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# Impact of running race in warm weather on hematological and biochemical parameters

A.M. ALHOWIKAN[1], H.M. AL-HAZZAA[2]

[1]Department of Physiology, College of Medicine, King Saud University, Riyadh, Saudi Arabia
[2]Health Science Research Center, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia

**Abstract. – OBJECTIVE: Exercise is highly essential for a healthy life. The athletes drink water to restore the body fluid volume and salt ingredients during the exercise. It is postulated that the blood parameters of athletes would greatly be affected if they run more than 10 km in controlled dehydration (without taking liquid) in a hot environment. This study aims to investigate the acute hematological changes in Saudi male athletes engaged in sports activities in a hot climate without taking fluid.**

**PATIENTS AND METHODS: In this cross-sectional study, the participants were adult Saudi athletes (n=12) who ran for a 10 km distance during the daytime when the temperature was ≥35°C. Blood samples were collected before and after the race and analyzed by standard methods for hematocrit, plasma volume, hemoglobin, total white cells count, red cells count, and blood lactate was examined.**

**RESULTS: The mean age of athletes was 22.83 years; their mean height was 173.8 cm, and the mean weight was 56.1 kg. The average body fluid loss during the race was 1.88 ± 0.70 L. The white blood cells, hematocrit, hemoglobin levels were increased significantly at the end of the running event ($p < 0.05$). However, values of red blood cells and insulin were decreased.**

**CONCLUSIONS: Exercise, mainly the running race in hot weather conditions, has a significantly increasing impact on athletes' hematological and biochemical parameters. The findings have an important message for the sports trainers and coaches to prepare prospective professional athletes and improve their performance for national and international sports events.**

*Key Words:*
Athletes, Dehydration, Exercise, Hematological parameters, Hot environment, Race.

## Introduction

There is a biochemical response to the body of sportspersons when they exercise in a hot environment because the exercise affects the chemistry of electrolytes of plasma and serum. During training, the human body's heat is dissociated from the atmosphere by increased sweating and skin blood flow. These thermoregulatory adaptations enhance physiological stress and dehydration during prolonged and intense exercise[1].

The human body has approximately 60-70% water of its total body weight in men[2]. The loss of body fluid or dehydration impairs the body's normal physiological functions, but it is unknown. Factors, such as diet, environmental temperature, and exercise change body fluid volume, as proven by the previous studies[3-5]. Therefore, athletes drink fluids and water to restore water volume and salt ingredients in their bodies when running exercise[6].

However, it is postulated that the performance of athletes would greatly be affected if they run in controlled dehydration (i.e., without taking fluid) in a hot environment. The question was to what extent their body fluid and plasma changes would greatly be affected. This opens a new research paradigm because little is known about the association of hydration and running exercise of Arab-origin athletes. Assessment of the hematological profile is an essential part of evaluating the health and performance of athletes. The serial blood chemistry analysis evaluation indicates the extent to which an out-of-range shift in blood parameters attributes to retaliating to physical activity, such as exercise or running. Hematological responses to endurance running have not been observed in Saudi athletes where the environmental conditions are hot and dry, especially in central Saudi Arabia.

The hematological changes occurring post-exercise are specific to the training status of the athletes, intensity, and duration of the sports activity. This study examined the hematological changes in Saudi male athletes responding to 10 km of the race without taking fluid or water. It also compared dehydration effects on the blood rhetological profile before and after a running race in a hot environment. This study was approved by the



*Corresponding Author:* Abdulrahman Mohammed Alhowikan, MD; e-mail: ahowikan@ksu.edu.sa

Institutional Review Board of the College of Medicine-King Saud University.

## Patients and Methods

This cross-sectional study was conducted in the Department of Physiology, College of Medicine, King Saud University Riyadh, Saudi Arabia, in July 2018. The daytime temperature of Riyadh city ranged from 30-46°C. In the early hours of the day, the ambient dry-bulb temperature and the relative humidity before the race were ≥34°C, and 10-13%, respectively. The twelve experienced distance runner Saudi males (22.8±5.23 years, 173.8±1.3 cm, 56.1±59 kg) participated in a 10 km foot race. They were healthy and non-smokers athletes (training >8 hr. of a week). The informed consent of the participants before taking part in this research was under the guidelines as set by the Declaration of Helsinki. Research procedures were approved by the Research and Laboratory Committee under Number BS 9/3_5_2021. The subjects gave their written informed consent to participate.

### Blood Sampling and Measurements

Venous blood samples (10 ml) were collected from the participants 30 minutes before the start of a foot race. To compare the hematological changes, the second blood samples were taken from all the athletes within 10 minutes of the end of the race in one EDTA tube containing lithium heparin (Becton, Dickinson and Company, Franklin Lakes, NJ, USA). The Dill and Costill method determined the pre-test and post-test changes in plasma volume[7].

Plasma hemoglobin levels were quantified using the HemoCue photometer system (Radiometer Limited, Crawley, UK). Hematocrit (Hct) was measured by micro-capillary technique after spinning in a bench-top centrifuge (Hawksley Ltd., Lancing, UK) for 3000 rpm at room temperature (25°C).

**Table I.** General physical characteristics of the Saudi male athletes (n=12).

| Athletes' parameters | Mean±SD | Range |
|---|---|---|
| **Age (years)** | 22.83±5.23 | 21-39 |
| **Height (cm)** | 173.8±1.3 | 171.6-177.3 |
| **Weight before the race (Kg)** | 56.11±5.9 | 44.70-65.40 |
| **BMI (Kg/m$^2$)** | 23.13±2.56 | 19.20-26.10 |
| **Body fluid loss (L)** | 1.88±0.70 | 0.60-3.40 |

The plasma insulin level was quantified in mmol/l using the radioimmunoassay (RIA) method by a commercially available kit (CIS Bio International, Gif-sur-Yvette Cedex, France). Plasma lactate was determined using Hitachi 704 Analyzer (Boehringer Mannheim GmbH, Germany). The red blood cells (RBC) and white blood cells (WBC) were measured using the Coulter counter.

### Statistical Analyses

The descriptive characteristic of the athletes was exhibited as mean ± SD; A 2-tailed paired *t*-test was applied, using SPSS package, version 20 (SPSS Inc, Chicago, IL, USA), to compare and differentiate the values between pre-race post-race samples of the athletes. *p*-value ≤ 0.05 was considered statistically significant.

## Results

Table I shows the general physical characteristics of Saudi male athletes. The athletes' age range was 21 to 39 years, their height range was 171 to 177 cm, and their weight range was 44 to 65 kg. The average body fluid loss during the race was 1.88 ± 0.70 L. The weight of the athletes decreased with the running exercise, and their weight loss was 1.71±0.65 %. The mean finishing time of the running race was 31.52 minutes (Table II).

**Table II.** Effects of running race in warm weather on hematological and biochemical parameters.

| Parameters | Reference range | Rest | End of Race | Differences | *p*-value |
|---|---|---|---|---|---|
| **WBC** | 4.0-10.0X10$^3$ /mm | 6.34±1.92 | 8.55±2.74 | 2.75±2.76 | 0.026* |
| **RBC** | 4.4-5.7X10$^6$/mm | 5.03±0.27 | 4.74±0.69 | 0.013±0.11 | 0.763 |
| **Hb** | 14.0-17.4 g/dL | 13.91±1.85 | 14.13±2.07 | 0.38±0.19 | 0.001* |
| **Hct** | 42-52% | 42.16±2.80 | 42.94±2.55 | 0.38±0.19 | 0.013* |
| **Lac−** | 0.5-1.5 mmol/L | 3.07±0.76 | 9.52±1.34 | 6.45±1.69 | 0.001* |
| **INS** | 5-25 mmol/L | 15.07±6.15 | 14.46±10.53 | -0.61±10.86 | 0.850 |
| **Weight (kg)** | -- | 56.12±5.9 | 54.41±5.946 | 1.71±0.65 | 0.001* |

WBC = White blood cells, RBC = Red blood cell, Hb = Hemoglobin concentration, Hct = Hematocrit, Lac = Blood lactate concentration, INS = Insulin, Difference between before and at the end of race * $p < 0.05$; Values are presented in means ± SD.

### *Hydration Status of the Subjects and Hematological Changes*

Overall, the hematological variables, except for the RBC and insulin, in dry conditions increased significantly at post-race (Table III). Comparing the pre- and post-race, a significant rise of Hematocrit (Hct) was observed at the end of the running race ($p$=0.013). Blood lactate increased to an average of 6.45±1.69 mmol/L (Table III). However, the red blood cells were lowered at the end of the race compared to the resting (pre-race) phase ($p$=0.76). Similarly, comparing the pre- and post-running race values, no significant difference was found between the insulin values in athletes ($p$=0.85) (Table III). This table illustrates the correlation coefficients of performance ranking and percent fluid loss with levels of changes (post minus pre values) in selected parameters. The finishing rank correlated moderately with changes in many of the selected variables. Moreover, there was a moderate positive relationship between finishing rank and percent of fluid loss (r= 0.496, $p$=0.101). Furthermore, change in in hematocrit level (r = 0.654, $p$=0.040), changes in hemoglobin levels (r = 0.654, $p$= 0.040), changes in red blood cell counts (r = -0.801, $p$= 0.017) and changes in white blood cell counts (r = 0.719, $p$ = 0.045).

**Table III.** Correlation coefficients ($p$-value) of levels of changes (post-pre values) in selected parameters with each of finishing rank and fluid loss (as % of body weight).

| Variable | Finishing rank | Fluid Loss (%) |
|---|---|---|
| **Fluid loss (%)** | 0.496 (0.101) | - |
| **Changes in WBC** | -0.129 (0.761) | -0.171 (0.685) |
| **Changes in RBC** | -0.191 (0.650) | -0.288 (0.498) |
| **Changes in Hg** | 0.394 (0.260) | 0.304 (0.393) |
| **Changes in Hct** | 0.394 (0.260) | 0.394 (0.393) |
| **Changes in blood lactate** | -0.369 (0.238) | -0.524 (0.081) |
| **Changes in insulin** | -0.472 (0.121) | -0.484 (0.110) |

WBC: white blood cells, RBC: red blood cells, Hb: hemoglobin, Hct: hematocrit %.

## Discussion

The effects of a 10 km foot race on hematological parameters were examined in this study. Hematocrit (Hct) values increased at the end of the running exercise. Brun et al[8] observed an increased Hct (+3-4U) due to exercise, resulting in considerable higher blood viscosity. A rise in hematocrit is beneficial for athletes[9]. However, hemorheological change because of running differs from other exercise mode, such as cycling or swimming. An absence of a competing group leads to a lack of interpretation of Hct as a beneficial adaptation. An altered Red Blood Cell (RBC) count was observed at the end of the race. It is considered that hemolysis of RBCs occurs because of exercise, resulting in a decrease in red blood cell mass[10].

This running exercise took place in a hot environment. The participants were not provided a fluid or water intake during a 10 km foot race. Dehydration and exposure to the hot climate produce adverse effects. The athletes had a loss of their body mass. Exercise, such as running and other sports activities involving whole-body movements reduces cardiovascular risk and facilitates weight loss because energy is more consumed during physical activity[11]. Besides, dehydration exercise added further weight loss[12].

The findings of this study showed an increased WBC count after the distance running race. Such results agreed with earlier reports with more WBC counts after an exercise[13]. The leukocytosis (an increased number of WBCS) after a race is generally thought to be due to the demargination of WBCs encouraged by increased blood flow or an inflammatory response caused by tissue injury. The levels of white blood cells appear to increase in proportion to the intensity and duration of the workout, as one study showed that runners' white blood cell levels remarkably increased during a medium distance run[14]. Similarly, the elevated lactate level found in the blood sample of athletes is induced by growth hormone, and exercise is one of the many possible mechanisms to stimulate growth hormone secretion. The emotional and neurological focus of athletes play a vital role in the release of growth hormone, and hence the lactate threshold is increased[15-17]. However, the hormonal level of the athletes at the end of the running exercise was not measured, which is a limitation of the study.

## Study Strength and Limitations

The strength of this study is that the literature lacks exercise physiology studies about running races in warm weather. This study highlights the significance of changes in athletes' hematological and biochemical parameters. However, the hormonal level of the athletes at the end of the running exercise was not measured, which is a limitation of the study.

## Conclusions

Exercise, mainly the running race in hot weather conditions, has a significantly increasing impact on athletes' various hematological and biochemical parameters. The study findings have a valuable message for the sports trainers and coaches to improve the better performance of their athletes for national and international sports events.

### Acknowledgments

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### Conflict of Interests

The authors declared that they have no conflict of interest.

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