student t-test was adopted as the statistical tool for this experiment. Pearson correlation was used to assess relationship between two parameters. Statistical significance was fixed at a value of $p < 0.05$.

3. Results

3.1. Anthropometric parameters

The body weight of male and female volunteers is presented in Table 1. The result showed a significant ($p < 0.05$) reduction in body weight of female participants after 14 days of the exercise regimen, no significant change in body weight of male participant was observed when compared to their baseline value before the beginning of the study. The heights of male and female participants after 14 days of exercise were relative to their baseline values before the start of the exercise regimen.

The result for body mass index (BMI) of male and female participants before and after 14 days of aerobic exercise is presented in Table 1. The result showed a significant ($P < 0.05$) decrease in BMI of female subjects after 14 days of exercise regimen when compared to the baseline value before the beginning of the exercise study. No significant change was observed in male subjects BMI after the exercise regimen.

3.2. Respiratory parameters

3.2.1. Forced expiratory volume in 1 s (FEV_1)

The forced expiratory volume in 1 s (FEV_1) is a measure of the amount of air an individual can forcefully exhale from the lungs in 1 s. The result for FEV_1 is presented in Table 1. The FEV_1 of both male and female participants showed a significant reduction ($P < 0.05$) after 14 days of moderate aerobic exercise when compared to their baseline values before the exercise regimen.

Table 1
Anthropometric and pulmonary function parameters in male and female subjects before and after acute moderate exercise. *$p < 0.05$ compared to before the exercise.

	MALE		FEMALE	
	BEFORE	AFTER	BEFORE	AFTER
BODY WEIGHT (kg)	65 ± 1.7	62 ± 1.8	63 ± 2.9	59 ± 3.2*
HEIGHT (cm)	176 ± 1.7	176 ± 1.5	175 ± 1.3 cm	175 ± 1.4
BMI (kg/m^2)	21 ± 0.74	20 ± 0.61	24 ± 1.7	22 ± 2.1*
FEV_1 (L/min)	2.5 ± 0.14	3.3 ± 0.11*	1.7 ± 0.19	2.5 ± 0.14*
FVC (L)	2.9 ± 0.13	3.8 ± 0.17*	1.8 ± 0.082	2.9 ± 0.07*
PEFR (L/min)	412 ± 6.9	618 ± 13*	398 ± 7.1	550 ± 14*

Anthropometric and pulmonary function parameters in male and female subjects before and after acute moderate exercise.

3.2.2. Forced vital capacity (FVC)

FVC is the maximum volume of air that can be expelled out forcefully after a deep inspiration. The result for FVC is presented in Table 1. There was significant ($P < 0.01$) increase in mean FVC of males and females after exercise when compared with the baseline FVC before the exercise.

3.3. Peak expiratory flow rate (PEFR)

PEFR denotes the highest rate at which the air can be expired after a deep inspiration. The result for PEFR is presented in Table 1. The result showed a significant ($P < 0.\ 05$) increase in mean PEFR of males and females after exercise when compared with the baseline PEFR before the exercise.

3.4. Pearson correlation analysis of respiratory parameter and BMI in volunteers

Table 2 shows the relationship between BMI, FEV_1, FVC and FEV_1/FVC% in male and female participants. The result showed that there was no significant correlation between BMI with FEV_1 and FVC after exercise in all participants. However, there was a positive ($p < 0.01$) correlation between BMI with FEV_I/FVC% in female participants after the exercise regimen.

3.5. Calories burnt of male and female volunteers

The calorie burnt in male and female participants is presented in Fig. 1. The result showed a significant increase in calories burnt in both male and female participants from day 4 to day 7 of the exercise. The calories burnt remained unchanged in all participants from day 7 to day 14 of the exercise regimen.

4. Discussion

This study was aimed at investigating the anthropometric and pulmonary functions of young male and female adults before and after moderate aerobic exercise. The results showed a decrease in female body weight after 14 days of acute moderate aerobic exercise. Body weight is a person's total mass or amount of heaviness in kilograms or pounds (Kim, et al., 2018). Although some factors can affect body weight, an individual body weight cannot be controlled by some factors such as age and genetic factors. However, factors with potential control measures include physical activity (exercise), diet, social and some environmental factors (Skou et al., 2022). Studies have shown that regular exercise can help in weight control by reducing body weight especially in obese individuals (Swift et al., 2018). The reduction in body weight in female participants observed in this study after exercise may be due to increase fat oxidation during the exercise regimen (Cao et al., 2019). Although body fat may not be a reliable parameter in determining an individual

Table 2
Correlation between BMI, FEV_1, FVC and FEV_1/FVC% in females and males.

Parameter	BMI vs. FEV_1 After	BMI vs. FVC after	BMI vs. FEV_1/FVC%
Females			
Pearson r	−0.2	0.26	−0.4
R squared	0.039	0.068	0.16
P (two-tailed)	0.3119	0.1808	0.0346
P value summary	Ns	Ns	*
P value summary	Ns	Ns	*
Males			
Pearson r	−0.36	−0.24	0.027
R squared	0.13	0.058	0.00072
P (two-tailed)	0.3026	0.5008	0.9413
P value summary	Ns	Ns	Ns

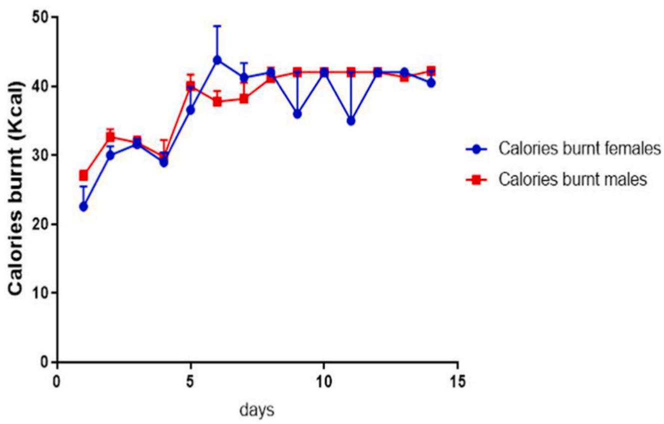

Fig. 1. Calories burnt in male and female participants during exercise period.

body weight, Fritzen et al. (2020) reported that increase adiposity which is common in females can contribute to weight gain with fat oxidizing enzymes (fat burners) being predominant in the skeletal muscle. Thus, during exercise, the increase in muscular activity can increase metabolic rate and the activity of these enzymes to burn fats and improve blood flow to active muscles which can lead to a decrease in body weight as observed in female participants in this study (Guirado et al., 2022). Our result is in line with the previous study of (Boldt et al., 2019) who demonstrated that females have higher preponderance of weight loss than male subjects after exercise. In male participants, no significant change in body weight was observed after exercise, which potentially could be attributed to a decrease in fat oxidizing enzyme activity and tissue adipocyte (Chávez-Guevara et al., 2022). Additionally, Santos-Rocha et al. (2022) showed that people who maintain appropriate body fitness, using judicious regimens of exercise and weight control, have the additional benefit of prolonged life.

Body Mass Index (BMI) is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults. The decrease in body mass index of female participants observed in this study after exercise though their heights remained unchanged could be due to the decrease in body weight, increase metabolic rate and increased activity of fat oxidizing enzymes during the experimental period. Additionally, increase metabolic demand and muscular activity can also play a significant role in reducing the BMI in female subjects. The results align with a previous study of Gavotto et al. (2023) which reported a decrease in body weight and BMI in young healthy female adults after moderate aerobic exercise. The exercise regimen did not have any significant change in BMI of male subjects probably because there was no observable change in their body weight and height during the experimental period. This also agrees with a previous study that reported no significant change in male BMI after moderate aerobic exercise (Ceylan et al., 2020).

The forced expiratory volume in 1 s (FEV_1) is the volume of gas expired over the first second of the forced expiration following a full respiration. The increase in FEV_1 in male and female participants observed in this study after exercise could be due to improved respiratory functions due to increased oxygen demand during the experimental period. The main benefits of exercise (both aerobic and nonaerobic) include improving breathing efficiency and reducing lung resistance. Conversely, increased physical activity, might aid in improving pulmonary function and reducing body fat (Ferdowsi et al., 2011). Our result is in line with the study of Kriemler et al. (2013) who reported that regular moderate aerobic exercise can increase FEV_1. Paull and Van Guilder (2019) also reported that increase oxygen demand during muscular activity can improve the respiratory muscles and increase pulmonary ventilation due to oxygen debt in the body.

Another way to measure lung capacity, expiratory resistance, and airway resistance is by assessing forced vital capacity (FVC). This is an index that measures the maximum volume of air that can be expelled out forcefully after a deep (maximum) respiration (Mankar et al., 2022). The value of the index is also influenced by how elastic the lungs are and how resistant the airways are. Our results showed a significant increase in forced vital capacity (FVC) in both male and female subjects after exercise. The findings of this study revealed that there were notable variations in the FVC in male and female subjects after acute exercise. The FVC increased as a result of the lungs' expanded volume and its elastic recoil during the experimental period which resulted in the respiratory muscles increasing in function. Thus, increase in FVC will therefore increase respiratory muscle strength and improve endurance even after exercise (Fritz et al., 2020). Our result agrees with previous study of Angane and Navare (2017), who showed a significant increase in FVC in young healthy male and female after aerobic exercise. Soliman et al. (2022) in their study also reported that aerobic exercise can improve lung function and cognition in mentally impaired young adults. Similar improvement in respiratory function after aerobic exercise was also reported by Jahan et al. (2020).

The peak expiratory flow rate (PEFR) is the maximum rate at which the air can be expired after a deep inspiration (Agrawal and Taruna, 2022). The observed increase in PEFR is in line with the previous study of Imanita et al. (2022) who reported that regular exercise can improve lung functions particularly PEFR in young adults. Also, Astuti and Huriah (2022), reported an increase in PEFR, mitochondrial and metabolic activity in healthy male and female subjects after aerobic exercise when compared with asthmatic patients, while Chinnaiyan and Ramayyan (2021), added that consistent aerobic exercise can increase PEFR in young healthy adults. Previous studies have found that frequent moderate aerobic exercise can strengthen the respiratory muscles and increase aerobic capacity (Halabchi et al., 2017; Mohamed and Alawna, 2020), probably due to increase contraction of respiratory muscle and the need for tissue oxygenation.

The Pearson correlation showed that there was a positive correlation between BMI and the ratio of force expiratory volume in first 1 s to forced vital capacity (FEV1/FVC %) in female participants. Regardless of body height or other potential variables, adult obesity is linked to an imbalance in ventilation and airway flow. FEV1/FVC, is a known marker of airway remodelling, and is directly used to assess airway collapsibility (Chae, et al., 2011). The positive correlation which exists between BMI and post bronchodilator ratio (FEV1/FVC) showed that there was an improved respiratory function due to reduced body weight and basal metabolic index (BMI) in female participants after exercise. This result supports the previous study of Ferdowsi et al. (2011) who reported that FEV1/FVC indicators relies on expiratory muscles and that weakness of the expiratory muscles will decrease FEV1/FVC index. The mechanism behind this positive correlation may be due to the influence of epinephrine and nor-epinephrine released into circulation during exercise. Epinephrine binds on beta receptors and cause dilation of bronchial blood vessels for effective oxygenation, while increasing basal metabolic rate and blood flow to skeletal muscles during exercise (Licker et al., 2021).

The energy expenditure represented as calories burnt after 14 days of exercise regimen showed an increase from day 5 to day 7 in both male and female participants. This could be attributed to an increase in energy demand by skeletal muscle during the first few days of exercise. The increase in energy expenditure especially in female participants could probably contribute to the decrease in body weight observed in female participants after 14 days of exercise. This result is in line with the findings of Pontzer (2017), who reported that aerobic exercise burns more calories than resistant exercise and has a greater impact of lean muscle mass especially during the few days of exercise regimen.

There are few limitations in this study. The basal metabolic rate of participants could not be measured due to experimental design and technical difficulties. This parameter could have enabled us determine to a large extent the energy expenditure and provided more information on the calories burnt during the experimental period. Also, oxygen saturation in blood (PO_2) could not be measured because we lacked the means to measure it. Our study could not monitor the respiratory functions hours after the 14 days of experimentation due to experimental design. This could have given information on the overall benefit of the short aerobic exercise after some hours. Further studies should include more sample size and even with known medical conditions such as diabetes mellitus and hypertension to know whether acute aerobic exercise could have benefit in such conditions.

5. Conclusion

The result of this study shows that moderate acute aerobic exercise in healthy male and female young adults decrease in body weight and BMI of female participants. It is concluded that moderate acute aerobic exercise improves respiratory functions and hence regular moderate exercise is beneficial and can be recommended to healthy individuals who may be predisposed to unknown respiratory and metabolic disorders.

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CRediT authorship contribution statement

Idara A. Okon: Conceptualization, Investigation, Writing – original draft, and writing, revision. **Albert E. Okorocha:** Project administration, Supervision. **Justin A. Beshel:** Validation, Writing – review & editing. **Happiness C. Abali:** Data curation. **Daniel U. Owu:** Visualization, Supervision, Methodology, Formal analysis, revision and correction.

Declaration of competing interest

The authors have declared that there is no potential conflict of interest.

Data availability

Data will be made available on request.

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