Bazaba Kayilou et al.

Physiological Responses of Footballers in a Hot and Humid Environment: The Case of the Republic of Congo

ELIVA PRESS

Physiological Responses of Footballers in a Hot and Humid Environment: The Case of the Republic of Congo

Physiological Responses of Footballers in a Hot and Humid Environment: The Case of the Republic of Congo

Bazaba Kayilou
Ahounou Aikpe
Dansou Pierre
Gbenou Joachim

ELIVA PRESS

Published by Eliva Press
Email: info@elivapress.com
Website: www.elivapress.com

ISBN: 978-1-63648-364-1

Cover Design: Eliva Press
Cover Image: Freepik Premium
Printed at: see last page

PHYSIOLOGICAL ASPECTS OF PERFORMANCE IN HOT ENVIRONMENTS

ABSTRACT

In order to reach the highest level successfully in football, a very well developed physical condition is necessary. In addition, technical, tactical and psychological skills must be developed. In addition, the players in football occupy different positions during the match. In addition to the factors mentioned above, the environment has a decisive effect on a footballer's performance. The ability to perform exercises in a warm environment is reduced. The mechanisms responsible for this reduction lead to a variety of homeostatic changes that occur in parallel with the increase in core body temperature. For this reason, this research aims to : 1) Measure anthropometric parameters, physical and physiological capacities of Congolese division 1 footballers according to the playing position; 2) Determine the physiological parameters of Congolese footballers per playing position in a hot and humid environment; 3) Study the metabolic and hormonal adaptations of division 1 footballers in Congo Brazzaville during a challenging match. **Methods:** The work was carried out in three studies with 22 footballers for the first study, 18 footballers for the second study and 06 footballers for the third study. Anthropometric parameters and physical capacities were obtained per playing position. Physiological parameters were obtained before and at the end of the game per playing position. Similarly, blood samples were taken before and at the end of the match to quantify metabolic parameters and hormones involved in hydro mineral balance during a challenging match. **Results:** A difference in anthropometric parameters and physical capacities was observed between the footballers per playing position. A very important water loss per playing position, higher than 2% was observed, despite the amount of water consumed by the footballers during the match. It did not compensate for the water loss at the end of the match. In addition, changes were observed in the metabolic level and in the hormones involved in the hydromineral balance during the match. **Conclusion:** Football is a demanding sport, its practice involves factors related to the physical abilities and qualities of footballers, the environment and their metabolic and hormonal adaptation capacity during the match or a period of competition.

Key words: physical performance, environment, football, metabolic parameters, hormones, Republic of Congo

INTRODUCTION

Football is one of the most popular team sports in the world. It is played at different age groups, ranging from cadets to seniors (Yang SM, Lee WD, Kim JH, et al. 2013). It is a sport between two teams of eleven (11) players and the match is played for at least ninety (90) minutes in official competitions. Performance in football depends on technical, tactical, physical, physiological and psychological parameters (Stolen T et al.2005; Castagna C et al.2010). To reach the highest level successfully in this sport, a very well developed physical condition is necessary (Reilly T, 1997). Optimising the physical potential of footballers is one of the main objectives of football teams and training centres. The elite footballer must be prepared to perform and withstand high training and match loads. The characterisation of certain anthropometric and physical parameters makes it possible to distinguish between elite and non-elite players (Reilly T ,1997; Gil S ,2007). These parameters also make it possible to determine at least one reference profile according to playing position (Carling C et al.2016).

Previous studies have shown that the profile of players differs according to playing position among elite players (Wong et al.2009). They also indicate that goalkeepers are taller and heavier than outfield players. Other authors have added that midfielders are the smallest and lightest outfield players while defenders are the tallest and heaviest (Hencken C and White C ,2006).

In addition, there are also physiological differences between playing positions and maximum oxygen consumption (V ̇O2max) with fullbacks and midfielders having the highest values (Reilly T ,1997). These marked anthropometric and physiological differences may potentially lead to specialisation of footballers according to playing positions during their training in teams and training centres.

Furthermore, different positions are occupied by players in football. These are strikers (AT), midfielders (MT), defenders (DF) and goalkeepers (GB). The distance and time of activity in football competition differs according to the position of play. The goalkeeper, in particular, has the lowest activity in the game and the shortest distance covered. Many studies have examined the different physical and physiological characteristics of footballers according to playing positions (Bangsbo J et al.1991; Dellat A et al.2012).

In football, physical activity is intermittent with brief and intense efforts (Stolen T et al.2005). During a match, each player performs approximately 1000 to 1400 short actions lasting between 2 and 4 seconds. These sprints are repeated approximately every 90 seconds (Stolen T et al.2005). It is widely accepted that these anaerobic efforts are an important key to sporting success (Bangsbo J et al.1991; Dellat A et al.2012).

. Mohr et al (2010) showed that a football player performs between 150 and 250 short, intense actions during a match and that the number of actions increases with the level of competition. Furthermore, the same authors demonstrated that the position occupied by the player has a significant effect on the number of sprints that the player performs during a match. Thus, the players who perform the most sprints are full-backs and forwards, whereas central defenders perform the least sprints. These sprints are generally performed over short distances (Mohr M et al.2003).

In addition to physical ability, training level and playing position, the environment has a determining effect on the performance of the footballer. The ability of a subject to perform exercises in a hot environment is significantly reduced compared to those working in cool conditions (Maughan RJ et al.2004, 2008, 2010). The mechanisms responsible for this reduction involve a variety of homeostatic changes that occur in parallel with the increase in core body temperature (Maughan RJ et al.2010).

Therefore, players exposed to heat stress must consider their hydration status before, during and after exercise. Prior dehydration of approximately 1.5-2% of body mass can reduce performance even during short exercise or after 30 minutes of repeated sprints (Maxwell NS et al.2009). Sweat rate is dependent on ambient temperature, humidity and exercise intensity, but varies considerably between individuals (Shirreffs SM et al.2010). Dehydration-induced water loss of 1-2% of body mass can exacerbate thermal and cardiovascular balance, which adversely affects athletic performance (Sawka MN et al.2007).

However, muscular exercise represents a rich model of physiology, as it has the particularity of involving an integrated response of the organism involving, in an adapted manner, cardiovascular, respiratory, metabolic and hormonal responses (M Doclos et al.2004). Hormones are most often the mediators of these coordinated and adapted responses. Moreover, the body's response does not stop with the end of the exercise (M Doclos et al.2004). The recovery phase of muscular exercise also represents a dynamic phase on the hormonal and metabolic level. It is a phase during which the organism is oriented towards reconstituting the energy reserves used during the effort and sets up the adaptation processes necessary for recovery. Hormones play an important role in the mobilisation and use of these energy substances. The physiology of muscular exercise can therefore be defined as the study of homeostasis linked to the right balance between muscular exercise and recovery (M Doclos et al. 2004).

Previous studies have demonstrated the physiological changes induced by exposure to exercise in hot environments (Francesconi RP etbal.1983). Hypo hydration greater than 2% of body mass associated with excessive water loss through sweating in hot environments impairs aerobic performance when body temperatures exceed 37°C. The decrease in performance induced by prolonged exercise in hot environments, with or without dehydration, results in altered haematological parameters, redox balance, tissue damage, metabolism and cardiovascular system disorders (Cheuvront SN, Kenefick RW ,2014). Longterm sport in a hot environment induces a hormonal and metabolic response in the body. It causes a loss of fluid from the subjects by sweating (Jovanovic M et al. 2011). Indeed, high-level sport is marked by the repetition of intense training sessions followed by short recovery periods. This increase favours the activation of new metabolic pathways and consequently variations in hormonal levels and other biochemical parameters (Galbo H ,2011). Playing elite football in a hot and humid environment leads to metabolic and hormonal changes. These changes vary according to climate and environmental conditions.

To address this concern, the International Olympic Committee (IOC) has emphasised the need for collaboration between the medical profession and sports federations in order to develop specific data for elite athletes playing in a hot environment (Bergeron M et al. 1991). Thus, several international federations, in particular the Fédération Internationale Football Association (FIFA), have set up a monitoring system to assess environmental conditions during competitions and their impact on players' performance (Nassis et al.2015). Since then, some sports federations have also changed their guidelines to further reduce the risks of illnesses caused by the disruption of exercise in a hot environment (Nassis et al.2015). Apart from heat stress, in the Congolese context athletes are still confronted with the thorny problem of lack of training ground and poor water intake habits during physical exercise.

In Congo Brazzaville, the national football championship is non-professional as in most third world countries. These championships are organised with much uncertainty in material conditions that are not conducive to good performance. This cause of poor performance of sportsmen and women is not yet perceived in most African countries. In these countries, although the living and practising conditions are not comparable to those of industrialised or developed countries, the sporting ambitions during international competitions are the same. As the realities in the Republic of Congo are not the same as those in Western countries, it would be hazardous to systematically generalise the results of work carried out on Western athletes with regard to physiological responses and physical performance during football practice in a hot environment.

Indeed, the Republic of Congo is a Central African country located on the equator where it is very hot depending on the season with a very high air density (hot and humid climate). Located between the 4th degree of northern latitude and the 5th degree of southern latitude, the Congo is under the influence of a Guinean forest climate subdivided into three climates: equatorial, sub-equatorial and tropical. The country is heavily irrigated and receives a lot of water during the rainy season. There are two main seasons: a dry season and a rainy season characterised by high temperatures and heavy precipitation, giving it a high relative humidity.

Very little research has addressed the impact of heat stress on football performance. Most of the time, the ministry in charge of sport organises days of reflection on the lack of results in sport in general and football in particular, without providing scientific answers. This is what justifies the realisation of this work in the context of the Republic of Congo where temperatures in the shade are between 23 and 38°C according to the meteorological station of Brazzaville (1949-2017). Furthermore, football competitions are organised twice a week without taking into account the environmental conditions and the players' possibilities of recovery. These football matches are often played during the rainy season when temperatures are close to 40°C. The practice fields are synthetic and emit heat making it difficult to play football. Players are forced to dip their feet in buckets of water. Moreover, Congolese sportsmen have a problem of dehydration and are subjected to a double thermal constraint: endogenous due to muscular exercise and exogenous in relation to the permanent rise in ambient temperatures (Bergeron M et al. 1991). It therefore seems essential that experimental research be carried out not only to solve the problems relating to the reduction in physical capacities mentioned above, but also to improve the performance of footballers in the Republic of Congo.

1.AEROBIC AND ANAEROBIC PHYSICAL CAPACITIES PER STATION BASED ON FIELD TESTS OF ELITE MELANO-AFRICAN FOOTBALLERS IN HOT AND HUMID ENVIRONMENTS

1.1MATERIALS AND METHODS

1.1.1Subjects

A football team ranked in the top five of the Congolese national elite football championship was selected by the not probability, reasoned choice method. To participate in the study, footballers would have to meet the following criteria: have a valid sports license, have a 2-year elite football license, reside in the Republic of Congo for the last two years, age between eighteen (18) and thirty (30), and give their free consent. Footballers with trauma were excluded from the sample. Thus, a total of twenty-two (22) footballers were selected to participate in this study.

1.1.2Experimental approach

The study took place during the national elite football championship in Congo Brazzaville during the winter break. This study was carried out at the Laboratory of Exercise Physiology and Biomechanics (Marien Ngouabi University, Brazzaville) and the Laboratory of Exercise Physiology (University of Abomey Calavi, Benin). The study was approved by the scientific committee of the Marien Ngouabi University (Brazzaville), according to a standardized protocol (Lohman T.G et al., 1988). A pre-test was organized before the experiment to learn the tests and to familiarize the participants with the evaluation material. On the day of the tests, the participants had a quantified free breakfast 2 hours before the tests, and the tests took place in two days. Participants wore spiked shoes during the CMJ, yoyo, reaction speed, and the RSA tests. No other activities were carried out during the test days so that 24 hours of rest between each test day could be sufficient to ensure optimal recovery for the athletes. On the first day, the anthropometric parameters and physical capacities were measured; the second day concerned the physical capacities that were not measured on the first day.

1.1.2.1Anthropometric measurements

The anthropometric parameters measured were height, obtained to within 0.1 cm using a Stanley. Body mass (kg), body mass index (kg/m^2), fat mass (%) and lean mass (kg) were measured using a TANITA Corporation BC-545N impedance meter scale (JAPAN); measurements were taken without clothing and bare feet. The circumferences of the thigh and calf in cm were taken using a tape measure. For each anthropometric measurement, two consecutive measurements were taken to retain the mean value.

1.1.2.2Physical performance tests

All tests were conducted in an atmosphere of 38°c and 50% humidity at the Brazzaville sports complex where the national championship matches are played on synthetic turf to simulate the playing conditions. Measurements included the counter-movement jump test with arms (CMJ), the reaction speed over 40 m and the Yo-yo R2. After a 15-minute warm-up with light runs, technical exercises, acceleration and stretching, the subjects performed the Counter Jump Movement (CMJ) tests and repeated 35 x 6 m sprints, respectively. These tests were interspersed with 10minute recovery periods to allow for recovery and to achieve the best performance during each test. The tests were conducted on a synthetic pitch reflecting the match conditions of the national football championship in Congo Brazzaville. For the vertical jump test (MJF), the subject starts from the 90° bent position at the knee joints, to make a maximum upward push. He was allowed to do a prior flexion before the extension (plyometric test). This test was carried out in the field using a Myotest (UE). Three tests were performed for each footballer with 1min recovery between tests and the best performance was chosen as the analysis value (Chamari et al., 2004; Ingebrigtsen et al., 2014). The fatigue index (IF) in percentage was obtained from repeated 35 x 6 m sprints using photoelectric cells (Microgate Corporation, UE). Players should run the 35-metre distance 6 times with 20 seconds of recovery between passes. The sprint time was measured by electric photocell barriers placed on the ground. Each sprint was initiated from a standing position with arms raised to chest height 20 cm behind the line of electric photocells (Mohr et al., 2010; Francesco Campa et al., 2018). Finally, the fatigue index (IF) was obtained using the equation described by Mohr et al. (2005).

IF (%) = (maximum power RAST-minimum power RAST)/
(maximum power RAST) X100

Power = (weight X distance) ^{2}/time^2

On the second day of the tests, the subjects performed the same warm-up procedure before the tests. Then, they performed the reaction speed test over a distance of 40 m interspersed with 10 m. The time was recorded using photoelectric cells (Microgate Corporation, EU). Subjects were allowed two passages after a 10-minute recovery period. The best performance was selected for analysis. After a 10-minute rest, the subjects performed the intermittent Yo-yo IR2 test (Bangsbo J, 1994) to determine the maximum oxygen consumption (VO_2max). The test consists of running a distance of 20 m when indicated by the soundtrack. The subject rotates and returns to the starting point at the beep. He has an active recovery period of 10 seconds, during which the subject must walk or jog in the recovery area before returning to the starting point. A warning is given when the subject does not complete a successful return shuttle within the allotted time. Each player is placed under the responsibility of a secretary who is responsible for recording the number of rounds completed on a sheet of paper.

1.1.2.3 Statistical analysis

The variables were recorded and processed using the IBM SPSS Statistics 22 IBM Corporation (USA) software. Descriptive statistics were used to generate the means and standard deviations of the total sample. The normality of the data was verified by the Shapiro-Wilk test. A one-factor (game station) analysis of variance (ANOVA) was used to determine the differences in the performance of the player by the game station. When ANOVA was significant ($p < 0.05$), Tukey's HSD post hoc test was used to compare the different parameters. A Pearson correlation analysis was used to determine different relationships between the variables. The level of significance of the statistical tests was set at $p <0, 05$.

1.2 RESULTS

The anthropometric characteristics are presented in (Table 1). No significant age differences were noted. Goalkeepers are taller ($p = 0.0044$), heavier ($p = 0.048$) than other players, a significant difference in thigh circumference was observed between goalkeepers and attackers ($p = 0.013$). In addition, for fat mass %, a significant difference was observed between defenders and attackers ($p = 0.020$). The average values of the vertical rebound of the player per playing position (Table 2) showed significant differences between goalkeeper and defenders ($p = 0.038$) and between goalkeepers and midfielders ($p = 0.005$). However, a significant difference in leg strength was observed between defenders and midfielders ($p = 0.038$) and between midfielders and attackers ($p = 0.035$). The reaction speed from 10 m to 40 m (Table 3), showed a significant difference between defenders and attackers at 10 m

Table 1. Anthropometric parameters of footballers by position held

		Playing station			
	GB1	GB2	DF(n = 5)	MT(n= 7)	AT(n = 8)
Age (year)	27	26	27,8 ± 1, 8	29,0 ± 1,34	27,5 ± 3,3
Weight (kg)	75,3*	76,8	71,4 ± 3, 4	65,9 ± 2,5	74,0 ± 7,2
Height (m)	1,8*	1,78	1,7 ± 0, 6	1,7 ± 0,7	1,7 ± 0,7
IMC ($kg.m^{-2}$)	23,3	24,23	23,3 ± 1,4	22,8 ± 1,6	23,3 ± 1,1
CirM (cm)	34,0	35,32	36,1 ± 2, 1	35,0 ± 1,5	37,2 ± 2,0*
CirC (cm)	52,0	51,68	55,3 ± 2, 6	55,9 ± 2,7	56,6 ± 2,6*
MM (kg)	50,8	51,2	52,5 ± 2, 8	52,5 ± 3,30*	52,2 ± 3,8
MG (%)	11,1	11,5	11,1 ± 1,4	10,46 ± 0,50	9,9 ± 0,6

BMI: Body mass index; *: Significant difference; GB: goalkeeper; DF: defender; MT: middle; AT: attacker, CirM: calf circumference; CirC: thigh circumference; MM: lean mass; MG: fat mass.

Table 2. Footballers' physical abilities by playing station

Playing station	CMJ (cm)	PCMJ (w)	LMB (m)
GB1	52,33	1076,31	15,30
GB2	52,78*	1080,12*	15,45*
DF (n = 5)	45,37 ± 5,68	1052,92 ± 92,89	12,59 ± 0,13
MT (n =7)	41,60 ± 4,21	915,35 ± 51,41	12,70 ± 0,73
AT (n = 8)	43,10 ± 4,06	1049,24 ± 133,44	13,73 ± 0,91

CMJ: against jump movement; PCMJ: Power against jump movement; LMB: Lancer medicine ball; GB: goalkeeper; DF: defender; MT; middle; AT: attacker, *: Significant difference.

Table 3. Footballers' reaction speed per game station

Playing station	0-10m (s)	0-20m (s)	0-30 m (s)	0-40m (s)	IF_{SR} (%)
GB1	1,98	3,24	4,31	5,63	32,00
GB2	1,97	3,26	4,34	5,65	32,08
DF (n = 5)	1,98 ± 0,10	2,99 ± 0,15	5,74 ±145, 96	5,33 ±,20	46,05 ±2,15
ML (n= 7)	1,97 ± 0,16	3,15 ± 0,14	4,28 ±0, 10	5,39 ± 0,11	49,29 ±1,23
AT (n = 8)	1,56 ± 0,56*	3,03 ± 0,05*	4,08 ± 0,17*	5,23 ± 0,08*	50,49 ± 2,04*

0-10m: Speed 10m; 0-20m: Speed 20m; 0-30m: Speed 30m; 0-40 m: Speed 40m; IFSR: Repeated sprint fatigue index; GB: goalkeeper; DF: defender; ML: midfield; AT: attacker, * : Significant difference.

Table 4. Physiological parameters of footballers by playing station in the yoyo test

Playing station	Fcr (bpm)	Fct (bpm)	Fcmax (bpm)	V_{O2}max (mL/kg/min)	Fcmax (%)
GB1	54	192	165	51,20	84
GB2	54	192	166	51,58	83
DF (n = 5)	59,00 ± 7,55*	192,12± 1,80	171,75± 3,75*	54,27± 2,36*	89,39±2,18*
ML (n = 7)	55,40 ± 5,36	189,00± 2,34	167,6 ± 6,08	53,99 ± 1,85	88,67±2,07
AT (n = 8)	56,20 ± 3,88	192,50± 3,30	169,28 ± 4,53	53,70 ± 2,44	88,36±2,06

Fcr: Rest heart rate; Fcmax: Maximum heart rate, Fct: Theoretical heart rate; VO2max: Maximum oxygen consumption; GB: goalkeeper; DF: defender; MT; middle; AT: attacker

Table 5. Correlation between anthropometric parameters and physical capacities

	Expansion technique			Reactivity Test		
Parameters	CMJ	PCMJ	0-10m	0-20m	0-30m	0-40m
Weight	0,140	$0,845^{***}$	0,142	-0,125	-0,103	-0,255
Height	$0,475^{*}$	$0,441^{*}$	0,006	0,028	-0,107	0,175
BMI	0,071	$0,460^{*}$	0,047	0,074	0,179	-0,066
CircM	0,098	$0,572^{**}$	0,019	-0,076	-0,045	-0,201

BMI : Body mass index : CircM : Calf circumference ; CMJ : counter jump movement ; PCMJ : Power counter jump movement ; 0-10m : Speed 10m ; 0-20m : Speed 20m ; 0 -30m : Speed 30m ; 0-40m : Speed 40m; *: Significant difference at $p < 0.05$; ** : Significant difference at $p < 0.01$; *** : Significant difference at $p < 0.001$.

(p = 0.024), between goalkeepers and defenders at 20 m (p =0.004), between goalkeepers and attackers (p = 0.009), between defenders and midfielders (p=0.017) and between midfielders and attackers (p =0.049). With regard to running speed at 30m, significant differences were noted between goalkeepers and attackers (p = 0.049), between midfielders and attackers (p = 0.040). At 40 m, there was a difference between goalkeepers and defenders (p = 0.006) and midfielders and attackers (p = 0.037). With regard to the fatigue experienced during repeated sprints (Table 3), a significant difference was observed between field players and goalkeepers (p = 0.0001). On the other hand, a significant difference was observed between defenders and midfielders (p = 0.028) and between defenders and attackers (p = 0.01). The values of the maximum oxygen consumption of the player per playing station (Table 4) showed significant differences between the goalkeeper and the defenders (p = 0.046). The percentage of the average heart rate in the yoyo test determined their intensity according to the playing position. Defenders had the highest intensity in the yoyo test more than other players (89% Fcmax). The power of the upper limbs in the medical ball pitch showed a significant difference between goaltenders and strikers (p = 0.009) and between goaltenders and midfielders (p = 0.003). Finally, a relationship was noted between anthropometric parameters and the physical capacities of Congolese elite footballers (Table 5). The height of the jumps, which is closely related to the power of the legs, showed a correlation with the weight (r=0.845, P<0.001) and calf circumference (r= 0.572, p <0.001) of the footballers playing in division 1. The fatigue index for repeated sprints is a determining factor in the physical performance of the footballers which shows a correlation with the circumference of the thighs (p=.0, 436). The maximum oxygen consumption (Table 6) showed a correlation with the circumference of the thighs and calves of football players, respectively (p=0.544, p=0.502).

Table 6. Correlation between anthropometric and physiological parameters

	Paramètres physiologiques			
P.AT	Fcr	Fcmax	VO_2max	IF_RSA
CircM	0,083	-0,014	0,502**	0,336
CircC	0,049	-0,328	0,544**	0,436*
%MG	-0,010	0,123	0,778***	-0,225

P.AT: Anthropometric parameter; BMI: Body mass index; CircM: Calf circumference; CircC: Thigh circumference; MM: Lean mass; %MG: Percentage fat mass; Fcr : Rest heart rate; Fcmax : Maximum heart rate ; VO2max : Maximum oxygen volume ; IF_RSA : Repeated sprint fatigue index ; * : Significant difference at $p < 0.05$; ** : Significant difference at $p < 0.01$, *** : Significant difference at $p < 0.001$.

1.3 DISCUSSION

The anthropometric parameters of Congolese footballers differ according to the playing position. Some footballers in relation to their playing position have had high body mass and fat percentage values. These parameters, at the goaltender level, were considerable as compared to other players, which contributed to the remarkable expression at the MJF. However, they were less efficient in the yoyo test and at 40 m reaction speed. This was expected, as it is well known that fat mass has a negative influence on football performance (Ingebrigtsen et al., 2014). Our results corroborate with the study by Gil et al. 2007. They assessed the morphological characteristics of the footballers by position. Several studies of elite footballers have shown that attackers have a higher muscle mass. (Mana Beatriz et al., 2017; Hencken White, 2006). The physical abilities showed a difference in values per playing position, the goaltenders presented different values to the MJF as compared to the other players. Our results are similar to the study by Loturco et al., 2017. The muscular power of the lower limbs is considered to be the determining factor of the performance (Capranica et al., 1992). The subjects of the study despite the lack of didactic material, power strength training developed their muscles because, most of the time, the coaches use muscle strengthening exercises of the lower limbs. In addition, the training sessions are conducted on sandy ground, the difficulty of the strides during the races brings an additional burden to the lower limbs.

In addition, other authors have assessed the anaerobic abilities of elite footballers on the relationship between speed, jump and strength abilities (Mana Beatriz et al., 2017). They showed that performance is linked to the abilities of sprints, strength and jumping. In this study, the reaction speed values were obtained per game station, the attackers have a more developed reaction speed than the other players. Our results are higher than those obtained by (Mana Beatriz et al., 2017), in semiprofessional footballers. In addition to the physical qualities of reaction speed, liveliness speed, velocity is the ability to sequence short and intense actions that characterize the highlevel player when he is well trained. Reference values in terms of jump, sprints and strength for footballers are scarce, although most of the available data are presented by the level of competition and position (Bloomfield et al., 2005; Hurley et al., 1984). The results of this study corroborate with those of the authors cited above. The reaction speed of the attackers over 40 m was more significant as compared to other players. Our results are close to those reported by Mana Beatriz et al., 2017, as well as with those obtained by other authors in the Tunisian and Senegalese junior players (Chamari et al., 2004; Cometti, 2002). The data obtained in this study will reinforce those in the literature for footballers working in difficult conditions; this is the strength of this study. In addition, there are other parameters involved in football performance, such as the VO_2max obtained indirectly by the intermittent yoyo test. It was more important for the defenders than for other players. In fact, it is suggested that this endurance test is one of the most instructive field tests for elite footballers (Carling et al., 2015; Fanchini et al., 2015). Maximum oxygen consumption ($V0_2max$) is characterized by the total oxygen that an individual can use during high-intensity physical exercise (Fanchini et al., 2015). $V0_2max$ is frequently used to measure the maximum cardiorespiratory level of individuals (Junior Bassett et al., 2000). A good aerobic capacity allows you to be more active and feel excessive fatigue during 2 x 45 min of a game, to recover better between two or more intense efforts, and to increase your training capacity in duration and intensity (Fanchini et al., 2015). Our results are similar to the work reported by Stolen et al. (2005), who obtained V02max values between 50 and 75 ml/kg/min. Better oxygenation means better circulation and recovery capacity. This was supported by Francesco Campa1 et al. (2018) who demonstrated that the factors related to RSA performance were related to the level of aerobic capacity measured by the yo-yo test and the reaction speed over 20 m. Similarly, the study by Stolen et al. (2005) showed that an improvement in $V0_2max$ with endurance training allows a good adaptation that leads to a decrease in the blood lactate levels.

2. Physiological responses by playing position of elite footballers during a challenging match in a hot and humid environment

2.1 MATERIAL AND METHODS

One football team was selected by the non-probability method from the top five teams in the Congolese elite national football championship. To participate in the study, footballers should meet the following criteria: have a valid sports licence, have played elite football for two years, have been resident in the Republic of Congo for the last two years, be between 18 and 30 years of age, and give their free consent. Footballers with injuries were excluded from the sample. Thus, 18 footballers aged 27.00±.58 years with a body mass index of 22.46 ±1.25 kg/m2 were selected to participate in the study.

2.1.1Experimental approach

A pre-experimental match allowed the subjects to become familiar with the measurement devices during a training session. Then an experimental football match was organised during the sports season.

The test match was played like an official match in two periods between two teams consisting of the starting players and the substitutes and players not included in the study. The intensity of the match was between 50 and 80% of the heart rate depending on the playing position. The duration of the match was set at 90 minutes including a 15-minute warm-up.

However, in the event of injury to a player selected for the experiment, the substitute players not included in the sample were used to supplement the numbers to allow for a balance of forces between the two teams. The test match took place in the south of the Republic of Congo (Brazzaville), during the rainy season at a temperature of 39°C and a relative humidity of 60%.

The experiment took place during the winter break of the national elite football championship.

On the day of the experiment, two hours before the match, the players were given a meal rich in carbohydrates and proteins. They were instructed not to consume alcohol or coffee the day before the experiment. Heart rate, core body temperature and body mass were obtained before and after the match. The activity profile during the match was assessed using a Garmin Forerunner R15 Quick Start accelerometer (USA). Prior to the warm-up, players were fitted with an accelerometer with a belt worn around the rib cage and a watch worn on the wrist, switched on, capable of continuously recording without interference the total distance covered, energy expenditure and heart rate during the match. It was calibrated for each subject. Total distance travelled included all categories of movement (walking, slow running, backward running, fast running, lateral movement).

Environmental temperature was obtained using a SUNROAD electronic hygrometer (China). At the beginning of the match, the ambient temperature was 39 °C, relative humidity 60% and wind speed 9 km.h-1. At the end of the match, the ambient temperature was 37°C, relative humidity 50% and wind speed 11km/h. Pre-game and half-time procedures and coaching were similar to official match scenarios. Heart rate, core body temperature and fluid loss values were obtained before and at the end of the match. The player was free to drink according to his thirst by signaling to the experimental team, which had the management of the water bottles. The bottles were labelled per player for control and monitoring purposes. The amount of water consumed during the warm-up was taken into account, at the end of the match the bottles were grouped by player to determine the amount of water consumed.

A pre-survey was conducted at training time to observe their fluid intake habits. The study was approved by the scientific committee of the Marien Ngouabi University (Congo Brazzaville) and is in accordance with the code of ethics of the International Journal of Sports and Medicine. The resting heart rate was taken for Each subject, in a seated position after 15 minutes of rest. It was obtained using a heart rate monitor (polar RS 100 running, France). The oral temperature was taken from each player using an electronic thermometer (TEMP'10, EU), the temperature taken is readjusted by +0.4°C to correspond to the rectal temperature. Regarding fluid loss, several methods are available to assess hydration status, each with limitations depending on how fluids are lost (Cheuvront et al., 2008; Cheuvront and Kenefick, 2014). In this study, we determined the percentage of fluid loss by weighing the players before and at the end of the semi-nude match (with underwear on) using a multifunctional impedance meter (TANITA Corporation BC-545N, JAPAN).

2.1.2 Statistical analysis

The Wilcoxon test was used to compare the pre- and post-match parameters. A two-factor (group vs. measure) analysis of variance (Friedman) was used to compare the pre- and post-match values between the groups.

When the Friedman analysis was significant, the Wilcoxon test was used for pairwise comparison. Pearson correlation analysis was used to determine the relationships between the study variables. The significance level for statistical tests was set at $p < 0.05$. All analyses were performed using IBM SPSS Statistics v 22 IBM corporation, USA.

2.2 RESULTS

Heart rate increased during exercise for all footballers regardless of position. The intensity of the match was 52% for goalkeepers, 83% for defenders, 80% for forwards and midfielders (Table 1). The comparison of the results between groups shows a dominance of the values of the defenders with a significant difference ($p< 0.05$). The core body temperature of the footballers during the match increased regardless of the playing position. It was 0.9 °C for defenders, 0.8 °C for goalkeepers, 0.92 °C for midfielders and 1.3 °C for strikers (Table 2). Comparison of inter-group values showed higher values for forwards with a significant difference ($p = 0.021$). With regard to water loss, the results obtained show a water loss percentage of 1.5% for goalkeepers, 3.33% for defenders, 3.55% for midfielders and 2.83% for strikers. The inter-group comparison shows a higher percentage of water loss for midfielders (Table 3). Furthermore, for the amount of water consumed during the match (Table 3), the results obtained show that the forwards consumed more water than the other players ($p = 0.034$).

The energy expenditure during the match per position was 794.80 ± 0.11 kcal for defenders, 649.60 ± 18.18 kcal for goalkeepers, 868.00 ± 99.52 kcal for midfielders and 834.00 ± 75.04 kcal for strikers (Table 3). These results showed that midfielders expended more energy during the match than other players ($p < 0.001$).

The total distance covered during the match was 7.88 ± 0.44 km for the défenseurs, 4,52 ± 0,60 km for goalkeepers, 8.95 ± 0.47 km for midfielders and 8.22 ± 0.47 km for forwards (Table 3). The comparison of the results shows that midfielders covered a longer distance during the match compared to the other players ($p < 0.001$).

Table 1: Comparison of match physiological parameters of footballers by playing position.

Playing position	**FCt (bpm)**	**FCE (bpm)**	**%FC = intensité**
Goalkeeper1	192	153	52
Goalkeeper2	192	152	51
Defenders (n = 5)	192,12 ± 1,80	166,4 ± 9,93	82,6 ± 1,81*
Midfielders (n = 5)	189,00 ± 2,34	160,4 ± 3,43	79,78 ±1,82
Forwards (n = 6)	192,50 ± 3,30	170,4 ± 8,73*	79,93 ± 1,82

MHR: Maximum heart rate, THR: Theoretical heart rate.

Table 2: Comparison of post-match core temperature by playing position.

Playing position	**Core temperature (CT, °c) (TC, °c)**		
	Pre-match	**End of match**	**Δ TCE**
Goalkeeper1	36,09	36,89	0,8
Goalkeeper2	36,04	36,86	0,56
Defenders (n = 5)	36,04 ± 0,50	37,04 ± 0,09	0,9 ± 0,41
Midfielders (n = 5)	36,14 ± 0,62	37,06 ± 0,20	0,92± 0,42
Forwards (n = 6)	36,35 ± 0,20	37,65 ± 0,16*	1,3 ± 0,04*

CT: core temperature; Δ TCE: change in core temperature during exercise; *: Significant difference at $p < 0.05$

Table 3: Water percentage, water quantity, energy expenditure and total distance covered during the match.

Playing position	**Water loss (%)**	**WC (L)**	**EE (Kcal)**	**TD (km)**
Goalkeeper1	1,48	1,80	649,60	4,50
Goalkeeper2	1,50	1,70	665,18	4,70
Defenders (n = 5)	3,33 ± 0,36	1,84 ± 0,11	794,80 ± 0,11	7,88 ± 0,44
Midfielders(n= 5)	3,55 ± 0,55*	2,00 ± 0,29	868,00 ± 99,52*	8,95 ± 0,47*
Forwards (n = 6)	2,83 ± 0,37	2,28 ± 0,37*	834,00 ± 75,04	8,22 ± 0,47

WC : water content; EE : energy expenditure; TD : Total

2.3 DISCUSSION

The present study was implemented to assess the physiological parameters per playing position of Congolese elite footballers and the distance they travelled during a demanding match. The results showed differences in the values of the physiological parameters and the total distance covered during the match per playing position.

During exercise, the cardiovascular system must adapt to the metabolic demand of the body to provide oxygen and energy substrates to the muscles in activity (Manzi et al., 2013). Furthermore, it allows the determination of match intensity based on maximum heart rate. In this study, match intensity was obtained per playing position. The footballers achieved a match intensity between 50 and 80% of the heart rate. Despite the high match intensity, the heart rate values obtained in this study are lower than in the literature (Bradley et al., 2009; 2010). Although our results are inferior to some of the data in the literature, they do corroborate the study by Gonzalez-Alonso et al. (2009). Similarly, physical exercise in the heat leads to a loss of water by sweating, when exercise is carried out at an optimal intensity.

Water loss has an effect on the performance of the footballer, especially in a hot and humid climate. Water loss has a negative effect not only on physical performance but also on thermoregulation (Edwards and Noakes, 2009). The study by Ryan et al (2017) on fluid balance in team sports athletes showed an average body mass loss of more than 2%. The study by Kouassi J-P et al (2019) on voluntary weight loss during a Judo training camp, showed that a weight loss of more than 3% exposes athletes to health risk and underperformance. A current study was conducted to find out the hydration status of footballers in a hot environment showed a weight loss of 2% (Lusamaki et al., 2014).

In the present study conducted in a hot and humid environment, data were obtained per playing position by weighing the players before and at the end of the match. Our results show a percentage water loss of more than 3% per playing position. These results are higher than those of other studies in a warm environment (Rico Sanz et al., 1996). This is justified by the environmental conditions. The experimental match was played on a synthetic pitch, the atmospheric heat combined with the chemical heat of the synthetic material exposed to the environmental heat is responsible for the hypo-hydration. This leads to thermal stress, which causes the players to cool their feet during the match by dipping them into buckets of water. In addition, the study subjects were in a state of hypo-hydration on a day-to-day basis due to poor hydration habits during training. This state of hypo-hydration had an impact on physiological parameters and total distance covered. To date, the majority of studies are potentially limited by their method

(Cotter et al., 2014).

The rise in body temperature that accompanies dehydration places a strain on the body's thermoregulatory mechanisms, increasing the risk of heat and exercise discomfort (Casa, 1999; Casa et al., 2007) and reducing the ability to perform optimally (Huggins et al., 2012). In addition, high levels of dehydration lead to a decrease in plasma volume and sweat rate, which reduces sweat through evaporation during exercise in a hot environment (Montain et al., 2010).

Under 'aggressive' conditions, the body is faced with a problem: arterial blood flow must deliver oxygen to the active muscles, while skin blood flow must also be increased, to maintain core temperature by increasing sweating. A competition is set up between these two major needs, that of motor performance and that of central thermal regulation. Normally, to avoid fatal hyperthermia, the need for thermal regulation takes precedence, which explains the collapse of performance, by lowering muscle blood flow (Laurent, 2019).

In this study conducted in a hot and humid environment, only core temperature was taken into account. Most previous work has measured body temperature, those taking core temperature into account are rare to our knowledge. Our results are lower than those of other authors (Casa et al., 1999; Huggins et al., 2012). There are several explanations for this difference. The nature of the physical activity, football is an intermittent sport where the athlete has the individual possibility of recovery except for the collective recovery granted at half-time of at least 15min according to the FIFA laws of the game (2014). The conditions of data collection, as players were allowed to drink when thirsty, by signaling to the research team. Positive correlations were observed between water loss, body temperature and total distance covered. Several studies on the observation of match actions in competition situations are available in the literature (Mohr et al., 2010; Rampinini et al, 2011). Some studies obtained values of total distance travelled during the match ranging from 8 to 11km (Mohr et al., 205, 2010). Others reported total match distances between 8 and 13km (Bangsbo et al., 1991; Di Salvo et al, 2007). This difference is explained by the observation techniques used. Our results are similar to those of Cazorla et al. (2014). These results show that the longest distances are covered by midfielders and full-backs, while centre-backs cover the shortest distances.

2.4 Practical application

The assessment of physiological and physical parameters during a match can be used to monitor footballers in order to maintain their health and achieve good performance. Furthermore, playing football in a hot environment requires special attention from coaches, sports scientists and organisers of sports competitions. Exceptional measures should be taken before scheduling a sports competition in an extreme environment. In addition, good water intake habits should be instilled in footballers before, during and after the match to avoid hypo-hydration, which is responsible for poor performance and physiological dysfunction of the body.

3. PHYSIOLOGICAL AND HORMONAL DATA OF SOCCER PLAYERS DURING A TOUGH MATCH IN A HOT AND HUMID ENVIRONMENT

3.1 MATERIALS AND METHODS

3.1.1 Topics

A soccer team was selected by the non-probabilistic method among the top five in the Congolese elite national soccer championship. A squad of 08 soccer players aged 27.00 ± 0.58 years with a body mass index of 22.46 ± 1.25 kg/m2 was selected to participate in the study. The participants had no known neurological or cardiovascular diseases. All participants were elite soccer players who had been participating in the national elite soccer championship for more than 2 years, residing in the Republic of Congo. Footballers who were absent during the various blood collection phases, those taking medication, smokers, and those with trauma were excluded from the sample.

3.1.2 METHODS

3.1.2.1 Experimental Protocol

Data collection was conducted in three phases during the day at the beginning of the winter break of the senior elite national championship. In the first phase the soccer players were taken to the laboratory for collection of rest blood. The second phase was devoted to the practice of soccer, an experimental match was organized during the winter period. The third phase consisted in taking the soccer players back to the laboratory for blood collection after the soccer match. The physical activity of the players before that day corresponded to 3 months of competition in the Aller phase of the national soccer championship of division 1 according to the calendar of the Congolese Football Federation (FECOFOOT).

The experimental match also made it possible to evaluate the intensity of the match in a warm environment. The teams were composed of the titular players selected for the experiment on the one hand, and players not included in the sample on the other. This experimental match was played on a synthetic field, where the national division 1 soccer championship is played. The match took place during the day, at an ambient temperature of 38°C, a relative humidity of 50% and a wind speed of 3000km/h during the great rainy season. Pre-match blood samples were taken on an empty stomach in the morning at the Moungali Center for Biological Analysis (CABM) for cortisol, catecholamines, aldosterone and antidiuretic hormone.

The match was played according to FIFA rules, in case of injury, substitute players not included in the study completed the workforce to allow the balance of forces between the two teams. In addition, players were allowed to drink according to their thirst during stoppages of play and during the extra break allowed due to the heat.

The activity profile during the game was assessed using a Garmin Forerunner R15 Quick Start accelerometer (USA). It provided the effort heart rate, energy expenditure and total distance traveled during the game. The intensity of the game was 60.78% of the average heart rate of the footballers. With respect to fluid loss, several methods are available to assess hydration status, each with limitations depending on how fluids are lost (Cheuvront et al., 2008; Cheuvront and Kenefick, 2014). In this study, we determined the percentage of fluid loss by weighing the players before and at the end of the game semi-naked (with underwear on) using an impedance meter (TANITA Corporation BC-545N, JAPAN). The amount of water scored during the game and at warm-up was accounted for using the mineral water bottles labelled for each player.

With respect to hormones, ten ml of venous blood is collected and stored in the laboratory in tubes containing EDTA (ethylene diamine tetraacetic acid). Samples are taken following the insertion of a catheter, and while lying down before and after the match for hormone dosage. The blood samples are immediately placed in looted ice and then centrifuged for 5 minutes at 4° and 3000 rpm. The decanted plasma is separated and then frozen at 80° until the different assays are performed.

This investigation was approved by the scientific committee of the University Marien Ngouabi (Brazzaville) and was conducted according to ethical recommendations in accordance with the revised Declaration of Helsinki (2008).

3.1.3 STATISTICAL PROCESSING

The data collected are represented in several study variables. The mean ± standard deviation was used as a model to present the results of the study. Given the sample size ($n < 30$), the non-parametric test was used for comparisons. Thus, the wilcoxon test was performed to compare the values of hormonal parameters taken before and after the game. The level of significance was set at $p < 0.05$. This statistical analysis of the data was made possible by the statistical software SPSS IBM (version 22.0, SPSS Inc., Illinois, USA).

3.2 RESULTS

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. Regarding the physical performance of the footballers during the game, the average values were 7.88 ± 0.44 km for the total distance covered during the game and 60.78% for the intensity of the game (Table 1). Similarly, a water loss of 3.33% was noted among the footballers despite the average amount of 2L of goal water during the game (Table 1).

With regard to catecholamines, the average values obtained were 1.66 ± 0.07 pg/ml before and 3.06± 2.37pg/ml after the game for adrenaline; 2.23± 0.31pg/ml before and 3.67± 0.21pg/ml after the game for noradrenaline (Figure 1). These results show a positive change at the end of the catecholamine soccer game with a significant difference at $p = 0.116$ and $p = 0.028$ respectively. We also assayed cortisol 1 hour after the game, a hormone involved in recovery. Recovery cortisol was assayed to see neoglucogenesis in soccer players after a soccer match in a warm environment. Mean blood cortisol values were 300.61 ± 61.58 ng/ml before and 160.61 ± 18.98 ng/ml after the game (Figure 1). The results obtained show a decrease in cortisol values 1 hour after the game with a significant difference at $p = 0.028$.

Regarding the hydromineral hormones involved in physical exercise under heat, the mean DHA values of elite footballers obtained are 2.20 ± 0.09 Pg/ml before the game and 7.34± 0.89 Pg/ml at the end of the game (figure 2). The DHA increased by 5.14 Pg/ml at the end of the game or a percentage of 42.80% with a significant difference at $p = 0.028$. The average Aldosterone values of the elite footballers obtained were 140.16 ± 1.50 Pg/ml before the game and 111.33 ± 1.50 Pg/ml at the end of the game (Figure 2). Aldosterone increased by 28.83 Pg/ml at the end of the game, a percentage of 20.56% with a significant difference at $p = 0.027$.

Table 1: Physiological parameters and match intensity of soccer players

Parameters	Mean ± Standard Deviation	Parameters	Mean ± Standard Deviation
QE (L)	2,00 ± 0,29	FCE (bpm)	160,4 ± 3,43
DE (Kcal)	794,80 ± 0,11	%FC= intensité	60,78 ±1,82
DP (km)	7,88 ± 0,44	P. Hydrique (%)	3,33 ± 0,36

QE: Quantity of water; DE: Energy expenditure; DP: Total distance traveled; FCE: Exercise heart rate; %FC: Intensity of the game; P. Water: Percentage of water loss

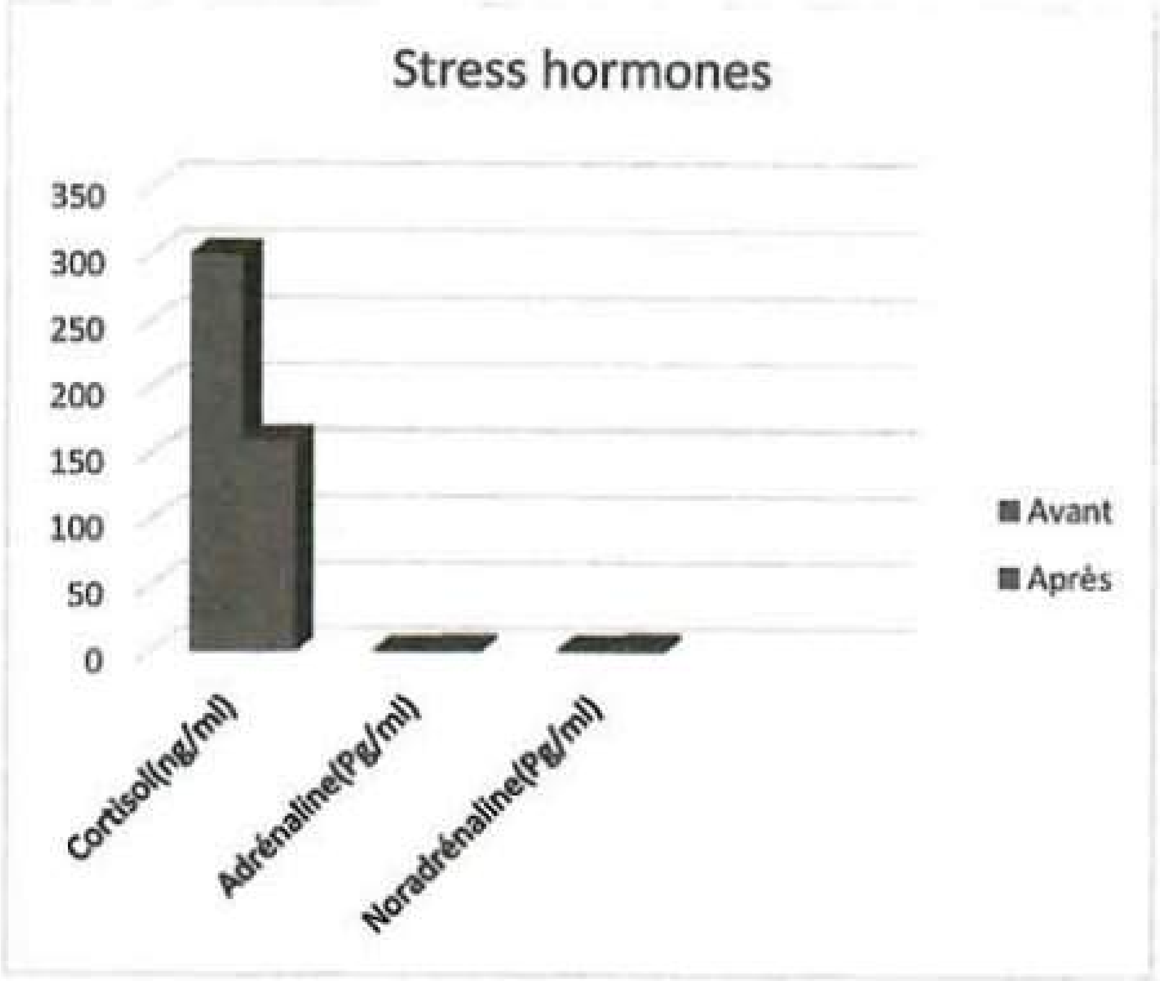

Figure1: Change in stress hormones during the game

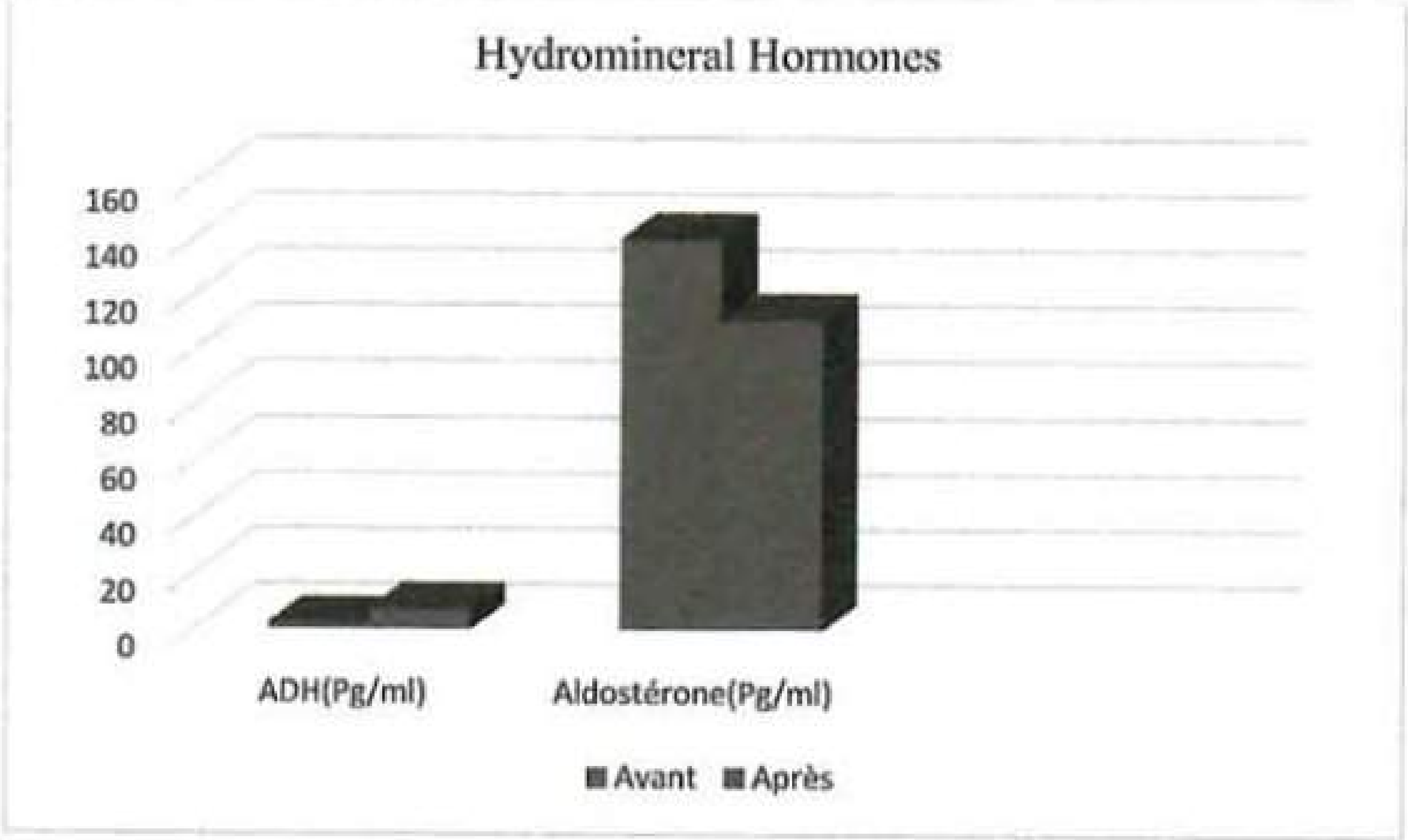

Figure 2: Variation in DHA and Aldosterone over the course of the game

3.3 DISCUSSION

Our cross-sectional type study took place during 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 50%. The high thermal stress did not allow the footballers to have a high intensity of the match. These results corroborate the study Bazaba KJM et al (2020), which assessed the water loss of the footballers in a hot and humid environment. High water loss in the footballers resulted in a decrease in math intensity. In addition, exercise-induced hypohydration resulted in increased plasma volume reduction (Mohr et al., 2010; Cheuvront et al., 2003). When body temperature increases during exercise, and this increase is even greater, it increases the rate of dehydration (Casa, et al.,2010).

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 (Laurent ,2019).

Moreover, dehydration alone does not justify this drop in intensity of the match, other factors are associated, in particular the disruption of stress-related hormones and those involved in the hydromineral balance. The progressive drop in cortisol levels one hour after the match in a hot environment represents an adaptive mechanism of the body to recovery for the reconstitution of energy reserves (Richards R et al.2014).

According to Hoffman al (2005), changes in cortisol concentration after exercise appear to be affected by several mechanisms. These include stimulation of the sympathetic nervous system, an increase in body temperature and lactate accumulation. Our results are consistent with those obtained by these authors.

A study conducted on blood cortisol concentration in male cyclists showed that cortisol levels are higher in the morning than in the evening (Alan Lins et al.2014). They considered the adrenal cortex response in men as necessary with positive effects in adaptation to stress (Gabbett TJ et al.2011). Our results corroborate those of these authors.

In this study, we also dosed catecholamines before and after the soccer match in order to identify their effect on physical performance during a soccer match in a warm environment. The results obtained show an increase in catecholamines at the end of the match with a significant difference. During physical activity, catecholamines induce physiological changes in the body, including an increase in heart rate (Fleshner M et al.2004). Some authors do not find any difference between the values before and after physical exercise of catecholamines (Stults-Kolehmainen MA et al.2014). On the other hand, others observe a decrease in basal noradrenaline values during exercise. Several methodological factors may help to explain the discrepancies in the results, such as the timing of blood sampling and the intensity of exercise (Meeusen R et al.2010). According to Kraemer et al (2005), catecholamines are elevated when blood is drawn immediately at the end of exercise.

The high concentrations of catecholamines measured at the end of the match lead to a significant increase in the physiological stress responsible for the decrease in intensity (Zouhal H et al.2008). In this study, adrenaline and norepinephrine values increased significantly and a decrease in match intensity was also observed (Braken RM et al.2010). In addition, there was an alteration of the aerobic energy system during the match. These results are also consistent with the study showing that a decrease in match intensity is accompanied by a slight decrease in the contribution of the aerobic energy system especially (Hill DW et al.2019).

In addition, the hormones involved in hydromineral balance were dosed before and at the end of the game in elite footballers in order to understand the activity of renal function during the game. The results show an increase in vasopressin values and a decrease in aldosterone at the end of the game in a hot and humid environment with a significant difference. The antidiuretic hormone (ADH), also called vasopressin, is involved in the reabsorption of water by the body. This hormone plays a role in regulating blood volume and water concentration in the body. The increase in vasopressin and aldosterone observed in this study can be explained by a high water loss in soccer players of more than 3%. It seems that the footballers consumed water during the game that did not help to compensate for the water loss observed during the game. This results in reduced blood flow to many organs, so that the kidneys may experience a three-quarters reduction in flow (Goffi E and .2006). 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 (Poortmans JR et al. 2006). Our results are consistent with those of the literature (Knechtle B et al. 1992). However, this decrease in performance is not limited to physiological and hormonal parameters. Other parameters are associated to explain the decrease in the performance of footballers in hot environments. A similar study by Bazaba et al (2020) on the physiological and metabolic data of footballers in a hot environment showed a decrease in match intensity linked to an increase in metabolic parameters.

Conclusion

This research was undertaken on the basis of the hypotheses that

1) Anthropometric parameters, physical and physiological capacities of Congolese footballers differ according to the playing position

2) Football matches played in a hot and humid environment lead to a physiological constraint responsible for the decrease in intensity and performance of footballers.

3) Playing football in a hot and humid environment is responsible for metabolic and hormonal dysfunction in the body.

To verify these hypotheses, three studies were carried out. The results obtained were analysed.

The anthropometric parameters, physical and physiological capacities of the footballers were evaluated per playing position. The subjects of this study have anthropometric parameters, physical and physiological capacities that are appropriate for elite football. A significant difference in these parameters was observed between the players by playing position. In addition, positive correlations were observed between anthropometric parameters and performance in the vertical expansion and reaction speed tests. This shows that anthropometric parameters are a significant performance factor in football.

Furthermore, during the match, the intensity of play, total distance covered, heart rate, maximum oxygen consumption and energy expenditure showed differences per playing position. A very significant water loss of more than 2% was observed in the footballers per playing position during the match. The players consumed more than 2L of water per playing position during the match which did not contribute to compensate the fluid loss by sweating. This shows that the study subjects were in a permanent state of hypo hydration accumulated during training. This was due to the footballers' poor fluid intake habits during the game and training sessions. This state of hypo hydration negatively influences the physical performance of the footballers and can affect their health.

Water status is a key determinant of physical performance when the match is played in a hot and humid environment. Furthermore, correlations were observed between water loss and physical performance of footballers during the match.

Finally, metabolic and hormonal parameters were measured in footballers before and after a demanding football match.

We found that metabolic parameters were disturbed during the match. A positive change in sodium and potassium was observed. A positive change in blood lactate, creatinine, FFA and creatine kinase was also observed. In contrast, blood glucose levels decreased after the match. This metabolic disturbance reflects the difficulty footballers have in exercising in a hot environment. This contributed to a decrease in the intensity of the match and consequently their performance capacity decreased. Similarly, stress and hydromineral hormones showed a positive change after the match.

Cortisol and catecholamines varied positively during the match in the heat. The secretion of these hormones is naturally linked to thermal and physiological stress. This stress, which is felt by the footballer before the match, can be incriminated in the determination and commitment of the footballer at the match to perform well. Similarly, antidiuretic hormone and aldosterone, hormones of the hydromineral balance, also experienced a transient disturbance. These results allow a better understanding and justification of the negative variation of estimated glomerular filtration rate (eGFR) during the match responsible for a transient renal dysfunction caused by hypo hydration that can be detrimental to the health of footballers.

During physical exercise in a hot environment, the footballer's body is confronted with a double problem: the arterial blood flow which must bring oxygen and nutrients to the active muscles, and the cutaneous blood flow which must preserve the central temperature by vasodilatation and increase sweating. It seems as if a competition is taking place between these two major needs, which are the needs of motor performance and those of central thermal regulation. We recall that to avoid fatal hyperthermia, the need for thermal regulation often takes precedence over the need for motor performance. It could also be explained that the drop in performance in footballers can be attributed to the high level of lactate obtained at the end of the match in a hot and humid environment.

Suggestions

Physical field tests determining V̇O2max (Yo-yo IR2), speed (reactivity), fatigue index (repeated sprints) and vertical jumps (SJ and CMJ) can be used for the evaluation and monitoring of athletes. Performance in these tests could allow coaches to quantify the positive or negative effects of training and compare players for their use during competition. In addition, it would seem worthwhile to avoid scheduling matches in the heat during the day. It is desirable to insist on good water intake habits before, during and after the match to preserve the health of the athlete and to optimise sports performance. This study may allow managers to work specifically on the low level of performance observed in football.

REFERENCES

Alan Lins Fernandes, João Paulo Lopes-Silva, Rômulo Bertuzzi, Dulce Elena Casarini, Danielle Yuri Arita, David John Bishop et al. Effect of time of day on performance, hormonal and metabolic response in a 1000 M cycling time trial. PLoS One. 2014; 9(10): e109954.

Bangsbo J, Lindquist F. Comparison of various exercise tests with endurance performance during soccer in professional players. Int J Sports Med. 1992; 13(2): 125-32.

Bangsbo J., Norregaard L., Thorsoe F. Activity profile of competition soccer. Cano 1 Sport Sei. 1991; 16(2): 110-6.

Bazaba KJM , Judith F. Ahounou AJF, Godonou1n JB, Gbenou3 JD , Dansou HP. Metabolic Data of Elite Footballers during a Tough Match in Hot and Humid Environment American Journal of Medical Sciences and Medicine. 2020; 8(3) :120-123. Doi :10.12691/ajmsm-8-3-4

Bazaba KJM, Boussana A, Ahounou AJF, Dansou HP, Gbenou JD. Physiological responses per playing position of elite soccer players during a challenging match in a hot and humid environment. Int. J. Biol. Chem. Sci. 2020 ; 14(4): 1273-1281.doi : https://doi.org/10.4314/ijbcs.v14i4.9

Bloomfield J, Polman R, Butterly R, O'Donoghue P. Analysis of age, stature, body mass, BMI and quality of elite soccer players from 4 European Leagues. J Sports Med Phys Fit : 2008. 45: 58-67.

Bradley PS, Di Mascio M, Peart D, Olsen P, Sheldon B. High-intensity activity profiles of elite soccer players at different performance levels. J Strength Cond Res.2010 ; **24**(9): 2343-2351.

Bradley PS, Sheldon W, Wooster B, Olsen P, Boanas P, Krustrup P. Highintensity running in English FA Premier. 2009

Braken RM, Brooks S. Plasma catecholamine and nephrine responses following 7 weeks of sprint cycle training. Amino Acids. 2010; 38: 1351-9.

Capranica L, Cama G, Fanton F, Tessitore A, Figura F. Force and power of preferred and non-preferred leg in young soccer players. J Sports Med Phys Fit. 1992 ; 32: 358-63.

Carling C, Bradley P, McCall A, Dupont G. Match-to-match variability in high-speed running activity in a professional soccer team. J Sports Sci. 2016; 34(24): 2215-23.

Carling C, Gregson W, McCall A, Moreira A, Wong P, Bradley PS. Match running performance during fixture congestion in elite soccer: research issues and future directions. Sports Med. 2015 ; 45(5): 605-13. doi.org/10.1080/02640414.2016.1176228

Carling C, Gregson W, McCall A, Moreira A, Wong P, Bradley PS. Match running performance during fixture congestion in elite soccer: research issues and future directions. Sports Med. 2015; 45(5): 605-13.

Casa DJ, Stearns RL, Lopez RM, Ganio MS, McDermott BP, Walker Yeargin S, Yamamoto LM, Mazerolle SM, Roti MW, Armstrong LE, Maresh CM. Influence of hydration on physiological function and performance during trail running in the heat. 2010; 45(2):147-56. doi: 10.4085/1062-6050-45.2.147.

Casa DJ. Exercise in the heat. II. Critical concepts in rehydration, exertional heat illnesses, and maximizing athletic performance. J Athl Train. 1999 ; 34: 253–262.

Castagna C, Manzi V, Impellizzeri F, Weston M, Barbero Alvarez JC. Relationship between endurance field tests and match performance in young soccer players. J Strength Cond Res. 2010; 24: 3227–3233.

Chamari K, Hachana Y, Ahmed YB, Galy O, Sghaïer F, Chatard JC, Hue O, Wisløff U. Field and laboratory testing in young elite soccer players. Br J Sports Med. 2004 ; 38(2): 191-6. doi.org/ 10.1136/ bjsm.2002.004374 .

Cheuvront SN, Kenefick RW. Dehydration: physiology, assessment, and performance effects. Compr Physiol. 2014; 4: 257–85.

Cometti G. Physical Preparation in Football. In: Chiron. Paris. 2002 ; 34-36

Cotter JD, Thornton SN, Lee JKW, Laursen PB. Sommes-nous noyés dans les conseils d'hydratation? Dommage pour plus ? Extrem Physiol Med. 2014 ; **3**: 18. Doi: 10.1186/2046-7648-3-18

Dellat A ,Rampinini E, Coutts A, Castagna C, Sassi R, Impellizzeri F. Technical and physical demands of small vs. large sided games in relation to playing position in elite soccer. Hum Mov Sci. 2012; 15(7): 118-9

Doclos M, Ben Ezzeddine-B L. Effects of regular physical activity on hormones. Biology and Health. 2004 ;4 :1-21.Doi:10.1519/JSC.0b013e3181aeb1b3.

Edwards AM, Noakes TD. Dehydration: cause of fatigue or sign of pacing in elite soccer? Sports Med. 2009 ; **39**(1): 1-13. Doi: 10.2165/00007256-200939010-00001

Fanchini M, Schena F, Castagna C, Petruolo A, Combi F, McCall A et al. External responsiveness of the yoyo IR test level 1 in high-level male soccer players. Int J Sports Med. 2015 ; 36: 735–741.

FIFA. Laws of the Game approved and adopted by the International Football Association. Board – Zurich. 2014

Francesconi RP, Sawka MN, Pandolf KB. Hypohydration and heat acclimation: plasma renin and aldosterone during exercise. J Appl Physiol. 1983; 55: 1790–1794.

Gabbett TJ, Jenkins DG, Aberethy B. Relative importance of physiological, anthropometric, and skill qualities to team selection in professional rugby league. J Sports Sci. 2011; 38(12): 344-350

Galbo H. Influence of aging and exercise on endocrine function. Int J Sports Nutr Exer Metab. 20011; 11: 49-57.

Gil, S., Ruiz, F., Irazusta, A., Gil, J., & Irazusta, J. Selection of young soccer players in terms of anthropometric and physiological factors. J Spzorts Med Phys Fitness. 2007; 47: 25-32.

Goffi E, Nielsens H. Can you play sports if you have chronic kidney failure, dialysis or transplant? AIRG-En Info Med. 2006;htt://www.airg-france.org:1-44.

Gonzalez RR, Cheuvront SN, Montain SJ, Goodman DA, Blanchard LA, Berglund

Hencken C and White C. Anthropometric assessment of Premiership soccer players in relation to playing position. Eur J Sport Sci. 2006; (6): 205-11.

Hencken C, White C. Anthropometric assessment of Premiership soccer players in relation to playing position 2006. Eur J Sport Sci 6: 205-11.

Hill DW, Borden DO, Darnaby KM, Hendricks DN, Hill CM. High-intensity interval training for health benefits and care of cardiac diseases - The key to an efficient exercise protocol. World J Cardiol. 2019; 11(7): 171-188.

Hoffman JR, Kang J, Ratamess, NA and Faigenbaum, AD. Biochemical and hormonal responses during an intercollegiate soccer season. Med Sci Sports Exercise. 2005; 37: 1237-41.

Hurley B.F., Hagberg lM., Allen W.K., Seals D.R., Young J.c., Cuddihee R.W., Holloszy lO. 1984. Effect of training on blood lactate levels during submaximal exercise. J Appl Physiol.1984 ; 56(5): 1260-4.

Ingebrigtsen J, Brochmann M, Castagna C, Bradley P, Ade ,; Krustrup P, Holtermann A. Relationships between field performance tests in high-level soccer players. J Strength Cond Res. 2014 ;28: 942–949.

Jovanovic M, Sporis G, Omrcen D, Fiorentini F. Effects of speed, agility, quickness training method on power performance inelite soccer players. J Strength Cond Res. 2011; 25: 1285-92.

Junior Bassett DR., Howley E.T. Factors for maximum oxygen uptake and determinants of endurance performance Med. Sei Sports Exere. 2000 ; 32(1): 70-84.

Kouassi J-P, Kouamé N, Tonon BA, Gouthon P, Nouatin BK, Tako A. Effect of voluntary rapid weight loss during a two-week training camp on hydro-electrolytic parameters and performance of elite judokas in Côte d'Ivoire. Int. J. Biol. Chem. Sci.2019 ;32(1): 70-85.

Kraemer WJ, Ratamess NA. Hormonal responses and adaptations to resistance exercise and training. Sports Med. 2005; 35: 339-361.

Laurent Grélot. Doha World Athletics Championships: when climate ruins performance and threatens athletes. Aix-Marseille University. 2019

LG, Sawka M. 2009. Expanded prediction equations of human sweat loss and water needs. J Appl Physiol. 2009 ; 107: 65-43.

Lohman T.G, ROCHE A.F, MARTORELL R. 1988. Anthropometry standardization reference manual. Champaign IL Hum Kinet.1988 .

Loturco I, Kobal R, Maldonado T, Piazzi AF, Bottino A, Kitamura K, Abad CCC, Pereira LA. Jump squat is more related to sprinting and jumping abilities than olympic push press. Int J Sports Med. (2017) ; 38: 604–612. DOI: 10.1055/s-0035-1565201

Lusamaki M, Nyongombe U, Batina A, Kayisu K, Losimba L. Hydration in soccer player of Kisangani under the completion and training seasons. J Exp Biol Agric Sci. 2014 ;3(2) : 27-33.

M Doclos, Ben Ezzeddine-B L. Effects of regular physical activity on hormones. Biol Santé. 2004; 4: 1-21.

Mana Beatriz B, pareja Fernando, David Rodriguez-Roseil, Juan Manuel yanez-Garcia, Ricardo-Custodio, Juan José Gonzalez-Badillo. Relationship between speed, jump and strength abilities and 800m power in male athletes at the national and international level. J Hum Kinet. 2017 ; 58-195.

Manzi V, Bovenzi A, Impellizzeri F, Carminati I, Castagna C. Individual trainingload and aerobic-fitness variables in premiership soccer players during the precompetitive season. J Strength Cond. . 2013

Maughan R , Shirreffs SM. Dehydration and rehydration. Scand J Med Sci Sports. 2010; 20(Suppl. 3): 40-7.

Maughan RJ , Shirreffs SM. Élaboration de stratégies individuelles d'hydratation pour les athlètes. Int J Sport Nutr Ex Metab. 2008; 18: 457-72.

Maughan RJ, Merson SJ, Broad NP, Shirreffs SM. Fluid and electrolyte intake and loss in elite soccer players during training. Int J Spot Nut Exerc Metab. 2004; 14: 333-46.

Maughan RJ, Shirreffs SM. 2010. Dehydration and Rehydration in competative sport. Scand J Med Sci Sports, **20**(3): 40-

Maxwell NS , Mackenzie RWA , évêque D. Influence de l'hypohydratation sur les performances de sprint intermittent à la chaleur. Int J Sports Physiol Perform. 2009; 4: 54-67.

Meeusen R , Roelands B. Central fatigue and neurotransmitters, can thermoregulation be manipulated? Scand J Med Sci Sport. 2010; 20(Suppl3): 19-28.

Mohr M, Krustrup P, Bangsbo J. 2005. Fatigue in soccer: a brief review. J Sports Sci, **23**

Mohr M, Krustrup P, Bangsbo J. 2017. Fatigue in soccer: a brief review. J Sports Sci 23(6): 593-9. doi.org/10.1080/ 02640410400021286

Mohr M, Krustrup P, Bangsbo J. Match performance of high-standard soccer players with special reference to development of fatigue. J Sports Sci. 2003; 21(7): 519-28.

Mohr M, Mujika I, Santisteban J, Randers MB, Bischoff R, Solano R, Hewitt A, Zubillaga A, Krustrup . 2010.Examination of fatigue development in elite soccer in a hot environment: a multiexperimental approach. Scand J Med Sci Sports.2010 ;20(3): 125-132. Doi:10.1111/j.1600-0838.2010.01217.x.

Montain SJ, Sawka MN, Latzka WA, Valeri CR. Thermal and cardiovascular strain from hypohydration: influence of exercise intensity. Int J Sports Med.1998 ; 19: 87–91. Doi: 10.1055/s2007-971887

Nassis et al. Performance des joueurs de football et leur incidence sur l'état hydrique. Sports Med. 2015; 38: 931-46.

Rampinini E, Bosio A, Ferraresi I, Petruolo A, Morelli A, Sassi A. Match-related fatigue in soccer players. Med Sci Sports. 2011

Reilly T, Ekblom B. The use of recovery methods postexercise. J Sports Sci. 2005 ; 23(6): 619-27.

Reilly T. Energetics of high-intensity exercise (soccer) with particular reference to fatigue. J Sports Sci. 1997; 15(3): 257-63.

Richards R , Richards D , Schofield PJ , Ross V , Sutton JR. Practical strategies for the prevention and treatment of heat-related discomfort. Can Fam Physician. 2014; 60(8): e392-e394.

Ryan P, Nuccio Kelly A, Barnes James M, Carter and Lindsay B.. Fuid balance in team sport atlète and the efeet of hypohydration on cognitive, technical and physical performance. Sport Med. 2017

Sawka MN, Burke LM, Eichner ER, et al. American College of Sports Medicine.American College of Sports Medicine position stand.Exercise and fluid replacement. 2007; 39: 377–90.

Shirreffs SM. Hydration - special issues for playing football in warm and hot environments. Scand J Med Sci Sports. 2010; 20(Suppl. 3): 90-4.

Stolen T, Chamari K., Castagna C. and Wisloff V. Physio1ogy of soccer: an update. 2005; 35(6): 501-36.

Stults-Kolehmainen MA, Bartholomew JB, Sinha R. Chronic psychological stress odd recovery of muscular function and somatic sensations over a 96-hour period. J Strength Cond Res. 2014; 28(7): 2007-17.

WONG, PW., CHAMARI, K., DELLAL, A., WISLÖFF, U. Relationship between anthropometric andphysiological characteristics in youth soccer players. J Strength Cond Res. 2009; 23(4): 1204-10.

Yang SM, Lee WD, Kim JH, et al. Differences in body componen ts and electrical characteristics between youth soccer players and non-athletes. Health (N Y). 2013; 5: 1010–1015.

Zouhal H, Lemoine Morel S, Mathieu ME, et al. Catecholamines and obesity: effects of exercise and training. Sports Med. 2013; 43(7): 591-600.

Contents

Publisher: Eliva Press SRL

Email: info@elivapress.com

Eliva Press is an independent publishing house established for the publication and dissemination of academic works all over the world. Company provides high quality and professional service for all of our authors.

Our Services:
Free of charge, open-minded, eco-friendly, innovational.

-Free standard publishing services (manuscript review, step-by-step book preparation, publication, distribution, and marketing).
-No financial risk. The author is not obliged to pay any hidden fees for publication.
-Editors. Dedicated editors will assist step by step through the projects.
-Money paid to the author for every book sold. Up to 50% royalties guaranteed.
-ISBN (International Standard Book Number). We assign a unique ISBN to every Eliva Press book.
-Digital archive storage. Books will be available online for a long time. We don't need to have a stock of our titles. No unsold copies. Eliva Press uses environment friendly print on demand technology that limits the needs of publishing business. We care about environment and share these principles with our customers.
-Cover design. Cover art is designed by a professional designer.
-Worldwide distribution. We continue expanding our distribution channels to make sure that all readers have access to our books.

www.elivapress.com

Scanné avec CamScanner

The aim of this book is to present as clearly as possible the physiological aspects of the performance of sportsmen and women in a hot and humid environment. It is intended for undergraduate students in science and technology of physical activities and sports (STAPS), coaches and physical trainers of team sports as well as sports managers.

It is organised in three main parts and is richly illustrated:

- The first part deals with the evaluation of physical capacities according to the energy channels: anaerobic alactic, anaerobic lactic and aerobic;

- The second part presents information on the physiological changes, total distance covered, energy expenditure and water loss of footballers during the match in a hot and humid environment;

- The third part outlines the metabolic and hormonal regulation system of footballers during the match in a hot and humid environment.

This information will help students, coaches and physical trainers to better understand and monitor the evolution of physical performance of footballers in a hot and humid environment. Sports managers should be aware of the risks that athletes face when exercising in a hot and humid environment. They should take into account the environmental conditions before organising a sports competition.

Bazaba Kayilou Jean Michel: Doctorat en STAPS, Université d'Abomey-calavi(Bénin), Directeur de la recherche(INJS-Brazzaville), entraineur de football (Licence A féderale).

Ahounou Aikpe Judith: Doctorat en STAPS, Université d'Abomey-calavi(Bénin), Chef de departement INJEPS-Benin.

Dansou Pierre: Doctorat en STAPS, Université d'Abomey-calavi(Bénin), Directeur de l'école doctorale STAPS-Benin.

Gbenou Joachim: Doctorat en Biochimie, Université d'Abomey-calavi(Bénin), Vice recteur à l'Université d'Abomey-calavi (Bénin).

ISBN 978-1-63648-364-1

9 781636 483641

ELIVA PRESS