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POST-EXERTION CASCADE: DECODING THE HAEMATO-BIOCHEMICAL INDICES OF DEHYDRATION IN ELITE HORSES

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ABSTRACT

Dehydration is a significant concern in elite racing horses, potentially triggering substantial haemato-biochemical that can compromise their physiological well-being and athletic performance. This study investigated these responses in 15 Arabian horses subjected to a standardized strenuous exercise protocol. Blood samples were collected before and after a 14,000-meter endurance race conducted under hot ambient conditions (average 36.9°C). Analysis of haemato-biochemical parameters, including packed cell volume (PCV), haemoglobin (Hb), erythrocyte count, total and differential leukocyte counts, total protein, albumin, glucose, urea, creatinine, aspartate aminotransferase (AST), creatine kinase (CK), and lactate dehydrogenase (LDH), was performed using established laboratory methods. Post-exercise, significant increases were observed in PCV, Hb, total protein, albumin, urea, and creatinine, indicative of dehydration. Concurrently, elevated AST, CK, and LDH levels suggested muscular damage and metabolic stress. The study's findings underscore the marked alterations in these parameters following intense exercise in Arabian horses. Continuous monitoring of haemato-biochemical parameters is crucial for preventing dehydration and muscle damage in these equine athletes. Implementing targeted strategies for optimal hydration and exercise management is therefore recommended for veterinary practitioners.

Keywords: Arabian Horses, Hydration status, Muscle damage, Physical exertion, Stress

INTRODUCTION

The Arabian horse, one of the oldest and most historically significant breeds, is renowned for its inherent beauty, graceful athleticism, exceptional endurance, and remarkable adaptability to arid environments (Olsen & Culbertson, 2010). These attributes make them highly sought after for demanding equestrian sports, including polo and endurance racing, where they can cover distances up to 160 km in approximately 8 hours while carrying a rider (Ricard *et al*., 2017; Van Erck-Westergren, 2024).

Racing-induced dehydration in horses is a multifaceted physiological event characterized by shifts in fluid balance, electrolyte disturbances, and metabolic changes resulting from substantial fluid and electrolyte loss through sweating (Lindinger, 2024). This process leads to alterations in key haemato-biochemical parameters, notably increases in packed cell volume (PCV), haemoglobin concentration (Hb), and serum biochemical markers associated with dehydration and muscle injury (Waller & Lindinger, 2006; Hodgson *et al*., 2013). Severe dehydration can pose a life-threatening risk to athletic horses during intense exercise or prolonged transportation, triggering a cascade of haemato-biochemical responses (Thomas *et al*., 2008; Adan, 2012) that can negatively impact their overall health and athletic capacity (Lacey *et al*., 2019). This study aimed to comprehensively evaluate the haemato-biochemical responses to racing-induced dehydration in Arabian horses to inform the development of effective strategies for mitigating its detrimental effects in these athletes.

MATERIALS AND METHODS

Ethical Consideration

All experimental procedures and animal management were conducted in strict adherence to the ethical guidelines of the University of Ilorin Animal Welfare Committee and international standards for the care and use of experimental animals. The study protocol received approval from the University of Ilorin Animal Care and Use Committee (Approval number: URE/FVM/2022/095).

Experimental Animal and Laboratory Analysis

Fifteen apparently healthy Arabian racehorses from a stable in GRA, Ilorin, Kwara State, Nigeria, were included in the study. These horses participated in a 14,000-meter endurance race conducted on a hot day in March, with an average ambient temperature of 36.9°C. Prior to both pre- and post-race blood sampling, a thorough physical examination and recording of vital parameters were performed for each horse within the study area.

Blood samples (approximately 10 ml) were collected aseptically via jugular venipuncture from each horse using 21-gauge needles. Four milliliters were collected into ethylenediaminetetraacetic acid (EDTA) vacutainers for haematological analysis, and six milliliters were collected into plain vacutainers for serum preparation. Serum was obtained by centrifugation at 2000 rpm for 15 minutes, harvested into labeled tubes, and stored at -20°C until biochemical assays were performed.

Erythrocyte (RBC), leukocyte (WBC), and differential leukocyte counts, as well as haemoglobin concentration (Hb) and packed cell volume (PCV), were determined using standard laboratory techniques. Thawed serum samples were analyzed for urea, creatinine, total protein, albumin, glucose, aspartate aminotransferase (AST), creatine kinase (CK), and lactate dehydrogenase (LDH) concentrations using an automated biochemistry analyzer (Roche, India) with commercially available kits (Randox, UK), following the manufacturer's instructions.

Statistical Analysis

Statistical analysis was performed using SPSS version 11.5 software. Paired Student's t-tests were used to compare changes in haemato-biochemical responses pre- and post-race. Results are presented as mean ± standard error of the mean (SEM), and statistical significance was set at P < 0.05.

RESULTS AND DISCUSSION

The vital and other clinical parameters of the horses before and after racing were as presented (Figure 1 and Table 1). Significant changes were recorded in the mean values of temperature, respiratory rate, heart rate, capillary refill time, and skin pinch rate after racing as compared to the pre-race values. Significant alterations were observed in the mean values of temperature, respiratory rate, heart rate, capillary refill time, and skin pinch test duration after racing compared to pre-race values (Figure 1 and Table 1). Significant increases were noted in RBC count, PCV, and Hb concentration post-race, while, total leukocyte count showed a significant increase after racing, accompanied by a significant neutrophilia (Figure 2). Post-race, the mean serum concentrations of total protein, albumin, urea, and creatinine, as well as the serum activities of AST, CK, and LDH, were significantly elevated. Conversely, glucose concentration was significantly reduced compared to pre-race levels (Figures 3 & 4).

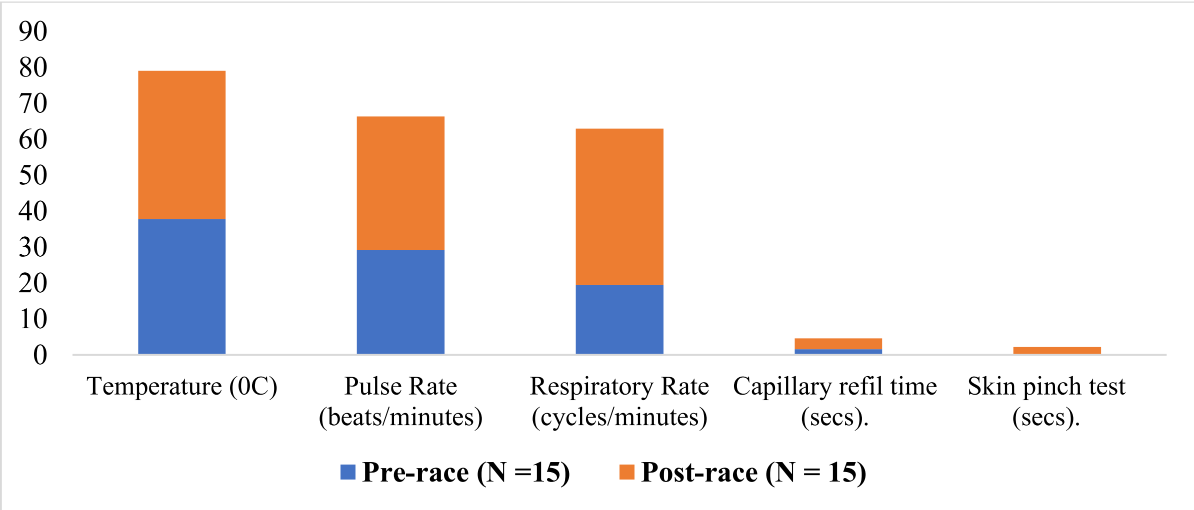

Figure 1: Physiological Parameters of Racing Horses Before and After the Race

Table 1: Other Clinical Indicators of Dehydration in Racing Horses Before and After the Race

Parameters	Before Exercise	After Exercise
Skin dryness	Normal	Abnormal
Sunken eye	Absent	Present
Hydration status	Euhydrated	Dehydrated
Mucus membrane	Light pink	Dark red
Gait	Regular	Irregular
Gut sound	Normal	Abnormal

Key: * = significant at $p < 0.05$

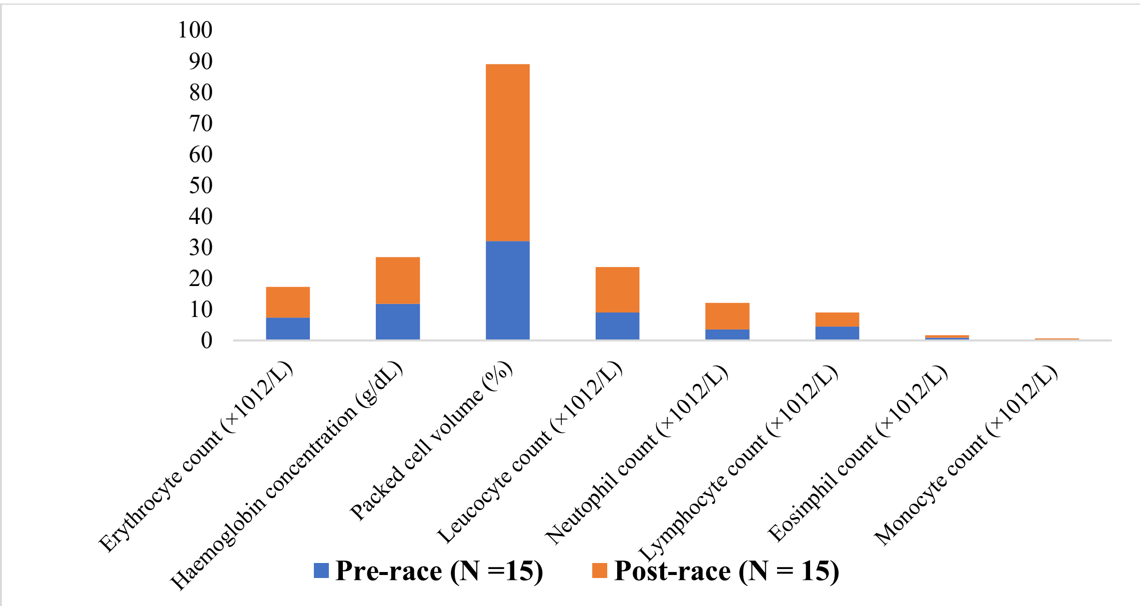

Figure 2: Haematological Profiles of Racing Horses Before and After the Race

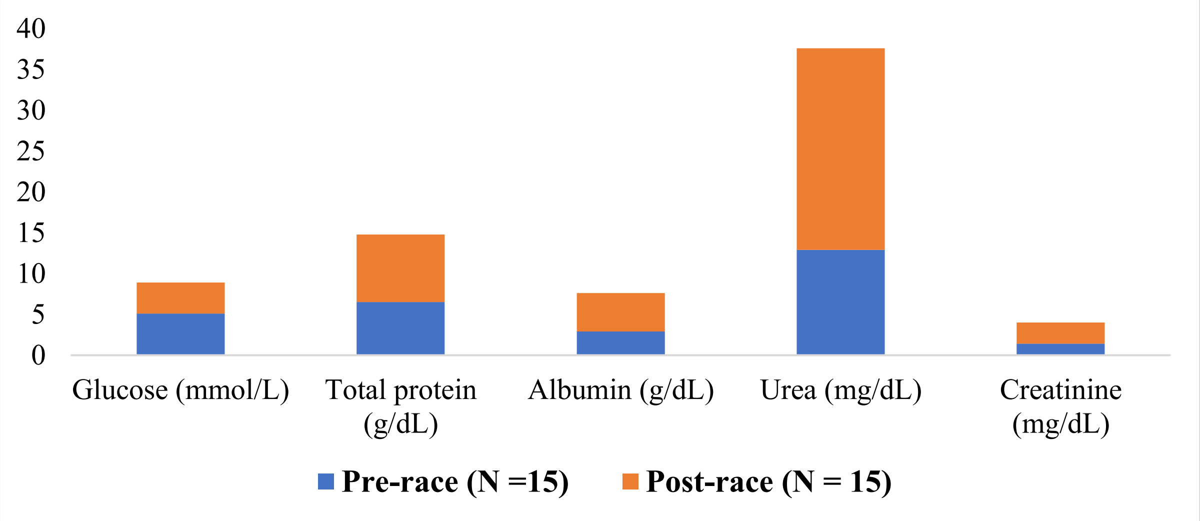

Figure 3: Renal, Protein & Energy Profile of Racing Horses Before and After the Race

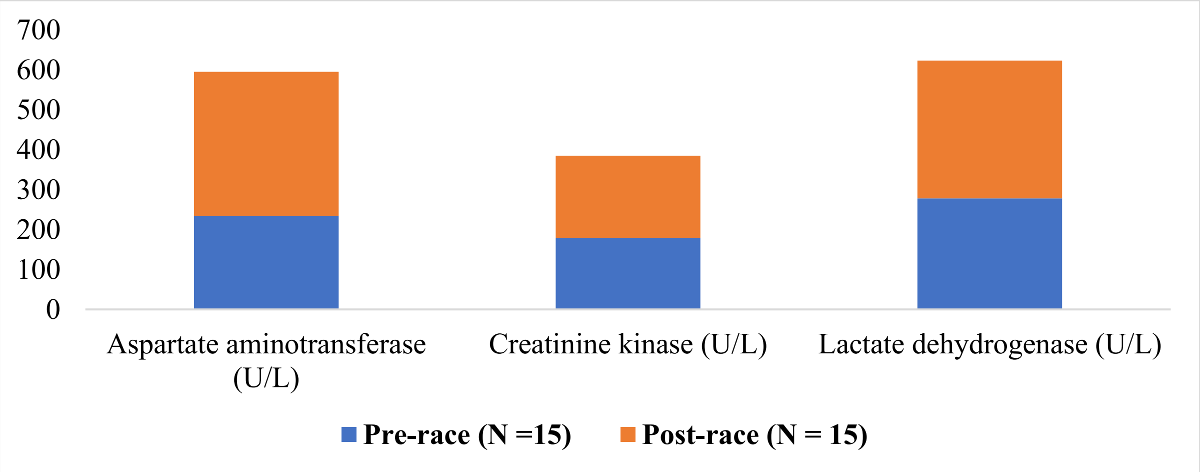

Figure 4: Hepatic & Muscle Enzymes activity of Racing Horses Before and After the Race

Discussion

This present study investigated the impact of racing on hydration status and associated changes and our finding reveals significant alterations in both clinical and haemato-biochemical parameters in Arabian horses following a 14,000-meter endurance race under hot environmental conditions. The observed fluctuations in clinical parameters such as temperature, respiration, and heart rate are consistent with the physiological demands of strenuous exercise. The significant increase in body temperature post-race likely reflects the heat generated by muscular activity during prolonged exertion, driven by ATP hydrolysis and fat metabolism (Fritzsche & Coyle, 2000). Similarly, the elevated heart and respiratory rates post-race are likely mediated by catecholamine-induced stimulation of the sympathetic nervous system to meet the increased oxygen demands of the working muscles (Thompson, 2018), a finding corroborated by previous research (Katz *et al*., 2000; Guirnalda *et al*., 2001; Hassan *et al*., 2015). Furthermore, the clinical signs of dehydration observed post-race, including increased heart rate, increased respiratory rate, elevated rectal temperature, prolonged capillary refill time, reduced skin elasticity, sunken eyeballs, dry mucous membranes, and altered gait (suggesting muscle fatigue), align with established indicators of dehydration in horses (Cheuvront & Kenefick, 2014; Robert, 2024).

The significant increases observed in packed cell volume (PCV), red blood cell (RBC) count, and hemoglobin concentration post-race strongly correlate with the established phenomenon of hemoconcentration secondary to dehydration (Atata *et al*., 2019). Fluid losses during intense exercise, primarily through sweating and respiration, lead to a reduction in plasma volume coupled with relative increase in the proportion of cellular elements, thus elevating PCV, RBC count, and consequently, hemoglobin concentration (Guyton & Hall, 2006). The magnitude of these increases likely reflects the degree of fluid loss experienced by the animals during the racing event, serving as readily measurable indicators of their hydration status (Piccione *et al*., 2008; Lawan *et al*., 2010; Satué *et al*., 2013).

Our findings of neutrophilic leukocytosis with concurrent monocytosis following racing are consistent with a physiological stress response (de Siqueira & Fernandes, 2024). Strenuous exercise, such as racing, triggers the release of catecholamines and corticosteroids, which can influence leukocyte kinetics. Corticosteroids, in particular, are known to promote the demarginating of neutrophils from the vascular endothelium into the circulating blood, leading to neutrophilia. Similarly, monocyte mobilization from the bone marrow can be stimulated by stress hormones and inflammatory mediators released during intense physical exertion (Obeagu, 2025; Balakin *et al*., 2025). These findings are consistent with reports from other studies (Ebrahim *et al*., 2019; Wakil *et al*., 2022; de Siqueira & Fernandes, 2024). The contrasting finding of neutropenia in some studies (Hassan *et al*., 2015) may be attributed to variations in breed and the specific demands of the racing protocol.

We observed a statistically significant increase in both total protein and albumin following racing events in racehorses. These elevations in proteins are consistent with the physiological response to dehydration (Axon & Palmer, 2008; Zadeh Mehrizi, 2023). During intense and prolonged activity such as racing, fluid losses through sweating and respiration lead to a reduction in plasma volume. This hemoconcentration effect results in a relative increase in the concentration of non-diffusible plasma components, including proteins such as albumin. Albumin, being the most abundant plasma protein and a major determinant of colloid osmotic pressure, contributes significantly to the observed rise in total protein levels (Guyton & Hall, 2006; Satué *et al*., 2023). The magnitude of the increase in total protein and albumin observed in our study likely reflects the degree of dehydration experienced by the horses and is similar to findings that have been reported in studies involving endurance athletes and horses undergoing strenuous exercise (Gomes *et al*., 2021; Mckenzie, 2024; Deniz *et al*., 2025), where hemoconcentration was identified as a primary driver of increased protein concentrations, a transient increase is a normal physiological response, while marked increase can influence the binding and transport of various substances, including hormones and medications and hence have detrimental effects on circulatory function and tissue perfusion (Gomes *et al*., 2021).

Furthermore, our findings revealed a significant post-race increase in both plasma urea and creatinine concentrations. These elevations are consistent with the physiological consequences of dehydration and strenuous exercise in horses. Reduced renal blood flow, secondary to decreased plasma volume during dehydration, can impair glomerular filtration rate, leading to a transient accumulation of these nitrogenous waste products in the circulation (Robert, 2024). The observed increases in urea and creatinine, in conjunction with the hemoconcentration-related rise in total protein and albumin, underscore the systemic impact of racing on fluid balance and renal function in these equine athletes. While these changes are often transient and resolve with rehydration, marked or prolonged elevations may indicate more severe dehydration or underlying renal compromise, warranting careful monitoring. Similar findings have been reported in equine (Cohen e*t al*., 1993; Klobučar e*t al*., 2019; McKenzie, 2024), camelids (El-Sayed *et al*., 2025), and human (Al-Qurashi *et al*., 2020; Díaz Martínez *et al*., 2022; Alaseem *et al*., 2024) athletes.

An intriguing finding of our study was the significant decrease in plasma glucose concentrations observed post-race in racehorses, contrary to some reports of post-exercise hyperglycemia (Chikhaoui *et al*., 2022; Melnik *et al*., 2022), This racing-induced hypoglycemia likely results from the substantial glucose utilization by skeletal muscles during intense exercise, exceeding the rate of hepatic glucose production and release (Rose & Richter, 2005). The magnitude of decrease observed in this current study may be influenced by factors such as exercise intensity, duration, and the animal's pre-exercise nutritional status and glycogen reserves.

The marked post-race elevations in serum AST, CK, and LDH activities are consistent with the intense physical demands of racing (Satué *et al*., 2019). The substantial increase in CK, a muscle-specific enzyme indicates muscle fiber microdamage and increased cell membrane permeability resulting from high-intensity contractions, anaerobic metabolism, and potential tissue hypoxia (Hodgson *et al*., 2013). Similarly, the rise in LDH, an enzyme crucial for anaerobic glycolysis, reflects the increased metabolic rate and reliance on anaerobic pathways during maximal exercise (Spriet *et al*., 2000). While AST is less specific to muscle, its post-race elevation likely reflects a combination of muscle damage and potential hepatic strain due to altered blood flow and increased metabolic demands during strenuous exercise (Billings *et al*., 2021). The magnitude and duration of these enzyme elevations are influenced by factors such as race intensity and duration, the horse's fitness level, individual susceptibility, and environmental conditions (McKenzie *et al*., 2024).

CONCLUSION

Racing horses experienced clinical dehydration characterized by significant changes in certain haemato-biochemical parameters as reported in this current study. This post-race increase among other changes is considered a physiological response to intense exercise and hence laboratory monitoring, in conjunction with detailed clinical assessment, will be critical for differentiating between physiological adaptation and pathological conditions. Future research could focus on establishing more refined reference ranges specific to different racing disciplines and fitness levels, as well as investigating the role of nutritional and management strategies in mitigating dehydration-induced haemato-biochemical alterations.

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