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Original Research Article

Relative Impact of Swimming on the Plasma/Serum Levels of Blood Glucose and Lipid Profile of *Wistar* Rats: A Clinical Trial from South Eastern Nigeria

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ABSTRACT

Background: Swimming is a form of exercise which can be of good value to mankind but in some cases may be detrimental to health. This study was designed to assess the role of swimming on the serum levels of blood glucose and lipid profiles.
Materials and methods: A total of 40 male *Wistar* rats were divided into four groups (A, B, C, D) which were allowed to acclimatize at room temperature for 2 weeks. Group A were not allowed to swim, while groups B, C and D swam for 2, 4 and 6 hours respectively, 3 times a week for one month. 4 ml of blood samples were collected before exercise, 2 and 4 weeks following exercise and 2 weeks post exercise through the orbital sinus. The plasma/serum levels of glucose, total cholesterol (TC), low density lipoprotein (LDL) triglyceride (TG) and high density lipoprotein (HDL) were analyzed spectrophotometrically.
Results: After 4 weeks of swimming, the mean values of the *Wistar* rats from groups B (4.41±0.12), C (4.36±0.02) and D (4.27±0.01) were significantly lower ($P<0.05$) than the *Wistar* rats that didn't swim (5.10±0.09). However, the mean serum levels of TC and LDL at 2 and 4 weeks of swimming were significantly lower ($P<0.05$) in *Wistar* rats in groups B (2.54±0.12; 2.51±0.06 and 1.05±0.02; 1.05±0.11), C (2.48±0.07; 2.45±0.02 and 1.06±0.06; 1.02±0.24) and D (2.22±0.26; 2.41±0.02 and 0.89±0.06; 1.02±0.12) respectively compared to group A rats (2.56±0.09; 2.51± 0.10 and 1.15±0.21; 1.16±0.15). While the mean value of HDL of groups B (1.24±0.04 and 1.25±0.03), C (1.26±0.09 and 1.28±0.09) and D (1.31±0.14 and 1.34±0.13) were significantly higher ($P<0.05$) when compared with group A *Wistar* rats (1.13±0.05 and 1.16±0.04) at 2 weeks and 4 weeks after swimming and non swimming respectively.
Conclusion: Swimming notwithstanding the duration, could be of good value in disease states such as diabetes mellitus and arthrosclerosis as shown be the significant decrease in blood glucose, TC and LDL and increase in HDL after hours and weeks of swimming.

***Keywords**:* Swimming, *Wistar* rats, Blood glucose, Lipid profile.

INTRODUCTION

Swimming is an aerobic exercise alongside with cycling, walking, skipping rope, rowing, running and playing tennis which focuses on increasing cardiovascular endurance. [1] Physical exercise is performed for various reasons including strengthening muscles and the cardiovascular system, weight loss or maintenance, boosting immune system, helping in preventing diseases of such as type 2-diabetes and obesity. [2,3] Swimming aids in the improvement of strength, flexibility, balance and coordination. It also helps to improve heart rate and lungs efficiency, and decreases blood pressure. It is one of the most exciting of the Olympic sports.

Glucose is a ubiquitous fuel in biology. It is used as an energy source in most organisms, from bacteria to humans. Use of glucose may be by aerobic respiration, anaerobic respiration or fermentation. Glucose is the human body's key source of energy, through aerobic respiration, providing about 3.75 kilocalories (16 kilojoules) of food energy per gram. Breakdown of carbohydrates (e.g. starch) yields mono- and disaccharides, most of which is glucose which can also be oxidized to CO_2 and water, yielding energy sources, mostly in the form of ATP. The insulin reactions, and other mechanisms, regulate the concentration of glucose in the blood. [4-6]

According to [7] moderate intensity exercise tends to lower glucose level in both Type 1 and Type 2 diabetics by using glucose from the blood and muscles for energy. While high-intensity exercise, on the, other hand increases glucose levels by promoting the production and release of glucose into the blood. High-intensity exercises is defined as greater than 80 percent of maximal oxygen consumption or $V0_2$ max and include anaerobic activities involving short bursts of energy such as power lifting, bench pressing, sprinting and swimming. [7] However, the use of glucose as an energy source in cells is by aerobic respiration or anaerobic respiration. Both start with the early steps of the glycolysis metabolic pathway thus, the alteration associated with moderate and high intensity exercise is misleading hence, the aim for this study.

Lipids are hydrophobic or amphiphilic micro-molecules which are classified into eight categories: fatty acids, glycerolipids, glycerophospholipids, sphingolipids, saccharolipids, polyketides, sterol lipids and prenollipids. [8,9] reported that vigorous exercise raises high density lipoprotein, a good kind of lipoprotein that actually keeps clear cholesterol from the blood. He showed that moderate exercise is not effective in reducing LDL-C or increasing HDL-C but it keeps cholesterol from rising. Genetics, weight, age, gender and diet contribute to individual cholesterol profile. Also, [10] showed that total cholesterol levels are lower in persons with aerobic fitness compared to low aerobic fitness. It is conclusively demonstrated that exercise training lowers total cholesterol. Therefore, the effect of exercise on lipid profile has been widely reported and the majority of research reported reductions in plasma triglyceride, cholesterol and lower density lipoprotein and increase in high density lipoprotein cholesterol when person with normal cholesterol level undertake physical exercise. [11-18]

Swimming is often done as a leisure or fun-filled event including sports with little or no knowledge on its role as an exercise. Several exercise related research have been implicated in some biochemical alterations with non on swimming as an exercise. [17-19] However, a study by [20] showed that exercise is associated with short term increase in liver enzymes which could impact negatively to the health of the exercising subjects. Notwithstanding, there was no report on the plasma/serum levels of glucose and lipid profile. Thus, this present study was designed to assess the role of swimming on the serum levels of blood glucose and lipid profiles with the aim of elucidating on the long term effects of exercise on these biochemical parameters.

MATERIALS AND METHODS

Study design and specimen collection for male *wistar* rats.

Forty (40) male *wistar* rats of 90 days old weighing 150±26g each were used for this study. They were further classified into 4 groups (A, B, C and D) respectively. Each group contained 10 rats. They were allowed to acclimatize for 2wks at room temperature and fed twice daily.

Group A: Control group rats that were not allowed to swim for.
Group B: Test group that were allowed to swim for 2 hour.
Group C: Test group rats that were allowed to swim for 4 hours
Group D: Test group rats that were allowed to swim for 6 hours

Ethical consideration:

Ethical approval for this study was obtained from the Ethics Committee of Nnamdi Azikiwe University Teaching Hospital (NAUTH), Nnewi. Informed written consent was obtained from the participants before the collection of data and blood samples.

Sampling technique:

The rats swam three times weekly for one month in round plastic tanks depth 50cm and width 45cm. Four milliliters (4 mls) of blood samples were collected before exercise, 2 and 4weeks following exercise and two weeks post exercise (swimming), through the orbital sinus. The samples were dispensed into well labeled plain specimen tubes, the serum obtained after centrifugation at 3000rpm for 10minutes were separated into aliquots and stored at -4^{o}C until analyzed.

Study site

The animals were housed in the animal house and the study was carried out the Chemical Pathology Department of Nnamdi Azikiwe University Teaching Hospital, Nnewi.

Statistical analysis

Version 20.0 statistical package for Social Science (SPSS) was used for statistical analysis. The result were expressed as mean and standard deviation (Mean±SD).Comparisons were made using ANOVA and paired t-test. P-value less than 0.05 (P<0.05) was taken as statistical significant.

RESULTS

The results of the mean plasma glucose following weeks of swimming and non-swimming in male *Wistar* rats as presented in table 1, showed no significant difference in the mean plasma glucose levels of the non-swimming rats (group A) (4.98±0.36) and the swimming rats (groups B, C and D) at zero (0) week (5.13±0.25, 5.15±0.40, 5.18±0.30) (P=0.16), and 2 weeks post exercise (5.08±0.22) and (5.03±0.33, 5.12±0.50, 5.08±0.31) (P=0.98) respectively. At 4 weeks of exercise the mean plasma glucose level of group A rats (5.10±0.09) were significantly higher than groups B (4.41±0.12), C (4.27±0.01) and D (4.36±0.02) (P=0.01) respectively.

Table 1: (Mean±SD) of plasma glucose concentrations (mmol/L) following weeks of swimming and non-swimming in male rats (n=24).

	0 wks	2 wks	4 wks	2wks post exercise
Group A (non-swimming). n=6	4.98 ± 0.36^{a}	5.22 ± 0.30^{a}	5.10 ± 0.09^{b}	5.08 ± 0.22^{a}
Group B (2hrs of swimming). n=6	5.13 ± 0.25^{a}	4.98 ± 0.43^{a}	4.41± 0.12^{b}	5.03 ±0.33^{a}
GroupC (4hours of swimming). n=6	5.15 ± 0.40^{a}	4.85± 0.35^{a}	4.36 ±0.02^{b}	5.12 ± 0.50^{a}
GroupD (6hrs of swimming), n=6	5.18± 0.30^{a}	4.72 ± 0.29a	4.27±0.01^{b}	5.08±0.31^{a}
F –value	1.94	0.82	5.05	0.06
P – value	0.16	0.50	0.01	0.98

Keys: a= non-significant difference across the groups, b = significant difference across the groups.

There was no significant difference in the mean serum cholesterol level of the non-swimming rats (group A) (2.83±0.13) and the swimming rats (group B, C and D) at 0 week (2.90±0.11, 2.88±0.27 and 2.91±0.07) (P=0.80) and at 6 weeks (2.82±0.012) and (2.83±0.11, 2.91±0.07, 2.88±0.08) (P=0.33) respectively. In addition, at 2 weeks and 4 weeks of swimming the mean TC level of group A (2.56±0.09 and 2.51±0.10) was significantly lower when compared with groups B (2.54±0.12 and 2.51±0.06), C (2.48±0.07 and 2.45±0.02) and D (2.22±0.26 and 2.41±0.02) (P=0.00) respectively.

Table 2: (Mean±SD) of serum cholesterol level (mmol/L) following weeks of swimming and non-swimming in male rats (n=24).

	0wk	2 wks	4 wks	2 wks post exercise
GroupA(non-swimming) n=6	2.83±0.13[a]	2.56±0.09[b]	2.51± 0.10[b]	2.82±0.12[a]
Group B (2hr of swimming) n=6	2.91±0.11[a]	2.54±0.12[b]	2.51±0.06[b,]	2.83±0.11[a]
GroupC (4hrs of swimming) n=6	2.88±0.27[a]	2.48±0.07[b]	2.45±0.02[b]	2.91±0.07[a]
Group D (6hrs of swimming) n=6	2.91±0.07[a]	2.22±0.26[b]	2.41±0.02[b.]	2.88±0.08[a]
F Value	0.33	6.52	4.35	1.20
P Value	0.80	0.00	0.00	0.33

Keys: a= non-significant difference across the groups, b = significant difference across the groups.

The result of mean serum low density lipoprotein level (mmol/L) following weeks of non-swimming group (A) and swimming group (B,C and D) in male *Wistar* rats presented in table 3, showed no significant difference in the mean serum low density lipoprotein levels of group A (1.21±0.12) and groups B (1.14±0.11), C (1.18±0.21) and D (1.27±0.14) at 0 week (P=0.51) and 2 weeks of post exercise (1.18±0.21) and (1.12±0.10, 1.16±0.21, 1.26±0.14) (P=0.53) respectively. However, at 2 weeks and 4 weeks of swimming the mean serum LDL-C level of group A (1.15±0.21 and 1.16±0.15) was significantly higher than the rats in groups B (1.05 ±0.02 and 1.05±0.11), C (1.06±0.01 and 1.02±0.24) and D (0.89±0.06 and 1.02±0.24) (P=0.00 and P=0.04) respectively.

Table 3: (Mean±SD) of serum LDL-C concentration (mmol/L) following swimming and non-swimming inmale rats (n=24)

	0 wk	2wks	4wks	2wks post exercise
GroupA(non -swimming) n=6	1.21±0.12[a]	1.15±0.21[b]	1.16±0.15[b]	1.18±0.21[a]
GroupB(2hrsof swimming)n=6	1.14±0.11[a]	1.05±0.02[b]	1.05±0.11[b]	1.12±0.10[a]
GroupC(4hrs of swimming)n=6	1.18±0.21[a]	1.06±0.06[b]	1.02±0.24[b]	1.16±0.21[a]
GroupD(6hrs of swimming)n=6	1.27±0.14[a]	0.89±0.06[b.]	1.02±0.12[b]	1.26±0.13[a]
F- value	0.85	6.01	0.61	0.75
P-Value	0.51	0.00	0.04	0.53

Keys: a= non-significant difference across the groups, b = significant difference across the groups.

The result of mean serum triglyceride (TG) concentration (mmol/L) following weeks of non-swimming group (A) and swimming groups (B, C and D) in male *Wistar* rats as presented in table 4 showed no significant difference in the mean serum TG levels of group A (0.98±0.03) and the groups B (0.98±0.02), C (0.91±0.06) and D (0.09±0.08) at 0 week (P=0.44) and 2 weeks post exercise (0.98±0.02) and (0.99±0.02, 0.95±0.06 and 0.93±0.06) (P=0.22) respectively. At 2 weeks and 4 weeks of swimming the mean serum triglyceride levels of group A rats (0.99±0.02 and 0.94±0.01) was significantly higher than the groups B (0.94±0.04 and 0.92±0.02), C (0.92±0.08 and 0.85±0.03) and D (0.82±0.00 and 0.82±0.01) (P=0.00) and (P=0.00) respectively.

Table 4: (Mean±SD) of serum TG concentration (mmol/L) following swimming and non- swimming in male rats (n=24)

	Owk	2wk	4wk	2wk post exercise
Group A (non-swimming) n=6	0.98±0.03[a]	0.99±0.02[b]	0.94±0.01[b]	0.98±0.02[a]
Group B(2hrsof swimming) n=6	0.98±0.02[a]	0.94±0.04[b]	0.92±0.02[b]	0.99±0.02[a]
Group C(4hr of swimming) n=6	0.91±0.06[a]	0.92±0.08[b]	0.85±0.03[b]	0.95±0.06[.a]
Group D6hrs of swimming) n=6	0.99±0.08[a]	0.82±0.95[b]	0.82±0.01[b]	0.93±0.06[a]
F- value	0.93	6.85	56.02	1.61
P-Value	0.44	0.00	0.00	0.22

Keys: a= non-significant difference across the groups, b = significant difference across the groups.

The result of mean serum HDL-C concentration (mmol/L) following weeks of non-swimming group (A) and swimming groups (B, C and D) in male *Wistar* rats presented in table 5, showed no significant difference in the mean serum HDL-C levels of group A rats (1.12±0.05) and groups B,C and D rats at 0 week (1.16±0.05, 1.21±0.07, 1.17±0.05) (P=0.18) and 2 weeks post swimming (1.12±0.05) and (1.16±0.03, 1.20±0.07, 1.16±0.09) (P=0.18) respectively. In addition, at 2 weeks and 4 weeks of swimming the mean serum HDL-C level of group A rats (1.13±0.05 and 1.16±0.04) was significantly lower than in the group B rats (1.24±0.04 and 1.25±0.03), C (1.26±0.09 and 1.28±0.09) and D (1.31±0.14 and 1.34±0.13) (P<0.05) respectively.

Table 5: (Mean±SD) of serum HDL concentration (mmol/L) following swimming and non-swimming in male rats (n=24)

	O WK	2WK	4WK	2WK post exercise
Group A(non-swimming)n=6	1.12±0.05[a]	1.13±0.05[b]	1.16±0.04[b]	1.12±0.05[a]
Group B(2hs of swimming)n=6	1.16±0.05[a]	1.24±0.04[b]	1.25±0.03[b]	1.16±0.05[a]
Group(4hrs of swimming)n=6	1.21±0.07[a]	1.26±0.09[b]	1.28±0.09[b]	1.20±0.07[a]
Group D(6hrs of swimming)n=6	1.17±0.01[a]	1.31±0.14[b]	1.34±0.13[b]	1.17±0.09[a]
F- value	1.83	4.28	4.46	1.83
P-Value	0.18	0.02	0.02	0.18

Keys: a= non-significant difference across the groups, b = significant difference across the groups.

DISCUSSION

Physical exercise is performed for various reasons which include strengthening of muscles and cardiovascular system, weight loss or maintenance, boosting immune system, helping in preventing the disease of affluence such as type 2-diabetes and obesity. [2,3]

In this study, there was a significant decrease in glucose level following swimming, which became more prominent after four weeks of exercise, whereas in non-swimming group serum glucose level remained unchanged, it could be used for hyperglycemic or diabetic subjects to reduce their glucose level. This finding agreed with the work done by Goodman [7] which showed that blood glucose levels are decreased during period of exercise. During exercise or in active state, there is usually increased energy demand by the body cells; therefore glucose is lowered by exercise due to increase permeability of glucose in the peripheral tissue. [7]

Furthermore, from this study there was significant decrease in the mean serum total cholesterol, triglyceride, and low density lipoprotein and an increase in high density lipoprotein at 2 and 4 weeks of swimming when compared with the non-swimming groups all of which normalized after two weeks of post swimming. Also in the non-swimming groups the mean serum levels of all the lipids remain similar throughout the duration of the exercise (swimming).This is in line with the report of majority of researchers who reported reductions in plasma triglyceride, cholesterol and low density lipoprotein and increase in high density lipoprotein cholesterol when subject with normal cholesterol level undertake physical exercise. [15-17] They also reported that the lipid levels return to baseline level 24hrs later while the lipoprotein lipase activity lasted longer, at least 48hours. Lower triglyceride concentration in the blood has been attributed to increase in skeletal muscle and adipose tissue lipoprotein lipase activity resulting from aerobic training. Lipoprotein lipase is the key enzyme for the breakdown of triglyceride rich lipoprotein. [21] The decrease of the body fat that often accompanies endurance training may be a contributing factor for the lowering effect of triglyceride due to exercise. It has also been reported that endurance trained athlete have much higher HDL-C values compared to sedentary populations. [14] Moderate and high intensity aerobic exercise training appears to be associated with elevated HDL-C value. The primary reason for the elevation of HDL-C is an increase in lipoprotein lipase activity in response to exercise. [21] The significant decrease in the LDL-C, TG, and CHOL and increase HDL-C level during swimming could be used as therapy for subjects with cardiovascular diseases since these could help in reducing the lipid level.

CONCLUSION

In conclusion in this study, swimming as an exercise has the capacity to influence the health conditions positively by decreasing plasma and serum levels of glucose, TC, LDL and TG and also increasing serum HDL. The increased serum level of HDL and decreased serum/plasma levels of TC, LDL and glucose suggests that swimming can be used as a therapy for cardiovascular disease (especially atherosclerosis) and diabetes mellitus. Thus, continuous recreational swimming and other physical exercise should be recommended for people with family history of diabetes and hypertension to enhance the prevention of these disease conditions which has become an increasing incidence in developing countries (Nigeria) inclusive.

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