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LEVELS OF TOTAL IRON, IRON BINDING CAPACITY AND SOME HAEMATOLOGICAL PARAMETERS AMONGST YOUNG UNDERGRADUATES EXPOSED TO AEROBIC EXERCISE

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ABSTRACT

Background: Aerobic exercise has varying effects on iron profiles and haematological indices, which can have a favorable or detrimental impact on individual health. **Materials and Methods**: This pre-post study evaluated the levels of serum total iron (TI), total iron binding capacity (TIBC) and some haematological parameters [(Red blood cell count (RBC), Mean corpuscular haemoglobin (MCH), Mean corpuscular haemoglobin concentration (MCHC) and Mean corpuscular volume (MCV)] amongst young undergraduates exposed to 3 weeks of aerobic (skipping rope) exercise. Thirty (30) male and female participants aged 18-35 years were recruited for the study using simple random sampling method. Participants were exposed to skipping rope exercise 30 minutes four times a week for three weeks (21days). Fasting venous blood samples were collected at baseline (pre-exercise samples; day 0) and after exercise (post-exercise samples; day 22) for determination of serum TI, TIBC, and haematological indices using standard methods. Body mass index (BMI) and Blood pressure (BP) were also determined while structured questionnaires were used to obtain other relevant data of the participants including age and gender. Results: Significant increases in mean levels of total iron (55.69±10.92 Vs. 45.96±6.45; $p = 0.001$), TIBC (232.32±12.47 Vs. 216.34±12.50; $p = 0.001$), RBC (4.60±.63 Vs 4.17±.86; $p = 0.031$), MCH (32.39±2.58 Vs. 28.83±2.59; $p = 0.001$), and MCHC (366.23±11.39 Vs. 329.03±15.99; $p = 0.001$) were observed after the intervention compared to before exercise. There were no significant differences in the mean levels of BMI, SBP, DBP, and MCV post-exercise compared to pre-exercise values ($p>0.05$). Also, BMI Vs. Total iron ($r = 0.401$; $p = 0.028$), SBP Vs Total iron ($r = 0.416$; $p = 0.022$), MCV Vs. MCH ($r = 0.921$; $p = 0.001$), and MCH Vs. MCHC ($r = 0.403$; $p = 0.027$) were positively correlated in post-exercise subjects. **Conclusion:** This study revealed that short-term aerobic exercise improved blood iron, TIBC, and haematological indices.

KEYWORDS: Exercise, aerobic exercise, rope skipping, Total iron, TIBC, haematological indices, body mass index, blood pressure.

INTRODUCTION

Aerobic exercise is defined as any type of physical activity that causes an increase in heart rate and respiratory volume in order to meet the oxygen demands of the stimulated muscle (Wang and Xu, 2017). There are various forms of aerobic exercise which include running, skipping, walking, jogging, cycling, swimming, and others (Choi, 2024). Aerobic exercise, a form of physical fitness is required not only by athletes for better performance but also by non-athletes for maintenance of physical and mental health (Gilani and Feizabad, 2019). Regular exercise improves both the physical and mental strength of a person. Long-term aerobic, aerobic-step, and strength activities have been shown to positively impact body weight and BMI values (Špirtović *et al.*, 2023; Jayedi *et al.*, 2024), leading to improved biochemical indicators (Amah *et al.*, 2017; Ezeugwunne *et al.*, 2018; Ihim *et al.*, 2018) and general human health.

Provision of oxygen (O2) and nutrients to the tissues, and removal of the carbon dioxide and waste products is the basic function of the circulating blood (Rhodes *et al.*, 2022; InformedHealth.org, 2023). The blood volume and haemoglobin amount increase with exercise (Lundby *et al.*, 2024; Lundgren *et al.*, 2021). According to Uzun (2016), the hemoglobin content stays constant or may even slightly decline as the blood volume rises in tandem with the hemoglobin content. Thus the hematological parameters can change, depending on the type, intensity and duration of the exercise (Ciekot-Sołtysiak *et al.*, 2024). Studies shown significant alterations in various haematological parameters post exercise (Okon *et al.*, 2025; Babatope *et al.*, 2022; Çiçek, 2018; Jafari, 2019; Khan *et al.*, 2019).

Iron is a vital mineral for proper functioning of the protein haemoglobin needed for the transport oxygen in the blood (Moustarah and Daley, 2024). Given its critical roles in oxygen transport, oxidative metabolism, cellular proliferation, and other catalytic events, iron is an essential trace metal for humans (Yiannikourides and Latunde-Dada, 2019). Over 95% of the iron in plasma is coupled to the circulating transport protein transferrin, which carries the majority of the iron to bone marrow erythroid progenitor cells that develop into adult red blood cells, or erythrocyte precursors (Knutson, 2017).

Several factors influence post-exercise iron homeostasis, including transferrin and ferritin, which can bind almost all iron in the serum (Cichoń *et al.*, 2022). Under physiological settings, this chelation makes iron soluble, inhibits iron-mediated free-radical toxicity, and promotes iron transport into cells (Cichoń *et al.*, 2022). As a result, serum total iron-binding capacity (TIBC) correlates with serum transferrin levels (Soldin *et al.*, 2004). TTIBC quantitatively evaluates serum transferrin and can aid in the diagnosis of iron deficient anemia, iron excess, and chronic inflammatory diseases (Faruqi *et al.*, 2024; Rusch *et al.*, 2023; Gottschalk *et al.*, 2000). Increased TIBC levels indicate that total iron body stores are low; increased concentrations may indicate iron deficiency anemia or polycythemia vera, which can occur during the third trimester of pregnancy (Soldin *et al.*, 2004).

Studies have shown that aerobic exercise can variably influence the levels of serum iron and TIBC which can impact individuals differentially (Cichoń *et al.*, 2022; Tayebi *et al.*, 2017). Despite that physical exercise has been reported to affect individuals haematological parameters including iron level, TIBC, ferritin, and haemoglobin concentration, limited work has been done on this and there has not been any final conclusion that these parameters either increased or decreased as a result of physical exercise. Therefore, this study is geared towards determining the levels of total iron, total iron binding capacity and some haematological parameters amongst young undergraduates exposed to 3 weeks' aerobic exercise.

MATERIALS AND METHODS

Study area

This study was conducted at College of Health Sciences, Nnamdi Azikiwe University, Okofia Otolo Nnewi Campus, Nnewi North Local Government Area of Anambra State.

Study design and population

This is a pre and post study designed to evaluate the Levels of total iron, total iron binding capacity and some haematological parameters amongst young undergraduates exposed to 3 weeks aerobic exercise. A total of 30 participants were recruited for the study by simple random sampling. Participants were male and female Nnamdi Azikiwe University students aged 18 to 35 from the Nnewi campus. The aerobic activity consisted of skipping rope for 30 minutes four times each week for three weeks (21 days). The exercise prescription specified the mode, frequency, intensity, and duration of the activity. There are numerous strategies for skipping rope, including the basic or easy jump technique. This technique involves jumping over the rope with both feet slightly apart. It is performed independently. Samples were obtained at baseline (pre-exercise samples; day 0) and after exercise (post-exercise samples; day 21) to evaluate the levels of total iron, TIBC and some haematological parameters [Mean corpuscular haemoglobin (MCH), Mean corpuscular haemoglobin concentration (MCHC) and Mean corpuscular volume (MCV)] in the participants. Participants provided informed consent, and structured questionnaires were used to obtain data such as age, gender, body mass index (BMI), socioeconomic status, dietary habits, history of any chronic conditions, etc., while participant blood pressure measurement was determined using digital sphygmomanometer.

Inclusion criteria

Participants in the study were up to the age of 18 and did not have any pathological illnesses such as cardiovascular disease and renal disease. They were also nonsmokers, had no history of bleeding disorders, and were not pregnant.

Exclusion criteria

This study excluded subjects below the age of 18, those with any pathological conditions, smokers and pregnant women.

Ethical consideration

Ethical approval was sought and obtained from the ethics committee of Faculty of Health Sciences and Technology, Nnamdi Azikiwe University, Nnewi Campus, before the commencement of the study.

Informed consent

Informed consent of all the participating Subjects was sought and obtained.

Sample Collection

Six milliliters (6 ml) of fasting venous blood samples were collected from the participants before (day 0) and after exercise (day 21). 2 ml was dispensed into Ethylene Diamine Tetra acetic acid (EDTA) container for full blood count (FBC) and whereas the remaining 4 ml was dispensed into plain container for serum total iron and TIBC estimation.

Laboratory methods

Full blood count (FBC) estimation

The red blood cell count (RBC), Mean cell volume (MCV), Mean cell haemoglobin (MCH) and Mean cell haemoglobin concentration (MCHC) were determined using a three part Biobase hematology analyzer (BK-6190, China) by following the manufacturer's instructions.

Serum total iron and TIBC Determination

The quantitative determination of total iron and total iron-binding capacity (TIBC) in the human serum was carried out by spectrophotometric method using iron and TIBC reagent kits (TECO Diagnostics, California) according to prescribed manufacturer's instructions.

Anthropometrics measurements

The weight was obtained using a manual weighing scale while height was obtained by the use of a measuring tape. Weight and height were measured and body mass index (BMI) was calculated as:

$$BMI = \frac{Weight\ (kg)}{Height^2\ (m^2)}$$ (WHO, 1995).

Blood pressure measurement

The systolic blood pressure (SBP) and diastolic blood pressure (DBP) of the participants were measured before activity (day 0) and after exercise (day 21) using a digital sphygmomanometer, OMRON 907 (OMRON, Hoofddorp, Netherlands).

Statistical analysis

The SPSS statistical tool, version 26.0, was used to analyze the data collected for this study. Paired t-test was used to compare the data acquired in the subjects before and after exercise. The correlation between the various parameters was examined using Pearson's correlation coefficient. Statistical significance was set at p<0.05.

RESULTS

There were statistically significant increases in the mean levels of total iron (55.69±10.92 Vs. 45.96±6.45; p = 0.001), TIBC (232.32±12.47 Vs. 216.34±12.50; p = 0.001), RBC (4.60±.63 Vs 4.17±.86; p = 0.031), MCH (32.39±2.58 Vs. 28.83±2.59; p = 0.001) and MCHC (366.23±11.39 Vs. 329.03±15.99; p = 0.001) post-exercise when compared to the pre-exercise levels respectively. However, there were no significant differences observed in the mean levels of BMI, SBP, DBP and MCV post-exercise than in the pre-exercise values (p>0.05) respectively. See table 1.

A gender-specific analysis revealed no significant difference (p = 0.110) in the mean level of total iron post-exercise compared to pre-exercise values in male participants, despite a significant increase in TIBC level post-exercise compared to pre-exercise (235.29±12.39 Vs. 212.46±13.30; p = 0.001). More so, both total iron and TIBC levels did not differ significantly in the female participants when compared before and after aerobic exercise (p>0.05). See table 2 and figure 1.

There were statistically significant positive correlations observed in the subjects in pre-exercise between the levels of SBP Vs. DBP (r = 0.548; p = 0.002), RBC Vs. MCHC (r = 0.450; p = 0.013), MCV Vs. MCH (r = 0.847; p = 0.001) and between MCH Vs. MCHC levels (r = 0.422; p = 0.020), respectively. On the other hand, significant negative correlations were observed in the participants in pre-exercise between the levels of BMI Vs. MCHC (r = - 0.376; p = 0.041), and RBC Vs. MCV (r = - 0.484; p = 0.007), respectively (Table 3).

There were statistically significant positive correlations observed in the subjects in post-exercise between the levels of BMIVs. SBP (r = 0.489; p = 0.005), BMI Vs. DBP (r = 0.431; p = 0.017), BMI Vs. Total iron (r = 0.401; p = 0.028), SBP Vs. DBP (r = 0.656; p = 0.001), SBP Vs Total iron (r = 0.416; p = 0.022), MCV Vs. MCH (r = 0.921; p = 0.001), and between MCH Vs. MCHC levels (r = 0.403; p = 0.027), respectively (Table 4).

Table 1: Levels of BMI, BP, Total Iron, TIBC and Haematological Indices in Pre-exercise and post-exercise groups.

Parameters	Mean (±SD) (N=30)		p-value
	Pre-exercise	Post-exercise	
BMI	21.91±3.41	21.96±3.31	0.954
SBP	120.63±7.05	116.93±10.04	0.104
DBP	82.00±5.77	79.60±8.84	0.218
TOTAL IRON	45.96±6.45	55.69±10.92	0.001*
TIBC	216.34±12.50	232.32±12.47	0.001*
RBC	4.17±.86	4.60±.63	0.031*
MCV	87.60±7.31	88.61±6.54	0.576
MCH	28.83±2.59	32.39±2.58	.001*
MCHC	329.03±15.99	366.23±11.39	.001*

*Statistically significant at p<0.05.

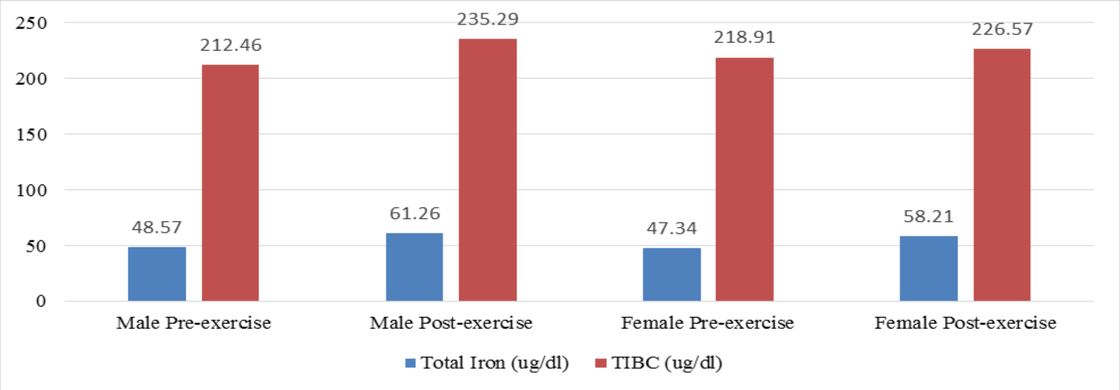

Figure 1: Gender wise differences in the mean levels of total iron and TIBC before and after exercise (mean±SD).

Table 2: Gender wise differences in the mean levels of total iron and TIBC before and after exercise (mean±SD).

Parameter	**Mean(±SD)**		**p-value**
	Pre-exercise	**Post-exercise**	
Male			
Total Iron(ug/dl)	48.57±6.71	61.26±30.29	0.110
TIBC (ug/dl)	212.46±13.30	235.29±12.39	0.001*
Female			
Total Iron(ug/dl)	47.34±10.06	58.21±17.61	0.090
TIBC (ug/dl)	218.91±13.43	226.57±20.97	0.340

*Statistically significant at p<0.05.

Table 3: Levels of association between parameters studied in Pre-exercise.

Parameters	**Correlation Coefficient**	**p-value**
BMI Vs MCHC	- 0.376*	0.041*
SBP Vs DBP	0.548	0.002*
RBC Vs MCV	- 0.484	0.007*
RBS Vs MCHC	0.450	0.013*
MCV Vs MCH	0.847	0.001*
MCH Vs MCHC	0.422	0.020*

*Statistically significant at p<0.05.

Table 4: Levels of association between parameters studied in Post-exercise.

Parameters	**Correlation Coefficient**	**P-value**
BMI Vs SBP	0.489**	0.005
BMI Vs DBP	0.431*	.017
BMI Vs Total iron	.401*	.028
SBP Vs DBP	0.656	0.001
SBP Vs Total iron	0.416	0.022
MCV Vs MCH	0.921	0.001
MCHVs MCHC	0.403	0.027

*Statistically significant at p<0.05.

DISCUSSION

This study evaluated the levels of total iron, total iron binding capacity and some haematological parameters amongst young undergraduates exposed to 3 weeks aerobic exercise. Our result showed significant increases in the levels of total iron, total iron-binding capacity, red blood cell count, mean cell haemoglobin and mean cell haemoglobin concentration after 3weeks of aerobic exercise in the participants.

These increases in serum total iron and TIBC found in this study may be attributed to the possible increased mobilization of iron stores and increased erythropoiesis commonly associated with short-term aerobic exercise in a bit to meet the increasing demand by body during such physical activity. Aerobic exercise is known to induce erythropoiesis (Mairbaurl, 2013). This finding aligns with the reports of Cichon *et al*. (2022) that found significant increases in iron and TIBC levels after acute exercise in young female basketball players suggesting that exercise is a stimulus that is capable of eliciting a hemolytic or non-hemolytic response that can influence iron and TIBC concentrations. Oluboyo *et al*. (2024) in variance with the current finding in this study recorded no significant differences in both iron and TIBC levels in apparently healthy males following short-term exercise in Ado Ekiti, Nigeria. Bukvi´c *et al*. (2024) observed no significant alteration in serum iron level with significant increase in TIBC level in Professional Water Polo Players which partly agrees with our current findings. Ordinarily when the mobilization of reticuloendothelial iron and enhanced absorption of iron are inadequate to meet the needs of erythroid marrow, the plasma iron tends to fall with the amount of serum transferrin increasing (Sharma *et al*., 2015).

This study found an increase in RBC count, which might be attributed to splenic contractions, reticulocyte release, and RBC release in response to adrenergic stimulation during exercise (Hu and Lin, 2012; Mairbäurl, 2013). During exercise, skeletal muscle contraction leads to increased adrenergic stimulation, which causes splenic contraction and the release of additional red blood cells to fulfill metabolic demands (Lindinger, 2022). Previous research suggests that moderate aerobic exercise in young adults leads to an increase in red blood cells (Khan *et al*., 2019; Bizjak *et al*., 2020; Okon *et al*., 2025). However other similar studies found either significant decrease (Cicek, 2018) or no significant difference (Okeke *et al*., 2020) in RBC count post aerobic exercise than in pre-exercise which is contrary to the current reports.

Also, we found significantly increased MCH and MCHC levels post-aerobic exercise than in pre-exercise. Exercise is synonymous with erythropoiesis because it is known to induce red blood cell production and haemoglobin synthesis via erythropoietin signalling, with the consequent hyperplasia of haematopoietic bone marrow and improved hematopoietic microenvironment brought on by exercise training which accounts for the increase in mean cell haemoglobin and mean cell haemoglobin concentration (Bhoopalan *et al*., 2020; Hu and Lin, 2012). Both MCH and MCHC are hemoglobin-related indices, and aerobic activity has been found to enhance haemoglobin levels (Sepriadi and Eldawaty, 2020). However, this result contrasts with earlier research that found no discernible differences in the subjects' MCH and MCHC levels after exercise and their pre-exercise values (Okeke *et al*., 2020; Ciekot-Sołtysiak *et al*., 2024; Bukvi´c *et al*., 2024). On the other hand, our study, like other studies (Ahmadizad and El-Sayed, 2005; Cicek, 2018; Nader et al., 2018; Ciekot-Sołtysiak *et al*., 2024), found no change in MCV after exercise. This demonstrates the absence of erythrocyte shrinkage (Nader *et al*., 2018). Furthermore, the mean TIBC was found to be significantly raised in male participants with no changes in total iron levels, whereas total iron and TIBC levels in female participants were similar before and after exercise. This may be related to differences in hormonal variations in males and females.

The current investigation found no statistically significant variation between the individuals' mean BMI before and after aerobic activity. This is consistent with the findings of Amah *et al*. (2017) and Ezeugwunne *et al*. (2018), but not with the findings of Cicek (2018), who found a significant drop in post-BMI and body weight in their participants. This could be attributed to the variations in exercise duration found in both investigations. Cicek's study (2018) involved 16 weeks of exercise, but our study involved only 3 weeks of exercise, resulting in no significant change in participants' BMI.

The non-significant blood pressure found in this study is in variance with previous studies by Okeke *et al*. (2020) and Brooks *et al*. (2005) who observed that during aerobic exercise, systolic blood pressure rises stating that as the intensity of the exercise increases, the heart works harder to pump more oxygenated blood to the muscles, while diastolic blood pressure remains relatively constant or may even decrease slightly.

There were statistically significant positive correlations observed in the subjects' pre-exercise between the levels of SBP Vs. DBP, RBC Vs. MCHC, MCV Vs. MCH, and MCH Vs. MCHC levels, implying that these indices have direct relationships and that as one increases in value, so do the other. On the other hand, significant negative correlations were identified in pre-exercise participants between the levels of BMI Vs. MCHC and RBC Vs. MCV, implying an indirection relationship between these parameters in that as one rises, the other decreases in value and vice versa.

In addition, there were statistically significant positive correlations observed in post-exercise subjects between the levels of BMI Vs. SBP, BMI Vs. DBP, BMI Vs. Total iron, SBP Vs. DBP, SBP Vs Total iron, MCV Vs. MCH, and MCH Vs. MCHC levels, respectively, indicating that a direct association exists between these parameters in post-exercise subjects, implying that as one increases, the other increases in a similar manner, and vice versa.

CONCLUSION

This study found significant increases in serum total iron, TIBC, RBC, MCH, and MCHC levels in subjects three weeks after aerobic activity compared to pre-exercise, with no significant changes in MCV, BMI, or blood pressure levels. Pre-exercise individuals showed strong positive correlations between SBP Vs. DBP, RBC Vs. MCHC, MCV Vs. MCH, and MCH Vs. MCHC levels, as well as significant negative correlations between BMI Vs. MCHC and RBC Vs. MCV levels. In post-exercise participants, there were also significant positive associations between the levels of BMI Vs. SBP, BMI Vs. DBP, BMI Vs. Total iron, SBP Vs. DBP, SBP Vs Total iron, MCV Vs. MCH, and MCH Vs. MCHC. As a result, this study found that short-term aerobic exercise improved blood iron, TIBC, and haematological indicators.

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