The Effect of Exercise on Serum Electrolyte Among Student Athletes of Madonna University

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Abstract

This study evaluated The Effect of Exercise on Serum Electrolyte Among Student Athletes of Madonna University Informed consent was obtained from all participants, and they were briefed that their blood samples would be used strictly for research purposes. A total of 100 blood samples were collected, comprising 70 samples from athletes (35 male, 35 female) (test group) and 30 samples from non-athletes (15 male, 15 female) (control group). The serum was separated from whole blood through centrifugation, and electrolyte levels were determined using the Ion Selective Electrode (ISE) method. The findings showed a Statistically significant increase ($p=0.013$) in serum sodium concentrations across groups, with male athletes (145.07 ± 3.15 mmol/L) exhibiting higher levels compared to female non-athletes (136.53 ± 1.06 mmol/L). There was also a Statistically significant increase ($p=0.000$) in potassium levels, with male athletes (4.95 ± 0.24 mmol/L) showing the highest concentration and female non-athletes (3.85 ± 0.11 mmol/L) the lowest. Calcium levels were notably higher in athletes, particularly male athletes (10.97 ± 2.32 mg/dL); calcium showed a Statistically significant increase ($p= 0.016$) when compared to non-athletes. Similarly, there is a Statistically significant increase($p=0.007$) was observed in chloride concentrations when compared across the groups, with male athletes (107.2 ± 3.08 mmol/L) recording the highest value. This study concludes that exercise significantly influences serum electrolyte concentrations, with both physical activity and gender contributing to variations. These results underscore the importance of electrolyte monitoring and nutritional regulation in athletic populations to support performance and maintain physiological balance.

Keywords

Exercise, Electrolyte, Student Athletes, Madonna University

1. Introduction

Serum electrolyte levels can be impacted by physical activity, and prolonged exercise can cause electrolyte loss through perspiration. The body's capacity to sustain appropriate fluid balance, muscle contraction, and nerve impulses may be affected by this loss. It is crucial for athletes and those doing intense physical activity to keep an eye on their electrolyte levels, particularly those of sodium, potassium, calcium, and magnesium [1].

Water and electrolytes, such as calcium, magnesium, potassium, and salt, are found in sweat. Excessive perspiration from prolonged or intense exercise might lower blood levels of certain electrolytes. The intensity of the exercise, the surrounding environment (such as temperature and humidity), and individual characteristics (such as age, sex, fitness level, acclimatisation status, and sweat rate) all have an impact on how quickly people perspire when engaging in physical activity. The body uses evaporative cooling to try to control its internal temperature, and high-intensity exercise, especially in hot and muggy conditions, can cause perspiration to increase dramatically. There is a greater chance of significant fluid and electrolyte loss under such circumstances.

A transient state of hypernatraemia can result after prolonged or intense physical exercise, particularly in heat-stressed environments, where fluid loss exceeds sodium loss, initially raising plasma sodium concentration. Continuous perspiration without sufficient electrolyte replacement, however, may eventually lead to a net loss of sodium and could culminate in hyponatraemia, a disorder marked by low blood sodium levels. In addition to affecting neuromuscular function, cognitive function, and thermoregulation, this imbalance might, in extreme situations, present major health hazards such circulatory collapse, seizures, or confusion.

Athletes, coaches, and medical professionals must thus comprehend how these variables interact in order to create efficient hydration and electrolyte replacement plans that will sustain performance, avoid problems, and promote general health while training or competing in a variety of settings[2].

As potassium is released from muscle cells during activity, levels may rise. However, some research indicates that sweat loss during and after extended exercise may cause potassium levels to drop. As these electrolytes are released from bone and muscle tissue during activity, serum levels of calcium and magnesium may rise, and they may fall during recovery. Serum electrolyte levels can be impacted by physical activity; therefore, it's critical to comprehend these impacts and maintain electrolyte balance both before and after exercise to maximise performance and avoid negative health outcomes [3].

Essential minerals with an electric charge that are vital to many body processes are called electrolytes. Exercise primarily affects three electrolytes: sodium, potassium, and chloride. Sodium aids in blood pressure and fluid balance regulation. Both the contraction and relaxation of muscles depend on potassium. Chloride is a necessary component of digestive juices and aids in maintaining fluid balance [4].

Muscle cramps, exhaustion, and other performance-related problems might result from changes in electrolyte levels. Electrolyte imbalances can occur in athletes in particular because of their high levels of physical activity, profuse perspiration, and poor diet [5]. Exercise's effects on electrolyte levels have been extensively studied, but little is known about how it specifically affects athletes at Nigerian colleges.

Exercise is a physical activity that has many positive effects on the human body, such as better mental health, stronger and more resilient muscles, and improved cardiovascular function. However, a number of physiological factors, particularly electrolyte levels, are also significantly impacted by exercise. Electrolytes, including sodium, potassium, and chloride, are essential for preserving adequate hydration, pH balance, and muscle and nerve function [6].

Muscle cramps, exhaustion, lightheadedness, and other performance-related problems might result from electrolyte imbalances brought on by exercise [7] Exercise length and intensity, as well as personal factors like hydration and dietary intake, all affect how severe these symptoms are.

An important electrolyte that aids in controlling blood pressure and fluid balance is sodium. Hyponatraemia, a disorder marked by low blood salt levels, can result from exercise-induced sodium losses. One essential electrolyte that is essential for controlling blood pressure and fluid balance is sodium. Exercise-induced salt loss can lead to hyponatraemia, a disorder marked by low blood sodium levels. This happens because sodium aids in preserving the right fluid balance both within and outside of cells; a decrease in sodium levels can cause cells to expand and may even result in health issues.

Because it regulates the flow of water into and out of cells, sodium is a necessary electrolyte that aids in maintaining fluid balance. It is also essential for the maintenance of steady blood pressure and the function of muscles and nerves.

When the blood's sodium content drops below the usual range, which is normally between 135 and 145 mEq/L, this disease develops. Excessive fluid intake, specific medical disorders, and—most crucially for athletes—sweating out salt after extended exertion are some of the causes.

People may lose a lot of sodium through perspiration after lengthy or vigorous activity, particularly if they are simultaneously drinking a lot of plain water, which further lowers sodium levels.

From moderate symptoms like nausea and weariness to more severe ones like confusion, seizures, and even coma, hyponatraemia can present itself in a variety of ways, depending on its severity [8].

Both the contraction and relaxation of muscles depend on potassium. Muscle cramps, exhaustion, and weakness might result from potassium alterations brought on by exercise. Muscle cramps, fatigue, and weakness can result from potassium imbalances, which can happen during exercise. Potassium is essential for both muscle contraction and relaxation. The electrical signals that cause muscle contractions are facilitated by potassium. Muscle dysfunction may result from the disruption of these signals caused by abnormal potassium levels.

When it comes to nerve and muscle function, particularly the transmission of electrical impulses that drive muscles to contract and relax, potassium is an essential mineral.

Hypokalaemia, or low potassium, can affect nerve transmission, making it harder for muscles to contract and rest as they should. Muscle weakness, exhaustion, and cramping may follow from this. Changes in potassium levels brought on by intense exercise may affect muscle function because some potassium is liberated from muscle cells into the circulation. This explains why athletes may feel tired or cramped, especially when engaging in lengthy or strenuous activity.

Muscle cramps and weakness can also be caused by electrolyte abnormalities, notably potassium, and dehydration.

Optimal muscle function depends on maintaining a proper potassium balance, and imbalances particularly those brought on by exercise—can result in a number of muscular issues [9].

Chloride is a necessary component of digestive juices and aids in maintaining fluid balance. Electrolyte imbalances and dehydration can result from exercise-induced chloride shifts. It is true that the body needs chloride for proper digestion and fluid equilibrium. As it follows sodium to balance charges, it is an essential part of digestive juices and aids in maintaining appropriate fluid levels. However, excessive sweating during exercise can cause electrolyte imbalances and possibly dehydration due to chloride loss.

For food to be broken down and nutrients to be absorbed, the stomach's gastric acid (hydrochloric acid) must include chloride.

Chloride aids in controlling the flow of water into and out of cells, preserving the body's ideal fluid balance. Maintaining blood volume and pressure is very crucial.

One important electrolyte that might upset the body's overall electrolyte balance is chloride.

Exercise causes the body to lose electrolytes, including chloride, through perspiration, especially in hot conditions. Dehydration and electrolyte imbalances may result from inadequate replacement of these losses.

Dehydration, particularly in athletes, can affect performance and cause a number of health issues.

Preventing electrolyte imbalances and dehydration, particularly during and after exercise, requires adequate electrolyte replacement and hydration through sports beverages, electrolyte tablets, or other means [10].

A thorough grasp of how exercise affects electrolyte levels can be extremely beneficial to athletes, coaches, and sports medicine professionals. Since electrolytes like sodium, potassium, calcium, and magnesium are vital for neurone function, muscle contraction, hydration, and acid-base balance, understanding this is crucial for maximising sports performance. Sports participants can avoid typical exercise-related problems including weariness, muscle cramps, dehydration, and in extreme situations, hyponatraemia or heat stroke, by carefully monitoring and controlling these electrolyte levels before, during, and after physical activity. Additionally, this knowledge enables the creation of specialised nutrition and hydration plans that are adapted to the unique requirements of various sports and environmental circumstances. In the end, this strategy improves performance and recuperation while also enhancing the athlete's general health, resilience, and lifespan [11].

The purpose of this study is to look into how exercise affects Madonna University student athletes' levels of sodium, potassium, and chloride. The electrolyte levels of athletes competing in track and field, basketball, football, and other sports will be compared to those of Madonna University's non-athletes.

2. Materials and Method

2.1 Study Area

The study was carried out in Madonna University Teaching Hospital (M.U.T.H), Elele, Rivers State, Nigeria.the hospital was founded by Rev. Fr. Prof. Emmanuel Matthew Paul Edeh CSSp, OFR. Elele is a town in Ikwere Local Government Area of Rivers state. The geographical coordinates of Elele are approximately latitude 5.1261^{o} N and longitude of 6.7853^{o}E. The community is known for its proximity to Port Harcourt, the capital of Rivers State, and serves as a hub for medical and educational activities. MUTH provides healthcare services to individuals from Rivers state and neighboring state, making it a suitable location for this study. The hospital has a 240-bed capacity. (Madonna University 2016).

2.2 Study Population

The study is consisted of 100 subjects (70 athletes, 30 non-athletes) comprising of 70 athletes (35 male athletes and 35 female athletes) and 30 non-athletes (15 male and 15 female) in Madonna university.

2.3 Criteria

2.3.1 Inclusion Criteria

The following criteria were enrolled for this study:

1.Subjects who have given written consent for the study.

2.Athlete that does not have any history of chronic or recent medicinal drug use.

3.subjects between 19 and 30 years of age

2.3.2 Exclusion Criteria

The following were excluded:

1.Subjects with History of kidney disease, heart disease, hypertension, or electrolyte imbalances.

2.Pregnant women

2.4 Ethical Approval

The research work was approved by the ethical community of Madonna University, Elele rivers state. The study was carried out according to the good clinical practice guidelines of the modified Helsinki declaration

2.5 Ethical Consent

Informed consent of the subjects involved was obtained. The subjects were told that their blood samples were collected for project research purposes.

2.6 Experimental Design

Blood sample was collected from 70 student athlete after exercise and blood sample was collected from 30 student who do not partake in exercise and analyze for serum electrolyte

2.7 Materials

Syringes, cotton wool, methylated spirit, tourniquet, plain container, needles, gloves, ion selective electrode.

2.8 Sample Collection

5ml (5 microliters) venous blood sample was collected in the mid cubital vein, in the forearm of the entire subject in sitting position (venipuncture) with minimal stasis. 5ml of Blood samples of each subject will then be carefully transferred into plain containers respectively. The blood sample in the plain containers will be separated by centrifugation at 40000rpm for 5 minutes. The plasma obtained was carefully pipetted using an automatic micropipette and transferred into another plain specimen container and tightly screwed. Then it will be deep frozen at -20^{o}C until analysis for electrolytes will be done for the samples that could not be analyzed immediately.

2.9 Laboratory Procedure

Determination of Sodium, potassium, calcium and chloride were carried out by Ion Selective Electrode (ISE) method

Principle of ISE: The principle of the Ion Selective Electrode (ISE) machine is based on the measurement of the electrical potential generated across an ion-selective membrane, which is specific to a particular ion; this potential is directly related to the ion's activity in solution according to the Nernst equation, allowing for accurate estimation of electrolyte concentrations

3. Statistical Analysis

Data obtained from this study was analyzed using Statistical Package for Social Sciences (SPSS) version 20 for windows 10. The results will be expressed as mean ± Standard deviation. Independent sample t-test which was used to compare means and values was considered significant at p<0.05 and non-significant at p>0.05.

4. Result

Table 1 below shows that there was a significant difference (p<0.05) in sodium concentration (mmol/L) of 140.4 ± 2.09, 145.07 ± 3.15, 136.53 ± 1.06, and 138.06 ± 4.54 for female athletes, male athletes, female non-athletes, and male non-athletes respectively.

There was also a significant difference (p<0.05) in potassium concentration (mmol/L) of 4.34 ± 0.22, 4.95 ± 0.24, 3.85 ± 0.11, and 4.77 ± 0.36 for female athletes, male athletes, female non-athletes, and male non-athletes respectively.

There was a significant difference (p<0.05) in calcium concentration (mg/dL) of 10.71 ± 2.38, 10.97 ± 2.32, 7.93 ± 1.1 and 8.4 ± 0.74, for female athletes, male athletes, female non-athletes, and male non-athletes respectively.

There was also a significant difference (p<0.05) in chloride concentration (mmol/L) of 102.4 ± 2.09, 107.2 ± 3.08, and 96.66 ± 2.96 and 97.53 ± 1.06 for female athletes, male athletes, female non-athletes, and male non-athletes respectively.

Table 1. Mean ± SD of Sodium, Potassium, Calcium, and Chloride levels of student athletes and non-athletes after exercise

Groups	Sodium (mmol/l)	Potassium (mmol/l)	Calcium (mg/dL)	Chloride (mmol/l)
Female Athletes (A)	140.4 ± 2.09	4.34 ± 0.22	10.71 ± 2.38	102.4 ± 2.09
Male Athletes (B)	145.07 ± 3.15	4.95 ± 0.24	10.97 ± 2.32	107.2 ± 3.08
Female Non-athletes (C)	136.53 ± 1.06	3.85 ± 0.11	7.93 ± 1.1	96.66 ± 2.96
Male Non-athletes (D)	138.06 ± 4.54	4.77 ± 0.36	8.4 ± 0.74	97.53 ± 1.06
F	18.23	35.62	12.41	42.80
P	0.013	0.000	0.016	0.007

P<0.05 .... Significant

p>0.05 .... Not significant

Table 2 shows a significant difference (p<0.05) in the sodium (mmol/L) concentrations of 140.4 ± 2.09, 145.07 ± 3.15, 136.53 ± 1.06, and 138.06 ± 4.54 obtained in female athletes, male athletes, female non-athletes, and male non-athletes respectively. There is also a significant difference (p<0.05) in the potassium (mmol/L) concentrations of 4.34 ± 0.22, 4.95 ± 0.24, 3.85 ± 0.11, and 4.77 ± 0.36 across the respective groups. Furthermore, a significant difference (p<0.05) was observed in calcium (mmol/L) concentrations of 10.71 ± 2.38, 10.97 ± 2.32, 7.93 ± 1.1 and 8.4 ± 0.74 in female athletes, male athletes, female non-athletes, and male non-athletes respectively. Similarly, a significant difference (p<0.05) was also observed in chloride (mmol/L) concentrations of 102.4 ± 2.09, 107.2 ± 3.08, 96.66 ± 2.96 and 97.53 ± 1.06 among the groups. These findings indicate that exercise and gender have measurable effects on serum electrolyte levels, particularly calcium and chloride, while the differences in sodium and potassium are also influenced by physical activity and sex-related physiological factors.

Table 2. Shows the mean ± SD of Sodium, Potassium, Calcium, and Chloride (mmol/L) concentrations in student athletes and non-athletes after exercise.

Groups	Sodium (mmol/L)	Potassium (mmol/L)	Calcium (mmol/L)	Chloride (mmol/L)
Group A (Female Athletes)	140.4 ± 2.09	4.34 ± 0.22	10.71 ± 2.38	102.4 ± 2.09
Group B (MaleAthletes)	145.07 ± 3.15	4.95 ± 0.24	10.97 ± 2.32	107.2 ± 3.08
Group C (Female NonAthletes)	136.53 ± 1.06	3.85 ± 0.11	7.93 ± 1.1	96.66 ± 2.96
Group D (Male Non-Athletes)	138.06 ± 4.54	4.77 ± 0.36	8.4 ± 0.74	97.53 ± 1.06
		Post Hoc p-Values:		
A vs B	0.021	0.029	0.002	0.003
A vs C	0.014	0.005	0.017	0.013
A vs D	0.029	0.044	0.001	0.001
B vs C	0.034	0.009	0.028	0.048
B vs D	0.036	0.012	0.001	0.000
C vs D	0.420	0.010	0.396	0.612

5. Discussion

The purpose of this study was to assess how exercise affected the serum electrolyte levels of Madonna University student athletes and non-athletes, both male and female. Exercise had a substantial ($p<0.05$) impact on sodium, potassium, calcium, and chloride concentrations, according to the data, and athletes and non-athletes differed significantly. This implies that electrolyte balance, which is necessary for neuronal function, muscle contraction, and fluid management, is maintained and modulated in large part by physical activity [12].

In this study, the concentrations of sodium, potassium, calcium, and chloride in the serum of both male and female athletes were significantly higher ($P<0.05$) than those of their non-athletic counterparts. This suggests that regular exercise may improve the mobilisation of calcium and the retention of chloride, which supports healthy neuromuscular function and acid-base balance both during and after exercise. Athletes' higher calcium levels could possibly be a result of greater skeletal integrity and increased bone remodelling activity brought on by physical activity. It is true that because of the mechanical stress of exercise, athletes with greater calcium levels had superior skeletal integrity and increased bone remodelling activity. This process involves a continuous cycle of bone formation and degradation to preserve bone strength and adapt to physical demands. Bone is constantly remodelling since it is a dynamic tissue. Whereas osteoblasts produce new bone, osteoclasts resorb (break down) preexisting bone. This mechanism is essential for preserving bone strength, repairing microdamage, and adapting to mechanical stress. Weight-bearing, high-impact exercises that encourage bone remodelling are common among athletes. Osteoblasts respond to the mechanical stress these activities place on bones by generating new bone tissue, which increases bone density and strength. Calcium, an essential component of bone, provides the mineral structure that gives it its hardness and strength. When bone is being remodelled, calcium is taken out of the bone during resorption and added to new bone during formation. [13].

Male athletes had considerably greater levels of potassium and sodium ($P<0.05$) than both female athletes and non-athletes. These physiological changes in muscle mass, perspiration rate, and hormonal impacts could be the cause of these gender-related disparities in electrolyte patterns. According to research, male athletes tend to have higher salt and potassium levels than female athletes and non-athletes. This is probably because to variations in perspiration rate, muscle mass, and hormonal impacts. According to studies, male athletes often have higher blood and sweat potassium and salt concentrations than both female athletes and non-athletes. Because men often perspire more than women, they lose more electrolytes, such as potassium and salt, through perspiration.

More muscular mass, which carries more electrolytes, is typically found in males. As a result, having more muscle mass might raise the body's overall electrolyte levels. The observed disparities between males and females may be attributed to the effects of hormones such as testosterone, which can affect metabolism and electrolyte balance.

Optimising hydration techniques for athletes and making sure they maintain appropriate electrolyte balance during physical activity require an understanding of these gender-related variations in electrolyte levels. The findings are consistent with previous research, including that of [14], which found that exercise affects electrolyte balance, specifically the redistribution of sodium and potassium as a result of sweat loss and cellular changes brought on by muscle activity.

The results of this study similarly support the findings of [8], who emphasised that electrolyte balance during exercise is essential for preventing cramps, weariness, and dehydration as well as for achieving peak athletic performance.

Athletes in this study had significantly higher ($P<0.05$) calcium and chloride levels, which is consistent with the findings of [15], who reported that regular exercise improves adaptive renal responses and electrolyte conservation. Exercise has been demonstrated to boost electrolyte conservation systems and the body's adaptive renal responses. The kidneys experience physiological changes during regular exercise that improve their ability to control fluid and electrolyte balance in stressful situations. These adaptations include better reabsorption of essential electrolytes like potassium and salt, enhanced blood filtration efficiency, and more accurate hormonal regulation through mechanisms like the renin-angiotensin-aldosterone system. Because of this, the body is better able to preserve essential electrolytes, particularly when exercising for extended periods of time or being exposed to heat, which increases fluid and mineral losses through perspiration. These renal changes eventually lead to better endurance and recovery, decreased risk of electrolyte depletion, and improved hydration status.

These results imply that regular exercise has a beneficial impact on the body's capacity to control and preserve ideal electrolyte balance. The body adjusts to repeated exercise by strengthening processes like fluid distribution, electrolyte reabsorption, and thermoregulation, which improves the body's ability to regulate vital ions like calcium, magnesium, potassium, and sodium. In addition to promoting effective neurological and muscular function during physical activity, this enhanced control lowers the likelihood of conditions including dehydration, cramping in the muscles, arrhythmias, and heat-related illnesses that are frequently linked to electrolyte imbalances [16]. As a result, consistent exercise may function as a buffer, enhancing the body's resistance.

The discovered gender disparities highlight the necessity of customised nutritional and electrolyte monitoring plans for male and female athletes. Serum electrolyte profiles, which are essential for maintaining performance and physiological stability during exertion, are strongly influenced by physical exercise, as this study supports.

6. Conclusion

The current study lends credence to the idea that student athletes' serum electrolyte levels are greatly influenced by physical exercise. Exercise was found to significantly raise levels of sodium, potassium, calcium, and chloride with different effects on sodium and potassium depending on gender. Compared to other groups, male athletes had greater amounts of calcium, potassium, sodium, and chloride. Exercise's physiological demands, which improve fluid balance, muscle activity, and electrolyte mobilisation, are responsible for these alterations. The observed variations further imply that electrolyte control and adaptive homeostasis are significantly influenced by gender and frequent exercise.

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