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Moderate aerobic exercise improves haematological indices without altering cardio-metabolic enzyme activities in sedentary healthy young adults

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Abstract

Background Regular aerobic exercise regulates cardiorespiratory functions by its effect on specific enzyme activities. This study investigated the immediate effects of moderate aerobic exercise on haematological parameters and cardio-metabolic enzymes activity in healthy young male and female adults.

Methods Forty young healthy sedentary subjects, twenty males (25 ± 5.6 years; 65 ± 4.0 kg; 176.9 ± 2.5 cm) and twenty females (25 ± 4.5 years, 62 ± 2.9 kg, 175 ± 1.3 cm) volunteered for the study. The exercise regimen was of moderate intensity lasting for 20 min daily on a treadmill at incremental speed of 3 km/h to 13 km/h for 14 consecutive days. The weight and height of participants were measured. Blood sample was collected via antecubital vein for haematological and biochemical analysis. The haematological parameters namely red blood cell and indices, leukocyte and differential white blood cell count, platelet and platelet indices were assessed. Cardiac troponin-T, creatine kinase, lactate dehydrogenase and N-acetyl-cysteine activated creatine kinase activities were assessed before and after exercise.

Results The result showed a significant ($p < 0.05$) increase in RBC (males 7%, females 11%) haemoglobin (males 8%, females 8.3%), haematocrit (males 5%, females 14%) leukocyte (males 54%, females 40%) and monocyte count (males 68%, females 55%) after 14 days of exercise. The enzymatic activities of lactate dehydrogenase, N-acetyl-cysteine activated creatine kinase (CK-NAC), creatine kinase (CK-MB) and cardiac troponin-T showed no significant change after 14 days of exercise.

Conclusion It is concluded that moderate aerobic exercise increased haematological parameters and maintained cardio-metabolic enzymes activities in young male and female adults.

Keywords Aerobic exercise, Cardiac troponin, Creatine kinase, Haematological parameters

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Introduction

Physical activity has been known to be helpful in enhancing the overall wellbeing of an individual. Exercise improves the cardiovascular health and is often linked with alterations in homeostatic and biochemical state of an individual. According to recent studies, exercise have influence on the haematological status of the individual and these haematological changes rely on the type, duration and intensity of the exercise performed [1, 2]. Frequent exercise increases the effectiveness of the respiratory, muscular, cardiovascular, and neurological systems [3]. Blood is an important medium of exchange of many substances in the body and has served in various diagnostic purposes due to its various compositions.

Blood volume and constituents are altered in various health or disease conditions [4]. Various forms and types of exercise such as acute or chronic and low or high intensity exercise may cause these changes [5]. Studies have reported that individuals that are exposed to exercise have increased blood volume in a 24-hour period by up to 10–12%. This increase can reach a plateau between 10 and 14 days of training [6]. Additionally, exercise have been reported to increase blood volume and cardiac output in less than six weeks of training [7]. There is no general agreement on the type of exercise that can cause changes in haematological parameters and cardiometabolic enzymes associated with exercise. However, conflicting reports showed that short-term exercise caused a rise in WBC count and a decreased RBC count [8, 9]. A reduction in WBC count and an increase in RBC count have also been documented [10], while no notable alteration in red blood cell parameters was observed after exercise. However, a recent study, has shown that short-term exercise can improve participants iron status and increase RBC count in healthy males [11]. These and other haematological parameters can be altered depending on the nature, time and intensity of the physical activity in addition to gender, age, environment or nutrition [12, 13] based on the experimental design of the studies.

Chronic inflammation is one of the reported effects of intense or prolonged exercise with accompanied increase in white blood cell count [14]. However, regular exercise is known to reduce oxidants, and raise the antioxidant capacity and antioxidant enzymes that help to protect against oxidative injury [15]. Additionally, the temporary rise in levels especially lymphocytes and neutrophils after exercise help to mobilize immune cells to potential sites of damage or infection [16]. There is general acceptance that regular exercise can boost the immune system and help prevent cardiovascular related diseases, improve mental health, prevent depression and promote positive self-esteem [17].

Platelets are small, non-nucleated blood cells that constitute a small fraction of the circulating blood cells under normal condition. The functions of platelets in the human body are influenced by physical training and regular exercise habit [18] and platelets also play a crucial role in haemostasis and function in initiating WBC recruitment [19, 20]. In humans especially those with chronic conditions like diabetes mellitus and hypertension, exercise impacts on platelet function are still up for more scientific investigations [21].

Several biomarkers such as enzymes and proteins have been used for assessing health, performance and recovery during exercise training. They include creatine kinase, lactate dehydrogenase, and cardiac troponins. The cytosol contains the enzyme creatine kinase and is found in many tissues including cardiac, skeletal muscle and brain, with moderate amounts in the uterus, bladder, kidney and the gastrointestinal tract [22]. Lactate dehydrogenase is an enzyme present in all tissues; they play a major role in converting lactate to pyruvate and back, while cardiac troponin is a calcium binding protein in the heart that enhances cardiac contractility during moderate or intense physical activities [23]. Although the exact mechanism underpinning elevated troponin level after exercise is still under debate, the release of troponin after exercise may be due to necrosis, apoptosis, increased membrane permeability and transient ischemia [24]. The serum level of these products can serve as a diagnostic tool in cardiac and muscular damage after exercise [25]. It has been reported that exercise can alter serum muscle and cardiac related enzymes such as creatine kinase that is increased during such physical activity [26]. In addition, some studies described cardiometabolic enzyme elevations in response to various forms of exercise, whereas other studies also report no alteration on the levels of these enzymes during exercise. The effects of muscular exercise on the enzyme activities may also vary depending on type of physical activity and gender of the individual.

Although it is a general notion that aerobic exercise in whatever form can induce haematological alterations by improving RBC and WBC counts in trained athletes [27], it is not clear if moderate aerobic exercise can affect the haematological parameter in apparently sedentary adults. It is not also known if this type of exercise can alter cardiometabolic enzymes that are markers of tissue injury. The present study compared haematology parameters and cardiometabolic enzymes of male and female sedentary subjects before and after moderate aerobic exercise. We hypothesized that a 14-day regimen of moderate aerobic exercise would significantly alter haematological parameters and cardiometabolic enzyme levels in sedentary individuals.

Materials and methods

Materials

The study utilized a motorized treadmill (model: INCLINE-MTM-ST-200-1700) for the exercise. Stadiometer was used to measure height while weighing scale was utilized for weight measurement. Auto hematological machine (Model PCE 210, Japan) was used for determining haematological parameters.

Study participants

Sixty young non-athlete undergraduate students of the faculty were contacted and recruited for the study after the protocol were explained to them. Male and female participants were recruited. The anthropometric parameters of all participants were determined. The males had mean ages, weights, and heights of 25 ± 5.6 years, 65 ± 1.7 kg, and 176 ± 1.6 cm, while female participants had mean ages, weights, and heights of 25 ± 4.5 years, 62 ± 2.9 kg, and 175 ± 1.3 cm respectively. The subjects who gave their consent were pre-screened to determine their eligibility to participate in the study using stated inclusion/exclusion criteria. Each participant filled the questionnaire and biodata sheet in order to evaluate their physical fitness status and medical history, in accordance with the International Physical Activity Questionnaire (IPAQ) [28]. The sample size was calculated using the Fischer's formula for unknown population. After the screening exercise, forty (40) of them (20 males and 20 females) met the stated inclusion criteria and were recruited.

Inclusion criteria

Apparently healthy adults of aged 18 to 30 years with no history of hypertension or any other respiratory, cardiovascular, or haematological conditions, including sickle cell anaemia, asthma, or myocardial infarction, and who signed a written consent form took part in the study.

Exclusion criteria

Exclusion criteria included any history of risk for heart disease or difficulty with exercise. Those who had suspicious waves on their resting electrocardiogram (ECG) during the pre-screening visit. Participants with a medical history, pregnant women, smokers, and those on medication were not allowed to participate in the study.

Exercise procedure

The level of intensity of exercise was moderate and followed the method as previously documented [29] with modification. Briefly, every participant carried out a 2 min warm up exercise before they ran on the treadmill. The treadmill protocol of Yilmaz et al. [30] was adopted with a starting speed of 4 km/h on a treadmill followed with an increment of 3 km/h every 3 min to a maximum of 13 km/h. The exercise lasted for a total of 20 min with 20 min rest between 10 min interval of exercise in order to prevent training effect and exhaustion. This speed was maintained throughout the exercise period. The treadmill exercise was carried out in the exercise lab of the department that was well ventilated. It was performed between 07 and 10 h GMT in the well-ventilated exercise lab of the Department. This was carried out for 14 consecutive days. The participants were informed not to engaged in any strenuous activities during the course of the study. The duration of 14 days was chosen since alterations in blood, plasma, and volume of red cells during physical exertion reach a plateau about 12–14 days [31].

Measurement of anthropometric parameters

A wall-mounted height meter (Model 222) was used to measure the participants' heights both before the exercise started and on the last day of the study. A weighing scale (Healthometer 402KL) was used to measure each participant's body weight, with light clothing and no shoes, to the nearest 0.1 kg. The body mass index (BMI) was calculated using the height and weight as previously reported [29].

Blood sample collection

All the subjects were advised to eat and drink till 10:00 pm the day before the start of the experiment. Participants were required to fast for at least 8 h prior to blood sample collection as baseline value. The sample was collected from each subject via the antecubital vein by a certified Phlebotomist. 5 ml of venous blood was collected and 2.5 ml was immediately emptied into the sample bottles containing EDTA for haematological analysis, 0.5 ml was used for platelet activity (clotting time) and the remainder was left to clot to obtain serum for biochemical analysis. On the 14th day, collection of the blood sample was repeated within 30 min after the exercise since the haematological parameters can return to baseline 1 h after exercise and was processed in the same manner as the basal sample.

Determination of haematological parameters

Haematological parameters were assayed using an automatic blood cell counter (Model PCE 210, Japan). Values for Red blood cell and red cell indices (Hb, PCV, MCV, MCH, MCHC), the platelet parameters, plateletcrit (PCT), mean platelet volume (MPV), platelet distribution width (PDW), and platelet counts (PLT) were obtained from the machine [32].

Determination of clotting time

A modified Capillary technique was utilised to ascertain the clotting time. A capillary tube was used to collect the blood, tilted downwards, and snapped off at 30 s

intervals. The blood column broke, but a thick strand of coagulated blood was seen. The total time from blood flow to fibrin strand appearance was recorded [33].

Measurement of cardio-metabolic biomarkers

Creatine kinase MB was measured using the human specific creatine kinase ELISA kit obtained from Cusabio (China) following the manufacturer's instruction. The serum level of lactate dehydrogenase activity was measured using human specific D-lactate dehydrogenase ELISA kit following the manufacturer's instruction. The level of cardiac troponin T was determined using human specific cardiac troponin T ELISA kit purchased from Cusabio (China) and the procedure was as directed in the manufacturer's guide.

Statistical analysis

Results were presented as mean ± standard error of mean. The data obtained were analysed using GraphPad Prisms software (version 9). The pre- and post-exercise measurements of various blood parameters were compared using the paired Student t-test since the subjects served as their own control. A probability value of <0.05 considered statistically significant.

Results

Anthropometric parameters

The results of the body weight and body mass index (BMI) obtained before and after exercise revealed that there were a significant ($p<0.05$) decrease in the body weight (62 ± 2.9 kg versus 59 ± 3.2 kg) and body mass index (23.9 ± 1.7 versus 21.3 ± 1.4 kg/m^2) in females after the 14 days exercise. There were no differences in body weight (65 ± 1.7 kg versus 62 ± 1.8 kg) and BMI (21.3 ± 0.74 versus 20 ± 0.6 kg/m^2) in males after the exercise.

Cardio-metabolic parameters

The result obtained for lactate dehydrogenase enzymes activity parameters for males and females before and after exercise are presented in Fig. 1A. At the end of the exercise, no significant change was observed in serum level of lactate dehydrogenase (LDH) enzymes activity for both male and female participants. Also, N-acetyl-cysteine-(NAC)-activated creatine kinase (CK-NAC) (Fig. 1B.) and creatine kinase (CK-MB) (Fig. 1C) enzyme activities for both male and female participants showed no significant change after 14 days of the moderate aerobic exercise. No significant change was observed in serum level of cardiac troponin T (CTnT) (Fig. 2) of both male and female participants after 14 days of the exercise regimen.

Haematological parameters

Red blood cell counts and indices

The results for RBC count in male and female participants are presented in Table 1. The RBC count in male and female participants showed a significant ($p<0.05$) increase after 14 days of moderate aerobic exercise when

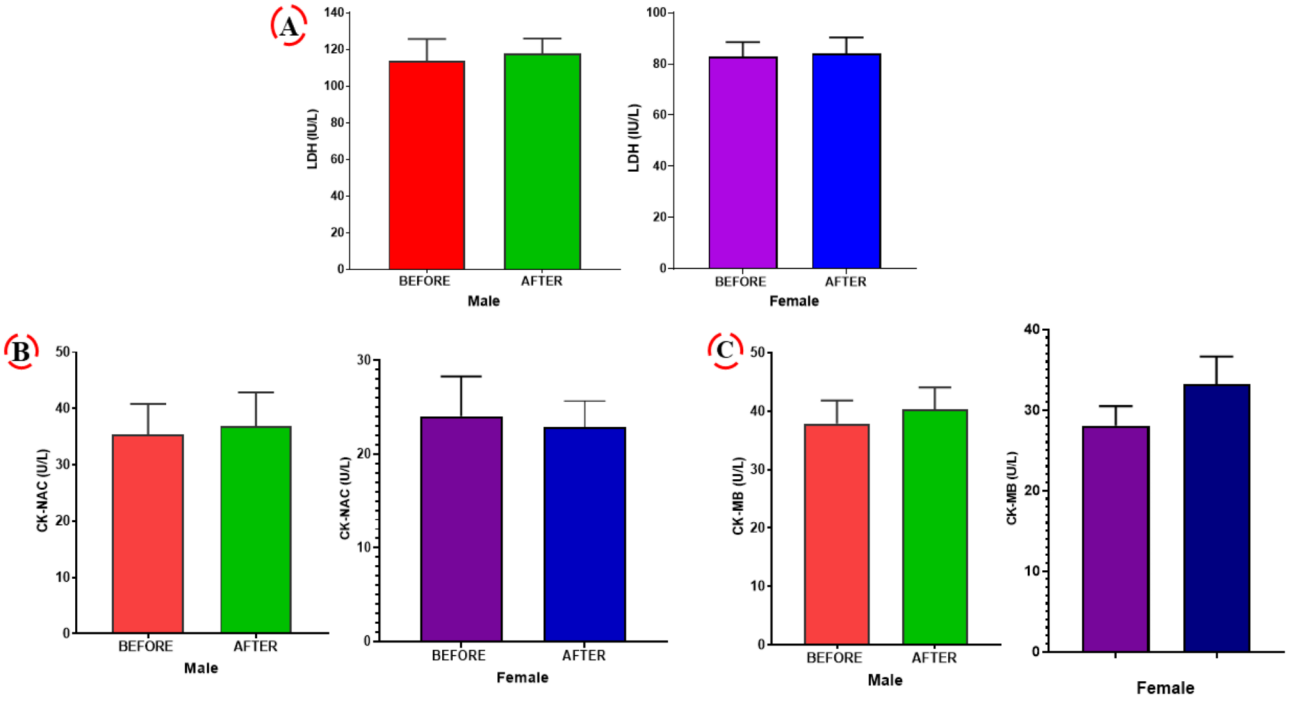

Fig. 1 (**A**) Lactate dehydrogenase enzymes. (**B**) Total creatine kinase (CK-NAC) activity. (**C**) Creatine kinase-MB activity. $N=40$ (20 male and 20 female). Values are express as mean ± Standard error of mean. No significant change was observed before and after the exercise in male and female participants

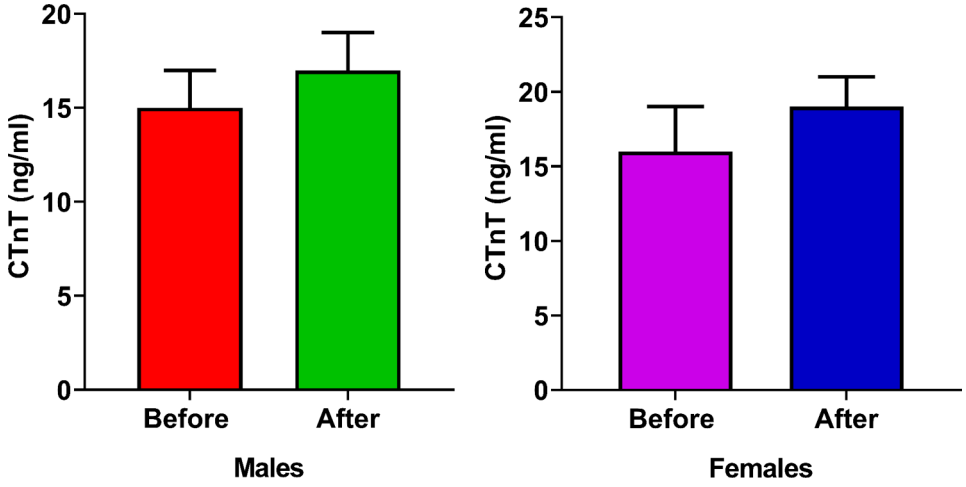

Fig. 2 Cardiac troponin T in male (**A**) and female (**B**) participants. *N* = 40 (20 male and 20 female). Values are express as mean ± Standard error of mean. No significant change was observed before and after the exercise

Table 1 Haematological parameters in male and female participants. *p < 0.05 compared to before the exercise. N=40 (20 male and 20 female). Values are express as mean ± Standard error of mean

Parameters	Males			Females		
	Before	After	Change (%)	Before	After	Change (%)
RBC (x10^{12} cells/L)	4.6 ± 0.058	4.9 ± 0.072*	7	4.6 ± 0.054	5.1 ± 0.051*	11
Haemoglobin (g/dL)	13 ± 1.3	14 ± 1.5*	8	12 ± 0.16	14 ± 0.14*	8.3
Haematocrit (%)	40 ± 0.31	42 ± 0.40*	5	39 ± 0.30	40 ± 0.26*	14
MCV (fL)	93 ± 0.27	80 ± 0.36*	-13	90 ± 0.62	78 ± 0.93*	-15
MCH (pg/dL)	27 ± 0.14	23 ± 0.14*	-15	27 ± 0.32	23 ± 0.29*	-15
MCHC (pg/dL)	30 ± 0.11	29 ± 0.09*	-3	30 ± 1.3	29 ± 0.12*	-3
WBC cells (x10^{9}/L)	4.6 ± 0.18	7.1 ± 0.31*	54	5.0 ± 6.9	6.9 ± 0.32*	40
Monocyte (%)	5.7 ± 0.31	9.6 ± 0.38*	68	7.1 ± 0.28	11 ± 0.27*	55
Lymphocyte (%)	44 ± 3.6	46 ± 2.6	4.5	48 ± 3.6	44 ± 3.8	-9.7
Granulocyte (%)	46 ± 5.9	49 ± 4.0	6.5	41 ± 3.0	43 ± 4.0	4.8
Platelet cells (x10^{9}/L)	258 ± 6.9	293 ± 8.2	13.5	299 ± 8.3	349 ± 14	16.7
MPV (f/L)	11 ± 0.13	9.6 ± 0.06*	-12.7	11 ± 0.06	9.8 ± 0.07*	-11
PDW (%)	15 ± 0.14	15 ± 0.07	0	14 ± 0.22	15 ± 0.10	7
PCT (%)	0.25 ± 0.033	0.24 ± 0.03	-4	0.31 ± 0.02	0.31 ± 0.02	0
Platelet to lymphocyte ratio	5.86 ± 0.4	6.37 ± 0.3	8.7	6.23 ± 0.4	7.93 ± 0.4	21
Clotting time (min)	2.3 ± 0.21	2.2 ± 0.11	-4.3	2.5 ± 0.29	2.4 ± 0.08	-4

*= $p < 0.05$ compared with before exercise; MCV = mean corpuscular volume, MCH = mean corpuscular haemoglobin, MCHC = mean corpuscular haemoglobin concentration, MPV = Mean platelet volume, PDW = platelet distribution width, PCT = plateletcrit

compared to their baseline values. Also, haematocrit and haemoglobin (Hb) concentration in male and female participants increased significantly ($p < 0.05$) after exercise when compared to same participant before exercise. However, the mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) decreased significantly ($P < 0.05$) in both male and female participants after 14 days of exercise regimen when compared to their baseline values before the exercise.

Total white blood cell and differential white blood cell count

The results for white blood cell (WBC) count and differential white blood cell count in male and female participants are presented in Table 1. At the end of the 14 days exercise, the result showed a significant increase in WBC in male and female participants after the exercise when compared to same participant before the exercise. Also, the result showed a significant increase in monocyte count in male and female participants after the exercise when compared to same participant before the exercise. However, no significant change in lymphocyte count and granulocyte count was observed after the exercise when compared to their baseline value.

Platelet and platelet indices

The results for platelet count and platelet indices in male and female participants are presented in Table 1. The result showed no significant change in platelet count, platelet distribution width (PDW) and plateletcrit (PCT) in both male and female participants after 14 days of exercise. However, the result showed a significant ($p < 0.05$) decrease in mean platelet volume (MPV) in both male and female participants after the exercise when compared with same participants before the exercise. No significant change was observed in clotting time after 14 days of exercise regimen in all participants. The platelet lymphocyte ratio is also presented in the table and shows no significant difference in the male and female participants after exercise regimens.

Discussion

This study investigated haematological parameters and cardio-metabolic enzymes activities of apparently young healthy males and females before and after moderate aerobic exercise. Our result showed increases in red blood cell count, haematocrits and haemoglobin concentration after 14 days of moderate aerobic exercise in both male and female participants. A reduction in body weight of female participants was also observed after 14 days of exercise. Body weight measures an individual body composition and can be used to assess a person's agility, endurance and fitness level [34]. Decrease muscle mass and high body fat in females may influence their body weight before and after exercise. Exercise enhances fat utilization by improving the activity of fat burning enzymes in female [29]. The effect of this on body weight depends on the intensity of muscular activity. This is supported by a study that revealed that moderate exercise can improve fat utilization, increase muscle strength and reduce body weight in female [35].

The increase in RBC count observed in this study could be due to splenic contractions, release of reticulocytes and, release of RBCs, which are known to occur in response to adrenergic stimulation during exercise [36, 37]. Increase adrenergic stimulation due to oxygen demand by the contracting skeletal muscle induced splenic contraction to release more red blood cell to meet the metabolic demands during exercise [38]. This is in line with previous reports of a rise in red blood cell after moderate aerobic exercise in young adults [39]. A decreased Hb concentration in anaemia reduces exercise performance and O_2 carrying capacity despite a rise in cardiac output [37]. Our study showed an increase in Hb concentration after 14 days of moderate exercise in both male and female participants, which is consistent with previous studies that reported a rise in RBC count, haematocrit and haemoglobin concentration shortly after exercise [31, 40]. Regular exercise increases the vasodilatory effects of nitric oxide, inhibits ROS production and improve cellular functions [41]. Thus, the inhibition of ROS production could probably cause the increased production of red blood cell as observed in our study.

Haematocrit is a test that reflects the proportion or percentage of red cells in the blood. Although the percentage in male (40.7–50.3) differs from female (36.1–44.3) under normal conditions, a change in haematocrit value can serve as a major diagnostic tool in blood related disorder. The increase in haematocrit observed in this study is in agreement with previous study that observed a rise in haematocrit after exercise [36, 42] and can be attributed to hypoxia-induced erythropoiesis as previously noted after moderate exercise. Although MCV, MCH and MCHC in both male and female participants decreased after 14 days of the moderate exercise regime, they were still within the normal physiological ranges and suggest no abnormal haematology in the participants.

One of the most consistent changes during moderate aerobic exercise is increase white blood cell count [43]. White blood cells and its subpopulation tend to rise in number during exercise due to hemodynamic shear stress and/or the effects of catecholamine on leukocyte β2-adrenergic receptors [44]. In our study, we observed a significant increase in leukocytes and monocyte counts after 14 days of moderate exercise training. The rise in leukocyte count may be due to redistribution of white blood cells from tissues to the blood stream, possibly to ensure immune surveillance during exercise or due to increase in plasma levels of soluble agents such as growth hormones, inflammatory cytokines and glucocorticoids which increase mobilization of myeloid cells during exercise [16, 26]. The increase in monocyte count in male and female participants agrees with the pervious study that reported an increase in monocyte count within 1–2 h after exercise, and also showed that this number can return to the resting baseline level within 6 h after exercise cessation [26]. Our result showed no significant change in lymphocyte count in both male and female participants after exercise. Studies have also shown that the initial increase and mobilization of lymphocytes during exercise is followed by reduced number of lymphocytes in circulation during the exercise recovery period [45]. The response of lymphocytes to chronic and moderate exercise training is biphasic and the initial increase could reflect mobilization of white blood cells from peripheral blood pool and lymphoid organ [46].

Platelets play a significant role in pathogenesis and progression of cardiovascular diseases and its functions in human body are influenced by physical training and regular exercise habit [47, 48]. Injury to a vessel activates a quick localized haemostatic reaction that is mediated by interaction between platelets, vascular endothelium

and coagulation cascade. Our result shows no significant change in platelet count, platelet distribution width and plateletcrit in both male and female subjects after 14 days of moderate exercise. However, there was a significant reduction in mean platelet volume in both male and female subjects. Previous study has shown that exercise training has an antithrombotic effect on basal platelet function and that low intensity exercise is adequate to have a positive impact on platelet function [49]. Plateletcrit shows the total platelet mass and provides a comprehensive data because it is equivalent to platelet count, while an increase in platelet distribution width is associated with ST-segment elevation in myocardial infarction and thrombolysis failure [50]. Our result is in line with previous studies that no alteration of platelet count in acute aerobic exercise and that platelet counts return to its baseline level after moderate exercise in healthy subjects [51]. The platelet-lymphocyte-ratios (PLR) is a valuable parameter recently used to depict inflammation in response to acute exercise [52]. Our results showed no significant difference in this value in both males and females after exercise. This implies that there was no adverse inflammatory response in the participants within the duration of exercise.

Clotting time which is also known as coagulation time is time required for blood to clot and it may vary between males and females due to genetic factors. However, in disease conditions such as hemophilia and von Willibrand's disease clotting time is expected to increase due to abnormality or absence of clotting factors. Our findings showed no significant change in clotting time of both male and female participants after 14 days of moderate acute exercise. This is in agreement with previous study that revealed that moderate aerobic exercise can normalized the fibrinolytic system and maintain clotting time in healthy young adults after exercise [53].

The result for cardio-metabolic enzymes activity which include lactate dehydrogenase, N-acetyl-cystein-(NAC)-activated creatine kinase (CK-NAC) and its isoenzyme (CKMB) and cardiac troponin T showed no significant difference before and after exercise in both male and female participants. Lactate dehydrogenase (LDH) is an essential enzyme in the anaerobic metabolic cycle that breaks down lactate [54]. During exercise the active muscles use up the available oxygen, causing lactate dehydrogenase enzymes to catalyse pyruvate into lactic acid [55]. Skeletal muscle releases about 40% of the lactate that is present in the bloodstream and is then largely absorbed by the liver and kidney, where it is oxidized to generate glucose [56]. As a cytoplasmatic enzyme, elevated serum LDH activity is an indication of inflammation or muscle injury [57]. Our result shows that no inflammation or muscle injury occurred before and after the experimental period. This result is in line with previous study that demonstrated that moderate aerobic exercise does not alter LDH activity in young male and female adults [58]. The observed result of lack of changes in the levels of LDH and CK could be due to the duration of exercise. Studies have reported that serum enzyme levels depend on the duration and period of rest after exercise [59]. For instance, short-term physical inactivity may reduce both the lymphatic transport of CK and the release of the enzyme from the muscle fibres [60]. A sensitive marker for the detection of skeletal muscle disease and the severity of severe muscle trauma is the measurement of CK-NAC activity in plasma. Creatine kinase (CK) enzyme is found in the skeletal muscle, cardiac muscle, and brain and is released the bloodstream when there is injury or damage to the muscles. The mechanism of an increase in the activity of this enzyme during exercise is controversial and has been traced to either increase in membrane permeability or metabolic effect on muscle. This may also be attributed to the mechanical effect on muscle fibres that can result in fibre necrosis and membrane damage [61]. Our results showed no significant change in N-acetyl-cysteine-(NAC)-activated creatine kinase (CK-NAC) and its isoenzyme (CKMB) activity before and after exercise in healthy young male and female adults. This also is an indication of no injury or damage during the experimental period. This result on CK-NAC and CKMB activities agrees with previous study that showed that moderate aerobic exercise maintains muscle integrity by regulating the activity of CK enzymes [62].

Cardiovascular regulatory proteins known as cardiac troponins (T and I) regulate the calcium-mediated interaction between actin and myosin contractile filaments. When identifying cardiac muscle injury, the measurement of serum cardiac troponin is more sensitive and specific. For proper diagnosis of myocardial infarction, increased cardiac troponin concentrations are currently considered a standard biochemical procedure [63]. Our result also showed no significant change of serum cardiac troponin- T level in both male and female participants after the exercise, which also confirmed that there was absence of injury either to the heart or the skeletal muscles. Regular moderate aerobic exercise modulates cardiac metabolic enzyme activities, improve antioxidant level and protect the blood cells [41]. As innate defense mechanisms, exercise increases the expression of heme oxygenase-1 (HO-1) and biliverdin reductase A (BVRA), which generate bilirubin, one of the strongest antioxidants [64]. When combined, HO-1 and BVRA reduce adiposity and inflammation. In addition to other contractile mechanism, the improved antioxidant level after exercise could probably maintain these enzyme activities and increased RBC and Hb levels.

There are few limitations to this study. The study involved few participants due to recruitment time and

the study was of short duration. Therefore, there is need to include more participants and to increase the duration and intensities of exercise. Future research should focus on the prolonged impact of exercise on biochemical and haematological parameters.

Conclusion

It is concluded that moderate aerobic exercise increases red blood cell count, haemoglobin concentration and haematocrit, white blood cell counts without altering the activities of cardiometabolic enzymes in apparently sedentary healthy young males and females. Since the haematological values are within the normal reference range for healthy population, the regular moderate aerobic exercise can be of immense benefit to sedentary population of non-athletes.

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Author contributions
IAO and DUO conceptualized the study, conducted the investigation and wrote the original draft. JAB ensure adherence to the study protocol. NNO visualized the study, reviewed and edited the draft manuscript. AEJ and LIE handled data curation.

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Data availability
Data generated in this study are available from the corresponding author upon request.

Declarations

Ethics approval and consent to participate
All subjects involved in this study gave their signed informed consent. The study was carried out in line with the declaration of Helsinki and approved by Human Research Ethical Committee of the University of Calabar Teaching Hospital (UCTH) with approval number UCTH/HREC/33/696.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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