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# Metabolic Data of Elite Footballers during a Tough Match in Hot and Humid Environment

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**Abstract** The objective of this study was to determine the metabolic profile during a challenging football match at the Congolese national elite championship. **Methods:** Physiological and metabolic parameters were measured in this study. Physiological parameters consisted of water loss and heart rate. Metabolic parameters consisted of blood ionogram, blood lactate level, creatinine, and blood glucose. **Results:** The data indicates a decrease in the intensity of play during the game in hot and humid environment. Water loss, increased lactate levels and decreased blood glucose levels were observed at the end of the game. In addition, determination of the estimated glomerular filtration rate revealed transient renal failure in football players. **Conclusion:** These results show the importance of physiological and biological monitoring of footballers playing in hot environment to optimize performance and preserve their health.

***Keywords:*** *metabolic parameters, hot and humid environment, elite football*

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## 1. Introduction

Football is a mass sport, played outdoors, exposing players to climatic conditions that are not conducive to good performance [1]. In Central African countries, the climatic conditions are difficult during the long rainy season. Despite these conditions, matches are scheduled during the day in a warm atmosphere. Thus, football is played in conditions that expose the body to a conflict situation related to the heat produced by muscle activity. This metabolic heat, combined with the thermal load of the environment, increases the body's thermal load during the match [2].

Therefore, playing football requires a good endurance and the ability to repeatedly perform an effort of maximum intensity. This observation has been reported in many scientific studies showing that aerobic and anaerobic metabolisms are called upon during a football match [3].

One study demonstrated the physiological changes induced by exercise in hot environment. Hypohydration greater than 2% of body mass caused by excessive loss of perspiration is detrimental to aerobic performance when body temperature exceeds 27 °C in hot environment [4]. However, performance degradation induced by prolonged exercise in hot environment, with or without dehydration, is associated with altered hematological parameters, redox balance and tissue damage [5,6].

For this reason, individualized and permanent medical follow-up are necessary to preserve the state of health of sportsmen and women. Biological examinations occupy an important place in this medical-sports management. In Republic of Congo, biological monitoring of athletes is rare or even non-existent.

This study aims to evaluate the biochemical parameters of elite footballers during the match in hot environment.

## 2. Materials

### 2.1. Subjects

A football team was selected by the non-probabilistic method among the top five in the Congolese elite national football championship.

#### 2.1.1. Inclusion and Exclusion Criteria

The study subjects met the following criteria:
- have a valid sports licence;
- have played elite football for two years;
- reside in the Republic of Congo for the last two years
- be between 18 and 30 years of age

- Be knowledgeable about the study and give its free and informed consent to participate in the study.

Footballers with traumatism were excluded from the sample. Thus, eleven (11) footballers aged 27.00±.58 years with a body mass index of 22.46 ±1.25 kg/m$^2$ were selected to participate in the study.

# 3. Methods

## 3.1. Experimental Protocol

Data collection was conducted in two phases two days apart at the beginning of the winter break of the senior elite national championship.

The objective of the first meeting with the players was to measure anthropometric parameters (Table 1). The physical activity of the players prior to that day corresponded to 03 months of competition in round trip of the Division 1 at national championship according to the calendar of the Congolese Football Federation (FECOFOOT).

Afterwards, an experimental match was organized during the second match to evaluate physiological parameters, match intensity and metabolic parameters during a challenging match in a hot environment. The teams were composed of the titular players. The experimental match was played on a synthetic pitch, where the national division 1 football championship is played. The match took place during the day, at an ambient temperature of 38°C, 50% humidity and a wind speed is 3000km/h during the long rainy season. Pre-match blood samples were taken at the Centre d'Analyse Biologique de Moungali (CABM) for blood ionogram, lactate and creatinine.

Blood glucose was measured with a True result Glucometer (France). Lactate was measured with lactate Pro2 before and at the end of the match. The match was played according to FIFA regulations. The players were allowed to drink according to their thirst during stoppage time and during the extra break granted due to the heat.

The activity profile during the game was evaluated using a Garmin Forerunner R15 Quick Start accelerometer (USA). It provided the effort heart rate, energy expenditure and total distance travelled during the match. The intensity of the match was 60.78% of the average heart rate of the footballers. In this study, we determined the percentage fluid loss by weighing the players before and at the end of the semi-naked (undergarment) game using an impedance meter (TANITA Corporation BC-545N, JAPAN) [7,8]. The amount of water scored during the game was taken into account from the warm-up to the end of the game using the mineral water bottles labelled for each player.

Blood samples were taken from all subjects at the end of the match in the sitting position.

In addition, glomerular filtration rate (GFR) was determined to assess the level of renal impairment after a challenging football match in a hot and humid environment. In this study, all GFR values < 95 mL/min/1.73 m$^2$ were considered abnormal because they reflected a slight decrease in GFR [9].

This survey was approved by the scientific committee of the MARIEN NGOUABI University (Brazzaville) and was conducted according to the principes of revised Helsinki Convention (2008).

## 3.2. Statistical Analysis

Comparisons of the mean values of the two sessions were made using the Wilcoxon nonparametric test for matched samples. The level of significance is set at $p < 0.05$.

# 4. Results

**Table 1. Main characteristics**

| Parameters | Mean ± SD | Parameters | Mean ± SD |
|---|---|---|---|
| **Age (years)** | 27.50 ± 0.70 | Cir Calf (cm) | 36.30 ± 0,42 |
| **Weight (kg)** | 69.55 ± 1.48 | Circ Thigh (cm) | 54.50 ±2,12 |
| **Size (m)** | 01.75 ± 0.07 | Fat mass (kg) | 53.85 ± 2,19 |
| **BMI (kg.m$^{-2}$)** | 22.74 ± 1.35 | Lean weight (%) | 10.06 ± 0,90 |

CC: Calf circumference; TC: Thigh circumference; FM: Fat mass; %G: Percentage of fat; % FC = intensity; P. Water (%) = percentage of water loss, N = Workforce = 11.

**Table 2. Physiological parameters and match intensity of football players**

| Parameters | Mean ± SD | Parameters | Mean ± SD |
|---|---|---|---|
| **QW (L)** | 2.00 ± 0.29 | HRE (bpm) | 160.4 ± 3.43 |
| **DE (Kcal)** | 794.80 ± 0.11 | %FC= intensity | 60.78 ± 1.82 |
| **TD (km)** | 7.88 ± 0.44 | P. Water (%) | 3.33 ± 0.36 |

QW: Water quantity; DE: Energy expenditure; TD: Total distance covered; HRE: Exercise heart rate; %FC: Intensity of the match; P. Water (%): Percentage of water loss, N = Workforce = 11.

The mean values of the physiological parameters were 160.4 ± 3.43 bpm for exercise heart rate and 794.80 ± 0.11kcal for energy expenditure. With regard to the physical performance of the footballers during the match, the mean values were 7.88 ± 0.44 km for the total distance covered during the match and 60.78% for the intensity of the match (Table 2). Similarly, a water loss of 3.33% was noted among the footballers despite the average amount of 2L of goal water during the match (Table 2).

**Table 3. Variation of the blood ionogram before and after a football match**

| Parameters | Sodium (mmol/L) | Potassium (mmol/L) | Calcium (mg/L) | Magnésium (mg/L) |
|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | Mean ±SD | Mean ±SD |
| **Before** | 140.67 ± 2.36 | 3.71 ± 0.19 | 91,14 ± 3,07 | 23.92 ± 0,67 |
| **End** | 146.34 ± 1.50* | 5.10 ± 0.51* | 91.14 ± 3.07 | 20.17 ± 1.73* |
| **p** | **0.028** | **0.028** | **1.00** | **0.028** |

SD: Standard deviation; N = Workforce = 11; *: Significant difference between the values taken before and after physical exercise at p < 0.05.

**Table 4. Variation in biochemical parameters before and at the end of the football match**

| Parameters | Lactate (mmol/L) | Créatinine (mg/L) | Blood glucose (mmol/L) | GFR (mL/min/1,73m$^2$) |
|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD |
| **Before** | 2.52 ± 1.18 | 8.58 ± 0.51 | 1.0033 ± 0.06 | 125.98 ± 6.00 |
| **End** | 8.58 ± 1.65* | 12.27 ± 0.82* | 0.6850 ± 0.07* | 92.07 ± 1.64 |
| **p** | **0.028** | **0.028** | **0.027** | **0.027** |

GFRe: glomerular filtration; SD: Standard Deviation; N = Workforce = 11 *: Significant difference between the values taken before and after physical exercise at $p < 0.05$.

The values of sodium, potassium and magnesium ions measured before and at the end of the footballers' match are presented in Table 3. The results obtained for sodium and potassium ions show an increase in the values at the end of the match with a significant difference ($p = 0.028$). On the other hand, a decrease in the values of magnesium ion was observed at the end of the match with a significant difference ($p = 0.028$).

The lactate, creatinine, blood glucose and glomerular filtration rate values measured before and at the end of the footballers' game are shown in Table 4. The results show an increase in blood lactate and creatinine values at the end of the game with a significant difference ($p = 0.028$). On the other hand, blood glucose and glomerular filtration rate showed a decrease in the post-match values with a significant difference at $p = 0.028$ and $p = 0.027$ respectively.

## 5. Discussion

This study was a cross-sectional study and took place during the first week of the winter break in April 2019 of the FECOFOOT elite national championship. The match took place at 2pm under a temperature of 38°C and a relative humidity of 60%. The high thermal stress did not allow the footballers to have a high intensity of the match. The average value of 60.7% match intensity was obtained in this study justifies the physical level of the players at the national senior elite football championship in Congo Brazzaville. In addition to decreased performance and water loss, exercise-induced hypohydration leads to a decrease in increased plasma volume and thirst [2,3]. When body temperature increases during exercise, and this increase is even greater, it increases the rate of dehydration [10].

Under "aggressive" conditions, the athlete's body is faced with a problem of arterial blood flow, which must deliver oxygen to the active muscles, while skin blood flow must also be increased to maintain core body temperature by increasing sweating. A competition takes place between these 2 major needs: that of motor performance and that of central thermal regulation. Normally, in order to avoid fatal hyperthermia, the need for thermal regulation takes precedence, which explains the collapse of performance by lowering muscle blood flow [11].

In addition, magnesium deficiencies, which are common in sportsmen and women, lead to anxiety problems, poor neuromuscular recovery, cramps and sleep disorders. Several consequences can result, in particular, the alteration of physical performance and an increase in oxidative stress. Hypomagnesemia was found in rugby players during one sports season, after three blood samples were taken [12]. Our results corroborate those cited in upstream. The results obtained in this study show a significant decrease in magnesium at the end of the match ($P = 0.028$). With regard to sodium ion, the results of this study revealed that during physical exercise, the individual is likely to have a reduction in the concentration of sodium ion. The reduction in blood sodium levels during exercise can be attributed to the loss of sodium in sweat during exercise [13].

However, it is expected that if the duration and intensity of exercise is prolonged and sweating increases, there will be an increase in blood sodium levels due to hydration and decrease in blood volume. Several authors have described cases of hyponatremia during endurance exercise in a hot environment [14]. These authors have indicated that individuals who engage in long-term exercise should drink as much water and fluids as possible to prevent dehydration and hyponatremia. The results of this study were obtained during an experimental football match in a hot and humid environment at a temperature of 38°C and 50% humidity. Despite the players being allowed to drink freely during the match, at the end of the match the players were dehydrated. Our results corroborate those of the literature cited above and show a decrease in blood sodium after the match with a significant difference ($p = 0.028$). Similarly, potassium was not left in the altered electrolyte changes during exercise. Potassium, which is predominantly intracellular, also interacts with blood sodium in the control of fluid and electrolyte balance and aids in the conduction of nerve impulses. However, the slight reduction in blood potassium may be due to the fact that the duration of exercise was associated with sweating. It is also expected that if exercise is prolonged without taking in water with a breakdown of glycogen to provide energy to the body, this would lead to an increase in potassium concentration.

An increase during the match in blood lactate has been observed, reflecting to some extent the difficulty footballers have in performing well during the match in the heat. Nevertheless, the high blood lactate concentration results indicate that the rate of blood lactate production is high during the match. Blood lactate was measured during an experimental football match between players of the same team divided into two groups. In addition, several studies have shown that the accumulation of blood lactate does not cause muscle fatigue [15]. Another indicator for the cause of muscle fatigue during intense exercise is the low pH concentration in the muscle. Our results corroborate those in the literature. All these studies suggest that temporary fatigue in football is not

causally related to high muscle lactate levels. Beyond the suggestions made in numerous studies, in this study we suggest that the decrease in match intensity is associated with environmental thermal stress and dehydration.

As far as blood sugar levels are concerned, we have observed a drop in blood sugar levels at the end of the game among elite football players. These results indicate that the rate of liver glucose release is not high enough to compensate for the use of glucose throughout the game. Our results corroborate those obtained by [16].

Indeed, heat stress has an impact on the drop in blood glucose levels during exercise, which is responsible for the drop in performance during aerobic exercise.

In addition, to assess the renal function of football players during a challenging match, we calculated their glomerular filtration rate. A decrease in glomerular filtration rate was observed at the end of the match in the footballers. These results corroborate those obtened by [17]. This results in reduced blood flow in many organs, so that the kidneys can experience a three-quarters reduction in flow [18]. The reduction in renal blood flow induces transient dysfunction in the kidneys, as after one hour of recovery these values tend to return to resting values [19]. Our results are consistent with those in the literature.

## 6. Conclusion

We noted a variation in heart rate and body mass suggesting a low intensity of the match. Decreased blood glucose and magnesium levels associated with increased blood lactate levels suggest low energy and fluid intake during the competition. Decreased glomerular filtration rate is indicative of high heat stress physical activity that may induce functional transient renal failure.

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