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# Short-term aerobic exercise does not change kidney function in students of Nnamdi Azikiwe University, Nigeria

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## ABSTRACT

**BACKGROUND**

Exercise has been known to have beneficial effects on human health. The kidneys play an important role in regulating acid-base and water-electrolyte balance disturbances induced by exercise. The objective of this study was to investigate the effect of short-term aerobic exercise (volleyball training) on the kidney function of apparently healthy individuals.

**METHODS**

An experimental study of pre-post test design was conducted involving 41 amateur volleyball players, comprising 22 males and 19 females. They were randomly divided into seven different teams. Each team trained for at least 45 minutes for four consecutive days for two weeks. Both pre-and post-exercise blood pressure (BP) was measured using an automatic blood pressure measuring device OMRON 907 (OMRON, Hoofddorp, Netherlands). Likewise, both pre- and post-exercise blood samples were collected into lithium heparin tubes and centrifuged at 3000 rpm for 10 minutes and the plasma separated into plain tubes. Electrolytes were analysed using ion selective electrode machine (SFRI 4000, Germany), urea using modified Berthelot method, creatinine using Jaffe-Slot method and uric acid using the uricase method and estimated glomerular filtration state (eGFR) was calculated using the Modification of Diet in Renal Disease (MDRD) formula.

**RESULTS**

The mean levels of pre- and post-exercise systolic blood pressure, creatinine, urea, sodium, potassium, chloride, bicarbonate and eGFR did not differ significantly ($p>0.05$). However, serum uric acid was significantly increased ($p<0.05$), while diastolic BP significantly decreased after exercise ($p<0.05$).

**CONCLUSION**

The study showed that short-term moderate intensity aerobic exercise does not have any significant effect on the renal functions.

**Keywords**: Short-term, aerobic exercise, kidney function, students

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## INTRODUCTION

Several studies have reported that exercise is associated with both long-term and short-term metabolic, physiological and hemodynamic changes which can impact either positively or negatively on the health of the exercising subjects. Physical activity has been shown to have a positive effect on many chronic conditions such as cardiovascular disease, chronic kidney disease and diabetes.(1)

The benefits of physical activity to renal health have been demonstrated in a few studies but there are still questions which remain unanswered. One of the unanswered questions is related to the longitudinal effects of physical activity on renal function. The few studies which have sought to address this question in humans have revealed conflicting results.(2,3) A study investigated the association between physical activity, measured objectively with an accelerometer, and kidney function, and showed that total and light physical activities were found to be positively associated with kidney function.(4)

However another study in middle-aged women showed that six months of aerobic training does not induce significant change in estimated glomerular filtration rate and blood urea nitrogen.(5) Students in the environment of Anambra state, Nigeria, are daily involved in physical activities, some of which have become part of their lifestyle (e.g long distance walking, climbing staircases, climbing down and up the hilly environment of the school etc) and some others as recreational activities (volleyball, badminton, soccer and jogging). Specifically, volleyball playing is becoming an interesting sport of choice for students in this community. However, no study has been done with regard to its effect on the kidney function in the environment of Anambra state, Nigeria. Therefore, this study is designed to assess the acute or short-term effects of exercise (volleyball practice) on the kidney function of apparently healthy students of Nnamdi Azikiwe University, Nigeria.

## METHODS

### Research design

This was an experimental pre-post test designed to assess the effect of short term exercise on the kidney function and was conducted from July to September 2016.

### Study area

The study was carried out in the College of Health Sciences, Nnamdi Azikiwe University, Nnewi, Anambra state, Nigeria. This is a multi-faculty college comprising the Faculties of Health Sciences and Technology, Medicine and Basic Medical Sciences. Each of these Faculties is made up of numerous departments such as Medical Laboratory Science, Anatomy, Nursing, Medical Rehabilitation, Medical Radiography, Physiology, Medical Biochemistry, Pharmacology, Community Medicine etc. It has sporting facilities including a football field, volleyball court, tennis court etc.

### Study subjects

The study participants were students of the College of Health Sciences, Nnamdi Azikiwe University Nnewi, Anambra State. A total of forty-one (41) student amateur volleyball players comprising 22 males and 19 females who volunteered to participate in the study, were recruited for this study. The inclusion criteria were apparently healthy students within the age range of 17–28 years, who play volleyball and were willing to participate in the study. The following subjects were excluded; those suffering from any renal disease or hypertension, those who sustained any form of musculoskeletal injury, alcoholics, smokers and those on any form of medication including herbal remedies. Sampling was done by stratified sampling technique, where students were grouped into strata according to their departments. Students were selected from each department of the faculty using simple random sampling.

**Exercise potocol**

The subjects were instructed not to participate in any form of sports for one-week. After the one week of rest, the subjects were randomly divided into six (6) teams comprising 6 participants each, while the seventh team was comprised of 5 participants. Each team was subjected to volleyball training for a minimum time of 45 mins for four consecutive days in one-week for two-week periods.

**Measurements**

Anthropometric parameters such as the height and weight of each subject were measured using a standard stadiometer and a weighing scale before the exercise session and their body mass index (BMI) were calculated from it. Subjects' dietary pattern and lifestyle were also obtained using a well-structured questionnaire. A pre-exercise blood pressure was measured by taking two blood pressure (BP) readings on the right arm placed at the heart level, using an automatic blood pressure measuring device OMRON 907 (OMRON, Hoofddorp, Netherlands) after the subjects had rested for at least 5 minutes in a sitting position upon arrival to the volleyball court. The measurements were taken 60 seconds apart and the average systolic and diastolic BP were recorded and used for data analyses. Post-exercise BP were also taken after exercise on the last day.

**Laboratory analysis**

Five mL each of pre-exercise and post-exercise blood samples was drawn from the ante-cubital vein of each of the participants before the commencement of the exercises. The blood samples were collected into lithium heparin anticoagulant containers before commencement of the exercise session and on the last day of the session after exercise. The blood sample was then centrifuged at 3000 rpm for 5 minutes and then the plasma was extracted and kept frozen until biochemical analyses were carried out.

Urea estimation was carried out using the modified urease-Berthelot methods.[(6)] The Jaffe-Slot method was used to estimate the concentration of creatinine.[(7)] Estimation of uric acid was determined by the uricase based methods.[(8)]

The electrolytes assayed include sodium ($Na^+$), potassium ($K^+$), chloride ($Cl^-$) and bicarbonate ($HCO^3$) and this was done using Ion Selective Electrode (ISE). The estimated glomerular filtration rate (eGFR) was calculated using an online calculator for the Modification of Diet in Renal Disease (MDRD) formula for adults.[(9)] The formula is given as:

GFR (ml/min /1.73m$^2$) = 186 x [plasma creatinine (µmol/L)]$^{-1.154}$ x [age]$^{-0.203}$ x [1.210 (if black)] x [0.742 (if female)].

**Statistical analysis**

Statistical package for Social Science Students (SPSS) version 16.0 was used for the analysis of the results. Data were presented as mean ± standard deviation (SD) and Student's paired t-test and independent t-test were used to determine level of significance set at $p<0.05$.

**Ethical consideration**

Ethical approval was sought and obtained from the ethics committee of the Faculty of Health Sciences, Nnamdi Azikiwe University (No 2011614024P). An informed consent of all participants was obtained before they were recruited for the study.

## RESULTS

The results of anthropometric measurements of the participants showed that there was no statistically significant difference in the mean values of the male and female participants' age (23.23 ± 2.30 years; 21.74 ± 1.33 years), height (1.76 ± 0.05 m; 1.67 ± 0.06 m) and BMI (23.05 ± 1.68 kg/m$^2$; 22.39 ± 3.22

Table 1. The distribution of mean values of anthropometric measurements in the subjects

| Parameter | Male (n=22) | Female (n=19) | p value |
|---|---|---|---|
| Age (years) | 23.23 ± 2.30 | 21.74 ± 1.33 | 0.087 |
| Weight (kg) | 71.23 ± 7.19 | 62.37 ± 10.04 | 0.021* |
| Height (m) | 1.76 ± 0.05 | 1.67 ± 0.06 | 0.611 |
| BMI (kg/m$^2$) | 23.05 ±1.68 | 22.39 ± 3.22 | 0.624 |

BMI : body mass index; Significant values set at p<0.05; *Significant

kg/m$^2$), respectively (p>0.05) except in their weight (71.23 ± 7.19 kg; 62.37 ± 10.04 kg) (p<0.05) (Table 1). As shown in Table 2, their diastolic BP was significantly lower after exercise (p=0.021). However, the pre and post exercise systolic BP showed no significant difference (p=0.087).

The post exercise uric acid mean concentration was higher than the pre-exercise value (p=0.011). However, there was no significant difference in the mean values of electrolytes, urea and creatinine (p>0.05). There was also no significant difference in the mean values of the participants' GFR before and after exercise (p=0.548) (Table 2).

## DISCUSSION

Several reports have shown that duration and/or intensity of exercise elicit different effects on minerals metabolism and that inadequate status of the body mineral composition can lead to a diminution of performance and endurance both in sportsmen and rats.[10,11] Longer duration of exercise is needed to elicit a significant decrease in some biochemical parameters. [12] During aerobic exercise, systolic BP increases, since as the exercise intensity increases the heart works harder to pump more oxygenated blood to the muscles. At the same time, diastolic BP remains relatively stable and may even decrease slightly. On average, men have higher BP than women during aerobic exercise.[13] Such changes could have transient effects on the GFR as well as the renal function.

The findings from this work revealed that during short-term volleyball exercise, diastolic pressure decreased significantly. This drop in the diastolic pressure can be attributed primarily to the vasodilation of the arteries from the exercise bout which causes a reduction in peripheral resistance. It could also be due to a decrease in the blood volume caused by dehydration from water loss after exercise. This finding is in consonance with the findings of Syme et al.[14] who conducted a study and showed a decrease in diastolic blood pressure post exercise. However, there was also a small

Table 2. The blood pressure and renal function test of the subjects before and after exercise

| Parameters | Pre-exercise (n=41) | Post-exercise (n=41) | p value |
|---|---|---|---|
| SBP (mmHg) | 112.71 ± 9.00 | 116.10 ± 12.74 | 0.087 |
| DBP(mmHg) | 79.98 ± 11.61 | 76.39 ± 8.20 | 0.021* |
| $Na^+$ (mmol/L) | 139.14 ± 2.36 | 138.41 ± 2.56 | 0.143 |
| $K^+$ (mmol/L) | 3.61 ± 0.30 | 3.61 ± 0.46 | 0.991 |
| $Cl^-$ (mmol/L) | 102.89 ± 6.59 | 101.44 ± 2.01 | 0.154 |
| $HCO_3^-$ (mmol/L) | 21.81 ± 2.58 | 22.70 ± 2.55 | 0.078 |
| Urea (mmol/L) | 3.60 ± 0.88 | 3.79 ± 0.83 | 0.133 |
| Uric acid (mmol/L) | 326.47 ± 109.20 | 380.04 ± 54.58 | 0.011* |
| Creatinine (µmol/L) | 72.36 ± 14.24 | 73.22 ±18.72 | 0.717 |
| GFR (ml/min/1.73m$^2$) | 135.51 ± 54.96 | 129.27 ± 27.50 | 0.548 |

SBP= systolic blood pressure; DBP= diastolic blood pressure; GFR= glomerular filtration rate; Significant values set at p<0.05. *Significant but insignificant increase in their systolic blood pressure.

The mean concentrations of electrolytes after the exercise session as compared to the pre-exercise values, showed no significant change. It was observed that although there was a slight decrease in the mean concentrations of sodium and chloride ions after the volleyball exercise, this decrease was not significant. This slight but insignificant decrease in sodium can be attributed to minute loss of sodium in sweat during the exercise. Also the slight but insignificant reduction in the chloride ion can be explained by the fact that during exercise, reduction in sodium is accompanied by reduction in chloride as both sodium and chloride ions are the main constituents of sweat. It was also found that there was a positive correlation between the pre- and post-exercise concentrations of sodium and chloride. These findings were in agreement with those of Baydil,[15] who reported that the change in the mean concentration of sodium and chloride ions in individuals who exercised to the point of exhaustion were not significant. However, another study showed that exercise reduced sodium and chloride concentration significantly.[16]

During exercise, muscle $K^+$ efflux increases with increasing exercise intensity, and therefore maximal exercise induces a marked elevation in arterial plasma potassium ion.[17] However, the present study revealed that there was no change between the pre-exercise mean concentration of potassium ion and the post-exercise concentration. This can be explained by the fact that the changes in extracellular potassium ion concentrations are initially buffered by movement of potassium into and out of the skeletal muscle, a phenomenon known as internal potassium balance. It may be also have been due to the fact that the exercise was moderate in intensity and lasted for forty-five minutes. This does not support the observations made by several studies [15,18] that reported a significant increase in potassium concentration following exercise.

Similarly, the post-exercise bicarbonate concentration changes in this work showed a small but insignificant increase when compared to the pre-exercise value. This increase can be attributed to the physiological re-absorptive adjustment made by the kidneys in order to buffer the blood pH which tends to acidity as a result of increased $CO_2$ production from respiration during the exercise session. This observation is in conformity with the findings made by Ugwuja et al.,[19] who reported that exercise caused no significant change in the serum concentrations of bicarbonate.

Glomerular filtration is one of the key functions of the kidney and assessing the glomerular filtration rate has important clinical implications. Previous work reported a decrease in GFR after exercise.[20] According to the report, this decrease is dependent on the exercise intensity. This finding can be explained by the fact that during exercise, the renal blood flow tends to reduce as a result of the effect of the sympathetic nervous system and the release of catecholamines which induces the reduction of blood flow to the kidneys, which in turn decreases the glomerular filtration rate. However, the work by Ayca et al.[21] revealed that the glomerular filtration rate of individuals performing volleyball exercise decreased slightly but not significantly. This insignificant decrease can be attributed to the moderate intensity and short duration of the exercise and possibly to the use of serum creatinine and MDRS formula in calculating GFR.

Furthermore, the present study showed that the mean concentrations of creatinine and urea before and after exercise were not significantly increased. This can be attributed to the moderate intensity and short duration of the exercise and also to the reduced renal blood perfusion and slight decrease observed in the GFR of the participants after the volleyball exercise. A previous study conducted on half-marathon athletes reported an increase in GFR and creatinine clearance which contradicts the observation made in our study.[22]

In the present study a significant increase in the mean concentration of uric acid of the participants was observed. This is in line with the findings of Dunlap et al.[23] The increase can be explained by the fact that during short and long term exercise, the increase in uric acid levels serves as a protective mechanism against exercise induced oxidative stress.

It was also observed in the present study that the pre-creatinine concentration correlated positively and significantly with age, height, weight and BMI, whereas no correlation was found between these parameters and the pre-exercise blood urea concentration. This is in accordance with previous studies.[24,25] Meyer et al.[26] reported that serum creatinine concentration varies closely with the skeletal muscle mass. Also the study showed that the post-exercise concentration of creatinine was correlated negatively and significantly with the post-exercise GFR value, whereas there was no significant correlation between the pre-exercise concentrations.

The limitation of this study was that the exercise was a short term plan and could have affected the study results that there was no significant change in the kidney function of the participants. Moreover the intensity of the volley ball training was not considered. A prospective study in this line should endeavour to consider using a larger sample size, engage participants on long term exercise (volley ball) for a month and ensure that training intensity is consistent.

## CONCLUSION

This study found that short-term aerobic exercise (volleyball training) caused slight but insignificant changes in the renal function tests, showing that invariably it caused no renal function impairment.

## CONFLICT OF INTEREST

The authors declare that no conflict of interest exists.

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## CONTRIBUTORS

ACI, SMC and NO contributed to draft the manuscript. ACI, SMC, NO and DOF contributed to conception and design of the study. EF, ENI and OCO contributed to acquisition of the data. SMC, ACI and PCO contributed to data analysis and interpretation. ACI, EJ, RNI, OCO and SMC contributed to revising the manuscript critically for important intellectual content. All authors read and approved the final manuscript.

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