

Comparison of the effect of 100-meter freestyle swimming and 400-meter running on the electrolytes of short-distance swimmers

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ABSTRACT

This study aimed to compare the effect of 100-meter freestyle swimming and 400-meter running on the electrolytes of short-distance swimmers. The researchers used the descriptive method. The research sample included 8 short-distance swimmers from the team of Mosul University, specifically from the College of Physical Education and Sports Sciences. Tests, measurements, technical devices, and scientific sources were utilized as means of collecting research data. The data analysis was conducted using the statistical package SPSS (version 23.0). When we made the comparison between the pre-tests and the post-tests, we observed that 100-meter freestyle swimming resulted in a significant increase in the concentration of potassium, sodium and chloride ions during post-test. However, 400-meter running resulted in a significant increase in the concentration of sodium and chloride ions, but the increase was not significant in the case of potassium. When we compared the post-tests of all the variables studied, we found no significant differences in potassium between swimming and running. Regarding sodium, the concentration of this ion was significantly higher after 100-meter freestyle swimming than after 400-meter running. However, with chloride the opposite happened, being the concentration of chloride ion significantly higher after running than after swimming.

KEYWORDS

Blood; Aqueous Medium; Aerobic Medium; Physical Effort

1. INTRODUCTION

The study of the responses of functional variables to different types of physical effort is of great importance. One of the fields that are related to the responses of functional variables has

captured the interest of researchers and scholars in the field of sports training physiology. Among these responses are mineral salts, as they are an essential and important part of the components of the body and it needs in small quantities to maintain health and sustain life. In addition, salts differ from other elements in that they are inorganic elements. Many mineral salts carry out vital processes of great importance to the body. These salts are also chemically active materials because they have negative and positive charges that affect their biological behavior, especially their absorption by the digestive system and their transmission to the body through blood and fluids. The lack of these salts for a long time leads to an imbalance in the construction processes and body functions.

The importance of mineral salts is also evident in directing the activity of the body, affecting muscle contraction and relaxation, and regulating the activity of the heart muscle. In addition, it has special importance in absorbing glucose from the blood during physical exercise. During the physical effort, blood salts and ions play an important role, especially in aerobic sports that continue for a long time. Moreover, the importance of these components appears when performing aerobic exercises, especially when repeating the performance for a large number of attempts (Al-Naqeeb, 2017).

Many types of research, studies, and articles dealt with the effect of exercise and physical training on the responses of blood salts. Wilkerson et al. (1982) studied the concentration of salts in plasma and changes that occur the result of exercise, Speich (2001) dealt with the effect of exercise on some biological variables, salts, and minerals for athletes, Koc (2011) focused on the effect of high-intensity exercise on the values of blood salts and ions in handball players, Meludu et al. (2002) studied the changes induced by aerobic exercise in plasma minerals. Furthermore, Huldani & Fauziah (2020) dealt with an article on the physiological functions of blood salts and ions during physical exercise, while Sprenger (2011) studied fluid balance before and during exercise and the effects of the dry on physiological responses. Furthermore, there are few studies that researchers have dealt with are related to blood salts and ions and the changes that occur when physical effort during exercise.

Given the importance of variables on the functioning of functional organs and the response of blood salts and ions and ions during physical effort. In addition to the foregoing, we note that there is a clear shortcoming and scarcity in the studies that dealt with the study of the response of a number of blood salts and ions to physical effort in different environments. Hence the importance of this research was crystallized by providing information about the nature of responses to a particular effort in different environments to be of help to researchers, scholars, and those concerned in the field of sports training physiology.

Through the researchers' review of scientific studies and research, it was found that there is a dearth of studies and research that dealt with the study of the responses of a number of blood components to physical effort in two different environments. This motivated the researchers to study the response of a number of blood salts and ions to two different mediums (aqueous-aerobic). The research questions were: 1. What is the effect of physical effort in a water medium (swimming 100 m) on a number of blood salts? 2. What is the effect of physical effort in an aerobic medium (running 400 m) on a number of blood salts? 3. Is there a difference according to the environment in which the physical effort is exerted on the response of a number of blood salts?

The research objectives were: 1. To detect the response of a number of blood salts and ions to physical effort in a water medium (100 m free swim). 2. To detect the response of a number of blood salts and ions to physical effort in the aerobic medium (400 m sprint). 3. To compare the response of a number of blood salts and ions between a 400-meter sprint and a 100-meter freestyle swim.

The research hypotheses were: 1. There are significant differences in the response of a number of blood salts and ions to a 400-meter sprint between the pre and post measurement in favor of the post-measurement. 2. There are significant differences in the response of a number of blood salts and ions to the 100-meter freestyle swim between the pre and post-measurements in favor of the post measurement. 3. There are no significant differences in the number of blood salts and ions between the two post measurements (running 400 meters) and (running 100 meters freestyle).

2. METHODS

2.1. Study design and participants

The researchers used the descriptive method (with the comparative causal method) due to its suitability to the nature of the research. The study was implemented during the period from 26-09-2021 to 03-10-2021. The research sample included short-distance swimmers from the team of Mosul University, specifically from the College of Physical Education and Sports Sciences. Eight swimmers were intentionally chosen, and Table 1 displays information about the research sample.

Table 1. Sample characteristics

Statistical parameters	Weight (kg)	Height (cm)	Chronological age (years)	Training life (years)
Arithmetic mean	68.633	173.365	21.500	6.288
Standard deviation	4.344	3.882	1.760	2.657

2.2. Instruments and procedures

The instruments used in this study were: “GenoTEK” device for testing blood salts; a total of 25 5 ml medical syringe, wound tape, medical cotton with Dettol for sterilization, plasters, double distilled water (DDW) free of ions, Dettol sanitizer, plastic syringes, bandages, rubber band, a device to incubate the test tube, micropipette device to draw blood serum, centrifuge device for separating the blood sample, blood tubes (E.D.T.A), a special container for storing blood samples and transporting them to the analysis laboratory (Cool Box), and 5 digital stopwatches that measure to the nearest 1/100 of the second.

The tests used in this research were: 1. Swimming test (100 meters freestyle). 2. Running test (400 meters). Regarding the swimming test, after the warm-up process, the research sample was tested in a 100-meter freestyle swim, and the international rules of swimming were applied when executing the test, and the time was calculated to the nearest 1/100 second. Regarding the running test, after the warm-up process, the research sample was tested by running a distance of 400 meters, and the international rules of athletics were applied when the test was carried out, and the time was calculated to the nearest 1/100 of a second.

We used the GenoTEK device for examining the blood salts and ions under study, where we took 150 minimum inhibitory concentrations (MICs) from the blood serum and entered it into this device to process it and show the results of the blood salts and ions studied (sodium, potassium, and chloride).

The ambient temperature and relative humidity variables were recorded. The ambient temperature was 21.1 - 23.4 degrees Celsius, and the relative humidity was 45% - 53% for the two main experiments. The data on the functional measurements were recorded in a form prepared for this purpose.

The variables under study were measured at rest time (before effort) on Wednesday 26/9/2021, from 2.00 until 2.15 pm, when the research sample sat and relaxed for at least 20 minutes before the blood drawing process, in order to stabilize the variables whose values are affected by the movement of the person.

The first main experiment (100 meters freestyle swim) was conducted on Wednesday 26/9/2021, from 2:30 until 5.00 in the evening. Each individual from the research sample warmed up for 20 minutes individually and consecutively, before starting the main experiment. Testing was conducted with a 100-meter freestyle swimming test at the maximum intensity and individually.

After completing a 100-meter freestyle swim, the blood sample was drawn from the players immediately, then placed in a special test tube and taken to the laboratory to measure the variables under investigation.

The second main experiment (400 meters running) was conducted on Wednesday 3/10/2021 from 2:30 until 4:30 in the evening. The same first main test procedure was repeated after the 400 m running. The two main experiments, after swimming 100 m freestyle and after running 400 m, included drawing blood samples to measure the blood salts and ions in an amount of 5 ml, where each blood sample was placed in a test tube, after which it was transferred to the laboratory for analysis.

2.3. Statistical analysis

The statistical package (SPSS) version 23.0 was utilized for processing the statistical data. The research employed the following statistical methods: arithmetic mean, standard deviation, and the T-test for both correlated and independent samples. For the present study, statistical significance was set at $p < 0.05$.

3. RESULTS

Table 2 presents a comparison between the pre-tests and the post-tests for all the variables studied. 100-meter freestyle swimming resulted in a significant increase in the concentration of potassium, sodium and chloride ions during post-test. 400-meter running resulted in a significant increase in the concentration of sodium and chloride ions, but the increase was not significant in the case of potassium.

Table 3 compares the post-tests of all the variables studied. In the case of potassium, there were not significant differences between swimming and running. Regarding sodium, the concentration of this ion was significantly higher after 100-meter freestyle swimming than after 400-meter running. However, with chloride the opposite happened, being the concentration of chloride ion significantly higher after running than after swimming.

Table 2. Comparison between pre-tests and post-tests

	Tests	Arithmetic mean	Standard deviation	t	p
Potassium ion (K) in the blood (mml/L)	Pre-test swimming	4.797	0.284	5.059	0.001*
	Post-test swimming	5.917	0.663		
	Pre-test running	4.797	0.284	1.562	0.162
	Post-test running	5.580	1.419		
Sodium ion (Na) in the blood (mml/L)	Pre-test swimming	147.125	1.220	13.688	0.000*
	Post-test swimming	161.137	3.432		
	Pre-test running	147.125	1.220	3.533	0.000*
	Post-test running	153.550	5.636		
Chloride ion (Cl) in the blood (mml/L)	Pre-test swimming	106.187	1.851	6.336	0.000*
	Post-test swimming	112.500	33.521		
	Pre-test running	106.187	1.851	9.414	0.000*
	Post-test running	114.537	2.597		

Table 3. Comparison of post-tests

	Post-tests	Arithmetic mean	Standard deviation	t	p
Potassium ion (K) in the blood (mml/L)	Swimming	5.917	0.663	0.751	0.477
	Running	5.580	1.419		
Sodium ion (Na) in the blood (mml/L)	Swimming	161.137	3.432	7.541	0.000*
	Running	153.550	5.636		
Chloride ion (Cl) in the blood (mml/L)	Swimming	112.500	3.521	2.614	0.035*
	Running	114.537	2.597		

4. DISCUSSION

4.1. Potassium ion

Our results indicated that there are statistically significant differences between pre and post-tests in both the aqueous medium and aerobic medium. These differences were more pronounced after the test in the aqueous medium, where it had a clear effect by increasing the concentration of potassium in the plasma after the effort compared to before the physical effort. In the aerobic medium, however, this increase in potassium ion was not significant.

The results of this study align with several previous studies on blood salts, ions, or electrolytes. For instance, the findings are consistent with the study by Tenan (2009), which observed that during physical exercise, the concentration of potassium in plasma generally increases in a linear manner with increased exercise intensity. Additionally, Vollestad et al. (1994) conducted a high-intensity test on a healthy sample aged 28 years and noted an increase in plasma concentrations of potassium after the graded test. Moreover, Al-Naqeeb (2017) investigated the response of various blood salt and ion variables after performing gradual aerobic exercise, concluding that gradual exercise significantly increased the concentration of these salts. Furthermore, Meludu et al. (2002) found an increase in potassium levels in the blood after performing anaerobic exercise on a stationary bike.

While some studies have not shown significant differences in saline ratios between pre- and post-effort periods, others have observed a reduction in blood salts and ions after physical exertion. For example, Vollestad et al. (1994) demonstrated a decrease in blood potassium levels in 10 healthy men following a 10-minute bike effort test. Similarly, Medbo et al. (1990) found a slight decrease in blood potassium levels in both long-distance and short-distance runners after completing a run on the treadmill. Additionally, a study by Raj et al. (2014) conducted on students in the College of Medicine reported no difference in potassium concentration before and after physical exercise using a treadmill device with intensities ranging from 64 to 76%.

Potassium is one of the most abundant substances in intracellular fluid, with an estimated amount of 140 mmol/L, and 4 mmol/L in extracellular fluid. It functions as an anti-sodium ion. The human body requires potassium in small quantities, and deviations in its levels can lead to various disorders such as digestive, cardiovascular, and metabolic disorders when levels decrease, or muscle weakness, decreased awareness and cognition, and paralysis when levels increase (Huldani & Fauziah, 2020).

The increase in blood potassium levels during physical activity occurs due to the transfer of potassium from intracellular fluid (CIS) to extracellular fluid (CES). This transfer happens because potassium is released into the extracellular fluid through sweat as a result of body overheating. To maintain potassium levels outside the cells, potassium travels from inside the cells to outside (Huldani & Fauziah, 2020). Furthermore, changes in potassium levels during physical activity may be associated with increased muscle fibers being recruited with increased exercise intensity. As more muscle fibers are depolarized during physical activity, more potassium is expected to accumulate in the blood due to the flow of potassium ions from muscle cells to extracellular fluid (Tenan, 2009, p. 38).

The degree of acidification also affects plasma potassium concentration. pH levels control the distribution of potassium between plasma and cells, with high pH (alkalosis > 7.4) increasing potassium movement into cells and low pH (acidosis) leading to potassium exit from cells. High plasma potassium levels also increase aldosterone excretion, leading to potassium loss from the body to restore balance. This change in distribution with acidic state means plasma potassium concentration may not reflect overall body content (source). Medbo & Sejersted (1990) asserted that the increase in potassium proportion regulates the body's acidity and basal levels during muscle work, as well as fluid balance, which is affected by exercise-induced increase in acidity due to elevated lactic acid in muscles (Medbo & Sejersted, 1990). Alkla (2009) suggested that increasing plasma potassium concentration indicates increased blood acidity, leading to hydrogen exchange with potassium on cell walls. Hydrogen enters cells while potassium ions exit, resulting in increased blood potassium levels.

4.2. Sodium ion

From our results, it is evident that there are differences in the levels of sodium in the blood, whether physical activity is performed in an aqueous or aerobic medium. The results of this study both agree and differ from various studies conducted on this variable.

The findings of the current study align with research by Sprenger (2011) on ice hockey players, where a significant change in sodium levels was observed after matches. Similarly, Wahyudi et al. (2008) found that most participants experienced an increase in sodium levels. Additionally, Montung et al. (2015) reported an increase in plasma sodium levels after an aerobic physical test in a sample of medical students. Contrarily, Wadud et al. (2012) discovered in their study, conducted on students of the College of Sports Education, that while sodium levels increased due to anaerobic effort, the group that performed anaerobic exercise did not show an increase in plasma sodium levels. While several studies, such as that of Engka et al. (2003) on footballers, have shown little change in blood salt levels, others have reported a decrease in plasma salt ratios. For instance, Emenike et al. (2014) found a decrease in sodium levels after games involving football, volleyball, and handball players. Similarly, in a study involving middle school children, a physical test using a walking device resulted in a significant decrease in sodium levels for some participants (Huldani & Fauziah, 2020).

The researchers posited that the increase in plasma sodium salts may occur due to dehydration resulting from sweating caused by the body's central heating. This leads to an increased concentration of sodium salts per liter of blood as sweating intensifies. This is supported by Emenike et al. (2014) and Huldani & Fauziah (2020).

According to Ferreira (2019), exercise affects plasma concentrations of sodium, which are essential for stimulating nerve and muscle capacity. Ferreira et al. (2020) noted that these concentrations depend on the activity of the enzyme Na⁺/K⁺-ATPase, which stabilizes salt concentrations during exercise. Sodium's main function is to regulate the body's osmotic equilibrium, which influences the movement of ions and solvents between body fluid compartments. Changes in blood sodium are detected by central receptors, triggering responses such as thirst stimulation, salt requirement, sympathetic nervous system activation, and regulation of renal fluid hormones and the renin-angiotensin-aldosterone system (Stachenfeld, 2014).

4.3. Chloride ion

Our results showed variations in the concentrations of chloride in plasma following physical exertion, with studies reporting conflicting findings.

The results of the current study are consistent with research conducted by Wilkerson (1982), who observed an increase in blood salt and ion concentrations in plasma after physical exertion on a treadmill, including chloride. Similarly, Medbo & Sejersted (1985) found an increase in chloride concentrations following high-intensity exercise. In contrast, some studies, such as Tibes et al. (1974) and Koc (2011), have reported no significant changes in chloride concentrations in plasma following physical efforts.

Chloride is the primary anion in extracellular fluid and plays a crucial role in maintaining various biological processes. It helps regulate blood volume, blood pressure, pH of body fluids, and acid-base balance. Additionally, chloride ions are essential for red blood cells' functions, such as removing carbon dioxide and forming hydrochloric acid for protein digestion (Pulur et al., 2016).

The concentrations of chloride in plasma are closely related to those of sodium, increasing and decreasing for similar reasons and in direct proportion to sodium levels. However, an imbalance in acid-base balance can lead to independent increases in blood chloride levels, with chloride acting as a regulator. During exercise, the functions performed by blood salts and ions are accelerated, requiring adequate mineral intake to optimize performance. Dehydration due to sweating can lead to an increase in plasma salts and ions per liter of blood, as observed in previous studies (Emenike et al., 2014; Huldani & Fauziah, 2020).

Furthermore, an increase in chloride ions may occur due to chloride shift, where carbon dioxide produced during aerobic cellular respiration is converted into carbonic acid, dissociating into hydrogen and bicarbonate ions. Bicarbonate ions are exchanged for chloride ions in red blood cells, leading to increased plasma chloride levels.

In the current study, differences in measured blood salts between aqueous and aerobic environments were noted, with most differences favouring the aqueous environment. This could be attributed to the physiological burden imposed by the water environment, intensifying physical efforts and affecting organ function. This aligns with Tenan's (2009) explanation that the concentration of salts in plasma increases linearly with exercise intensity.

5. CONCLUSIONS

In conclusion, 100-meter freestyle swimming resulted in a significant increase in the concentration of potassium, sodium and chloride ions during post-test. However, 400-meter running resulted in a significant increase in the concentration of sodium and chloride ions, but the increase was not significant in the case of potassium.

When we compared the post-tests of all the variables studied, we found no significant differences in potassium between swimming and running. Regarding sodium, the concentration of this ion was significantly higher after 100-meter freestyle swimming than after 400-meter running. However, with chloride the opposite happened, being the concentration of chloride ion significantly higher after running than after swimming.

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AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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