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ORIGINAL ARTICLE

Hydro electrolytic responses after a training session in some Cameroonian soccer players

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ABSTRACT

Playing soccer in hot climates can lead to significant fluid and electrolyte losses, resulting in higher levels of dehydration. The aim of this study was to quantify the fluid and electrolyte sweat losses among selected Cameroonian soccer players during a training session. Thirty soccer players aged 22 ± 5 from two teams (RENAIS and JACY) playing in the first division participated in a specific training session lasting about 1 hour 30 minutes. Before and after the session, all players were weighed. Sweat samples were collected to determine the sodium concentration. Ten participants completed a questionnaire providing information on their dietary and fluid intake, sweating habits, and salt intake routines. We found that JACY players had a significantly higher average sweat rate (1.73 ± 0.45L/h) compared to RENAIS soccer players (p = .038). A positive correlation (r = 0.47; p = .023) was observed between body mass index and sweat rate. A percentage of 33.3% of players presented the "*salty sweater*" profile. A dehydration level of 3.3% was found. 30% of players admitted to experiencing frequent cramping. The results indicate that Cameroonian soccer players experience significant fluid and sodium losses and are not adequately hydrated during training sessions.
Keywords: Performance analysis, Dehydration, Sweating, Hydration, Sodium, African athletes.

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INTRODUCTION

Soccer is the world's most popular sport. It is played in various countries with different climatic conditions. During regular matches or 90-minute training sessions, players cover significant distances (10 to 13 km), of which 10% are covered at high intensity, resulting in significant fluid loss through perspiration (Shephard, 1999; Rampinini et al., 2007; Andrzejewski et al., 2015; Palucci-Vieira et al., 2018). Furthermore, sweating can lead to hypovolemia, which can have several consequences for athletes. These include impaired thermoregulation, increased heart rate, increased muscle glycogen utilization, and impaired central nervous system function (Montain & Coyle, 1992; Gonzalez-Alonso et al., 1995).

Environmental factors can affect sweating. In sub-Saharan Africa for example, where the climate is hot, sweat rates can be very high. According to Sawka et al. (2007), a heat-acclimatized athlete has higher and more sustained sweat rates during exercise, but lower associated sodium losses (Buono et al., 2007). Several studies have shown that elite soccer players commonly experience significant dehydration, defined as a body mass deficit of over 2% (Ozolina et al., 2013; Laitano et al., 2014; Phillips et al., 2014; Arnaoutis et al., 2015; Nuccio et al., 2017). In soccer players, the average sweat rate is reported to be 0.94 ± 0.38 L/h, and the sodium loss rate 34.6 ± 1 mmol/h (Barnes et al., 2019).

Rivera-Brown & Quinones-González (2020) reported higher values for soccer players acclimatized to tropical climates. Specifically, they found sodium losses of 43.2-44.0 mmol/L and an average sweat rate of 1.2 ± 0.5 L/hr - 1.5 ± 0.5 L/hr. The authors also provide standard hydro-electrolyte values to be taken into account for the same athletes in all age groups. Understanding these aspects is crucial for optimizing an athlete's water balance. This explains why some authors (Shirreffs, 2010; McCubbin et al., 2020) recommend for soccer players the following: hyperhydration before exercise, consumption of specific beverages based on conditions (isotonic or hypotonic beverages before the match, isotonic drinks during the match, hypertonic drinks after the match), ingestion of icy or cold drinks before and during exercise, and assessment of fluid balance during exercise, gastrointestinal tolerance to fluid intake, and appropriate thirst responses. Unfortunately, sub-Saharan African federations make no use of the above information due to a lack of studies locally and insufficient financial and technical resources. A classic and effective way of determining water losses in order to adjust an athlete's fluid requirements is to measure the difference between pre-exercise and post-exercise weights using a simple impedance meter scale. If the effect of exercise on hydration status is of interest, determining the body mass just before and after training is the most effective way to quantify fluid losses, so as to prescribe the appropriate quantity of drink to be consumed after training. Therefore, individualized hydration strategies must be implemented to optimize the athlete's hydration status. This process entails measuring the sweat rate of each athlete in conditions that simulate real competition settings so as to estimate the amount of fluid needed for rehydration on the day of the competition (Rowlands et al., 2022).

In addition, many authors use sweat marker assays to identify "*salty sweaters*" who may benefit from sodium supplementation. Salty sweaters are individuals whose sweat sodium concentrations are greater than or equal to 60 mmol/L (Lara et al., 2016). Mc Cubbin (2023) has recently developed mathematical models for sodium supplementation in some sporting disciplines. Although ultra-endurance was the discipline with the most well-defined sodium requirements, he admitted that soccer players could also experience high levels of sweating, associated with significant sodium losses, thus joining these models. Therefore, African players who are accustomed to hot climates should be wary of fluid and electrolyte losses. In recent years, there have been several cases of sudden death during soccer matches in African leagues. The cause of these deaths could be attributed to a failure of thermoregulatory mechanisms caused by severe dehydration, which induces blood hyperviscosity. Acute hypohydration can reduce endothelial function, increase sympathetic nervous system activity, and worsen orthostatic tolerance (Watso and Farquhar, 2019). Alas, no data on fluid and electrolyte losses associated with soccer practice in sub-Saharan contexts currently exist. The purpose of this study was to assess the fluid and electrolyte (sodium, potassium) sweat losses, in professional soccer players from Cameroon, during a training session.

To achieve our aim, we first measured the sweat rates of our soccer players. Next, we measured their sweat markers (sodium and potassium). And finally, we determined the association between hydro-electrolyte losses and certain complaints reported by the soccer players (muscle cramps, eye irritation).

MATERIALS AND METHODS

Ethical clearance

We obtained an ethical clearance from the Institutional Ethical Review Board for Human Health Research of the Centre Region (CEN°00115/CRERSHC/2023). The study was conducted in compliance with the revised version of the Declaration of Helsinki (2013). All participants provided written informed consent before being included in the study.

Participants

Participants (age: 22 ± 5 years, height: 1.75 ± 0.07 m, weight: 73.67 ± 7.28 kg) were recruited from two first division soccer teams in the city: *Jeunesse Athlétique Club de Yaoundé* (JACY) and *Renaissance Club de Ngoumou* (RENAIS). A total of 30 footballers, all outfield players, took part in the study. They had an average sports experience of 6 ± 3years and a weekly training schedule of 11 ± 2hours.

Experimental protocol

The study was conducted between January and April 2023, coinciding with the end of the sports season. Working days were chosen in agreement with the coaches according to their training schedules (between 9:30am and 12:30pm). Each session lasted an average of 90 minutes and was coordinated by the coaches of the various clubs. Data collection was done at the training grounds of each club. Prior to arriving on site, participants were briefed by their coaches on the study's objectives. Once on the field, the investigators provided them with additional information regarding hydration during the session. Each participant (code J for *JACY* players and R for the *RENAIS* players) was provided with two labeled 1.5-liter bottles of *Supermont* mineral water for hydration during the training session. Additionally, an empty labeled bottle with the same code was provided for urine collection. The temperature and humidity of the field were acquired using a WS6826 WHI-SIL Weather Station (La Crosse, Wisconsin, USA). Prior to the training session, participants were weighed using a TERRAILLON impedance meter scale. Their heights and blood pressures were measured at rest using a GIMA stadiometer (Gessate, Italy) and an OMRON blood pressure monitor, respectively. After taking the anthropometric and vital signs, we cleaned the skin with an alcohol-soaked cotton pad. Then, we placed a single layer of sterile gauze on each of the participant's shoulder blades, covering them with plastic, and securing them with plaster. Following the training session, sweat was collected in 1.5 mL Eppendorf tubes for subsequent analysis of sweat markers (sodium and potassium). At the end of the session, participants completed a questionnaire on their dietary, hydration, and sweating habits. The investigating team assisted each participant in filling out the questionnaire when necessary.

Training session sequence

The training session comprised standard soccer field exercises, such as warm-up, active mobility, soccer drills, and a match session between teammates.

Determination of sweat rate and percentage of dehydration

The sweat rate was evaluated using a formula that takes into account the variation in pre- and post-exertion body mass corrected by ingested fluids and excreted urine.

$$\text{Fluid loss (L)} = \text{Pre-weight (Kg)} - \text{Post-weight (Kg)} + \text{Amount of water drunk (Kg)} - \text{Quantity of urine (Kg)}.$$

$$\text{Sweat Rate} = \frac{\text{Preweight} - \text{Postweight} + (\text{Amount of water drunk} - \text{Quantity of urine})}{\text{Time (hours)}}$$

$$\text{Percentage of Dehydration} = \frac{\text{Fluid Loss} * 100}{\text{Preweight}}$$

Where Pre-weight and post-weight represent the initial and final weights of the subject, respectively.

Sweat collection procedure

Just before the training session, the skin was thoroughly cleaned with alcohol and then dried. A single layer of pre-cut sterile gauze (10cm x 7cm) was then placed on each of the participant's shoulder blades, covered with plastic (15cm x 11.5cm), and secured with plaster. After the session, the sweat-imbibed gauzes were removed, placed in the barrel of a 5ml syringe, and the sweat collected in 1.5ml Eppendorf tubes. The sweat samples were then frozen at -20°C in the biochemistry laboratory of the Faculty of Medicine and Biomedical Sciences, University of Yaoundé I, for subsequent analysis of sweat markers (sodium and potassium).

Determination of sodium and potassium concentration in sweat

The determination of sweat markers (sodium and potassium) was performed using two pocket ion analyzers Na+ and K+, Horiba B-722 and Horiba B-731, respectively (LAQUAtwin, Minami-ku Kyoto, Japan) (Baker et al., 2014). Prior to each test, the ionometers were calibrated according to the manufacturer's instructions. A 2-point calibration was performed using 150 ppm and 2,000 ppm standard solutions for the Horiba B-722 (Na +) analyzer. A 1-point calibration was performed using a 150 ppm standard solution for the Horiba B-731 (K+) analyzer. The calibration was repeated after every 10 measurements to avoid instrument drift (Goulet et al., 2012). After the samples were thawed, a 300 µL volume of sweat was collected with a micropipette and rapidly deposited into the dosing cell of the ionometers. The measurement was automatically displayed in ppm within a maximum of 10 seconds. To report Na+ and K+ concentrations in mmol/L, the ppm values were converted to mEq/L by dividing by the molar mass of the ions (22.989 for Na+ and 39.098 for K+). The ionometer sensors were rinsed with distilled water and gently dried with a cloth between sweat samples.

Questionnaire administration

The research team designed the questionnaire to focus on the sports profile, dietary habits, sweat profile, health profile, and hydration habits of our participants.

- The sports profile evaluated the level of sport practiced, including novice, intermediate, advanced, and professional levels, as well as the number of training hours per week and the longevity within the sport.
- Dietary habits assessed adherence to a specific diet (vegetarian, others), frequency of meat consumption (0, 1-3, >3), number of daily meals (1, 2, 3, >3), consumption of salty foods (yes, no), etc.
- The sweat profile assessed the sweating habits in everyday life (imperceptible sweating, tolerable sweating), the sweat rate during sports (low, moderate, high, very high) etc.

- The health profile assessed the occurrence of cramps, thirst, and sweat-induced eye irritations during competitions, with response options ranging from never to often.
- The hydration habits assessed the frequency of hydration (every 15 min, every 30 min, every 60 min, more than 60 min), the type of beverage consumed during sports (mineral water, tap water, commercial sports drink, homemade drink, others) etc.

Statistical analysis

We used StatView v5.0 (SAS Institute, Inc., Chicago, IL, USA) and GraphPad Prism version 8.3.0 (GraphPad Software, La Jolla, California, USA) for statistical analysis. Before the statistical analysis, variables were entered, coded, and cross-checked for accuracy and consistency. Results were presented in tables or charts (boxplots, histograms) as appropriate. Quantitative variables were expressed as mean ± standard deviation (SD), while qualitative variables were presented as counts and percentages. Non-parametric tests namely, Mann-Whitney and Kruskal-Wallis were used to compare mean values between groups if the variables did not fit a Gaussian distribution. Pearson's chi-square (χ^2) test of independence and Fisher's exact test were used to compare percentages, after testing for Cochran's rule (Cochran, 1952). The Pearson's and Spearman's correlation coefficient (r) was used to analyse the relationship between [Na^+] and [K^+], sweat rate, percentage of dehydration, and other variables such as age, BMI, DBP, SBP, and heart rate. A two-sided *p-value* < .05 was considered statistically significant.

RESULTS

Our study population consisted of 30 male soccer players. The anthropometric, physiological, thermo-hygrometric, and hydro-electrolytic characteristics of this population are described in Table 1.

Table 1. Anthropometric, physiological, thermo-hygrometric, and hydro-electrolytic characteristics of the study population.

Characteristics	Total (N = 30)	JACY (N = 15)	RENAIS (N = 15)	*p-Value*
Age (years)	22 ± 5	23 ± 6	21 ± 3	.32
Height (m)	1.75 ± 0.07	1.76 ± 0.07	1.72 ± 0.07	.18
Pre-weight (Kg)	73.67 ± 7.28	76.03 ± 7.32	71.32 ± 6.68	.07
Post-weight (Kg)	72.52 ± 7.05	74.43 ± 7.16	70.62 ± 6.62	.14
BMI (Kg/m^2)	24.13 ± 1.62	24.43 ± 1.73	23.83 ± 1.50	.32
SBP (mmHg)	121 ± 9	113 ± 2	128 ± 6	<.0001
DBP (mmHg)	79 ± 11	79 ± 9	78 ± 15	.87
rHR (bpm)	64 ± 12	65 ± 12	63 ± 14	.69
Quantity of water drunk (Kg)	1.36 ± 0.31	1.38 ± 0.39	1.34 ± 0.22	.71
Quantity of urine (Kg)	0.059 ± 0.101	0.075 ± 0.089	0.043 ± 0.114	.41
Fluid loss (L)	2.45 ± 1.19	2.90 ± 1.50	1.99 ± 0.50	.03
Dehydration (%)	3.31 ± 1.48	3.82 ± 1.89	2.80 ± 0.65	.07
Sweat rate (L/h)	1.44 ± 0.3	1.73 ± 0.45	1.33 ± 0.17	.038
Outdoor Temperature (°C)	36.3 ± 7.7	44.0 ± 0	28.6 ± 0	<.001
Humidity (%)	58.5 ± 11.5	47.0 ± 0	70.0 ± 0	<.001
[Na+] (mmol/L)	48.0 ± 21.1	48.0 ± 20.7	48.0 ± 20.3	.618
[K+] (mmol/L)	2.9 ± 0.6	3.3 ± 0.5	2.5 ± 0.2	.019

Note. total number of participants, n: number of participants per team, BMI: Body Mass Index, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, rHR: Resting Heart Rate, JACY: Jeunesse Athlétique Club de Yaoundé, RENAIS: Renaissance Club de Ngoumou; [Na+]: sodium concentration in sweat; [K+]: potassium concentration in sweat.

The study found that RENAIS players had a significantly higher SBP ($p < .001$) than JACY players, despite being slightly younger.

There were no significant differences in mean water intake and urine output between the two groups, although JACY players drank and urinated more than RENAIS players. The average sweat rate of the players was 1.44 ± 0.3L/h. We found that JACY players had a significantly higher sweat rate ($p = .038$) compared to RENAIS players (1.73 ± 0.45L/h vs. 1.33 ± 0.17L/h). The outdoor temperature was also significantly higher ($p < .001$) during the JACY training session than during the RENAIS session. Conversely, humidity was significantly higher ($p < .001$) during the RENAIS training session. Overall, the mean sodium concentration of the total population was 48 ± 21.1mmol/L. There was no significant difference ($p = .618$) between the sodium concentrations of the two clubs. However, the potassium concentration of JACY players was significantly higher ($p = .019$).

The players were distributed according to their field positions. Their sweat rates per field position is presented in Table 2.

Table 2. Distribution of study population by field position in relation to sweat rate.

Features	Forward (N = 7)	Defender (N = 11)	Midfielder (N = 12)	*p* - Value
Sweat rate (L/h)	1.20 ± 0.09	1.47 ± 0.3	1.74 ± 0.3	.154

In our study population, midfielders were the most represented. The players from RENAIS were evenly distributed across the different field positions (33% per position), whereas the players from JACY were heterogeneously distributed, with midfielders being the majority (47%) among them. Forwards were the least represented (13%) among the JACY players. Although there was no significant difference ($p = .154$) in sweat rate across the different playing positions, we found that midfielders had the highest sweat rate.

Table 3. Distribution of players according to sweat sodium concentration.

[Na+] (mmol/L)	Total (N = 30)	JACY (N = 15)	RENAIS (N = 15)	*p* - Value
<30 (slightly salty)	8.0 (26.7%)	5.0 (33.3%)	3.0 (20.0%)	
[30-60[(moderately salty)	12.0 (40.0%)	6.0 (40.0%)	6.0 (40.0%)	.601
≥ 60 (highly salty)	10.0 (33.3%)	4.0 (26.7%)	6.0 (40.0%)	

Note. N: total number of players; n: number of players per team; [Na]: sodium concentration in sweat; JACY: Jeunesse Athlétique Club de Yaoundé; RENAIS: Renaissance Club de Ngoumou.

It was found that over a third (33.3%) of the players had highly salty sweat. An inter-club comparison showed a much higher percentage (40%) of "*salty sweaters*" in RENAIS soccer players.

Figure 1 shows the distribution of players according to the percentage of dehydration.

In the figure above, 46.6% (7/15) of RENAIS players showed dehydration percentages between 2.51-3%. Dehydration levels equivalent to > 4% were present in 33.3% (5/15) of JACY footballers. Dehydration levels in ranges [3.01-3.50%] and [> 4%] were present in 1/3 of footballers in each of the two clubs, comprising midfielders and defenders.

Tables 4 and 5 show the players' attitude in relation to hydration, muscle cramps, discomforts experienced, and the type of beverage consumed.

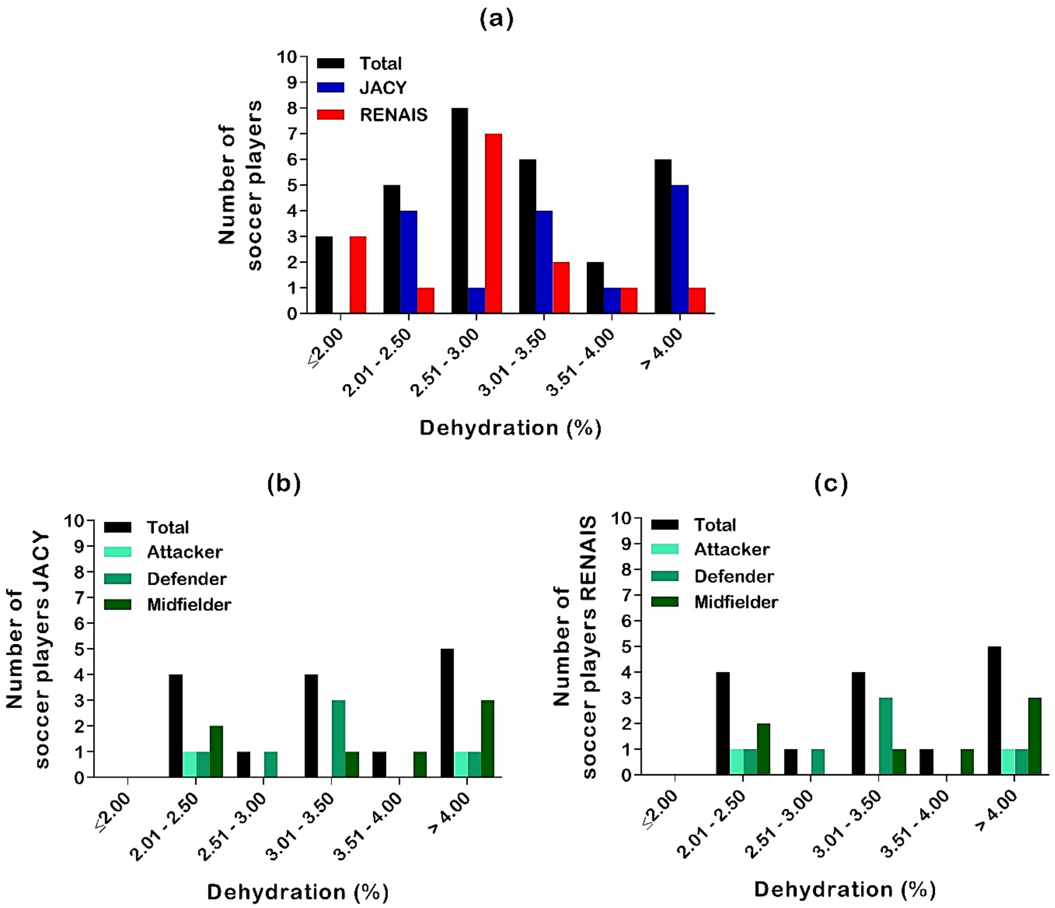

Figure 1. Distribution of players according to percentage of dehydration.

Table 4. Behaviour of players in relation to hydration, muscle cramps, discomfort, and type of drink consumed.

Variables	Categories	n	%
One or more signs of dehydration	Never	1	10
	Sometimes	4	40
	Rarely	3	30
	Often	2	20
Most frequent signs	Dry mouth	1	10
	Dry lips and mouth	3	30
	Dry lips + Low urine output	1	10
	I don't know	5	50
Discomfort during sports	No	7	70
	Yes	3	30
Fluid intake during training	No	1	10
	Yes	9	90
Average Fluid intake frequency	Every 15 minutes	1	10
	Every 30 minutes	8	80
	Over 60 min	1	10
Type of beverage usually consumed	Others	1	10
	Tap water	5	50
	Mineral water	4	40

Hydration during competitions	No	1	10
	Yes	9	90
	Every 30 minutes	9	90
	Over 60 min	1	10
Type of beverage during competitions	Tap water	4	40
	Mineral water	6	60

Table 5. Players' behaviour in relation to hydration, muscle cramps, discomfort, type of drink consumed.

Variables	**Categories**	**n**	**%**
White marks on clothing	Never	8	80
	Sometimes	1	10
	Rarely	1	10
Sweat-induced eye irritation during sports	Never	5	50
	Sometimes	2	20
	Rarely	1	10
	Often	2	20
Quantity of salt lost	Low	1	10
	Moderate	3	30
	High	4	40
	I don't know	2	20
Muscle cramps during exercise	Never	4	40
	Rarely	6	60
Muscle cramps during competition	Never	7	70
	Rarely	3	30
Daytime muscle cramps	Never	7	70
	Sometimes	1	10
	Rarely	2	20
Evening muscle cramps	Never	5	50
	Sometimes	3	30
	Rarely	2	20
Thirst during training	Never	2	20
	Sometimes	2	20
	Rarely	2	20
	Often	4	40
Thirst after training	Sometimes	3	30
	Rarely	1	10
	Often	6	60
Thirst during competition	Never	1	10
	Sometimes	4	40
	Often	5	50
Thirsty after competition	Sometimes	3	30
	Rarely	1	10
	Often	6	60

The tables above show that 80% of respondents had a hydration frequency during competitions equivalent to "*every 30min*". Half of our study participants drank tap water during training. And half of the respondents were thirsty during competitions.

DISCUSSION

The main objective of the present study was to evaluate fluid and electrolyte losses in selected Cameroonian soccer players during a training session. Our study revealed that, at the end of a training session lasting about 90 minutes, JACY players had a higher average sweat rate (1.73 ± 0.45L/h) (p = .038) than RENAIS players (1.33 ± 0.17L/h). This could be explained by the fact that the two teams trained under very different environmental conditions; temperature and relative humidity at JACY were conducive to greater sweating (higher temperature and lower humidity). Indeed, humidity is a limiting factor to sweating as a warm, dry environment is more conducive to sweating (Dziedzic et al., 2014). In the same sense, the water losses (2.45L) observed in our study were higher than those observed in other studies involving a similar methodology. Shireffs et al. in 2005 reported mean water losses of 1.23L after a 90 minutes training session taking place between 7:30pm and 9:30pm in soccer players. Conversely, Shireffs (2010) showed a sweat rate of 1.5L/hr in some footballers playing in very hot temperatures, while the study by Godek et al. (2010) revealed a variation in sweat rate among players of American football per field position (backs and receivers, linebackers and quarterbacks, and linemen). They obtained values ranging from 0.45-1.42L/h for running backs and receivers, 0.49-1.98L/h for linebackers and quarterbacks, and 0.75-2.16L/h for linemen. These results concur with those of the present study, where we also observed a higher sweat rate among midfielders (1.74 ± 0.3L/h) compared with defenders (1.47 ± 0.3L/h) and forwards (1.20 ± 0.09L/h). The correlation between sweat rate and sodium loss in sweat was inversely proportional. This implies that sweat loss is not always synonymous to electrolyte loss in equal quantities. Our study revealed that the concentration of sodium lost in sweat does not depend on sweat rate but could be explained by other aspects related to the degree of heat acclimatization and hydration status prior to physical activity (Buono et al., 2007; Karlsen et al., 2015). It was observed that there was no association between the amount of water consumed during the training session and sweat rate. Similarly, no association was observed between the amount of water drunk and the amount of salt present in sweat. These results show that the determinants of sweat flow can be complex even though sweat trigger thresholds and environmental conditions greatly impact it (Dziedzic et al., 2014; Eichner, 2008). Moreover, a study by Maughan et al., 2012 showed that sweat rate and sodium loss varies with the environment in which the athlete performs exercise.

Sodium being the major electrolyte in sweat, we sought to compare the sodium losses of the players in our two clubs. Overall, the mean sodium concentration found in sweat (48 ± 21.1mmol/L) in our players are those generally observed in soccer players (Shireffs, 2010; [Na+] varying between 40 and 50 mmol/L) after a training session. Given that the average plasma sodium concentration is 140mmol/L, the above losses recorded in 90mins are significant and should be replaced by the players during training sessions. This will allow the player to remain well hydrated and avoid the occurrence of hyponatremia, whose consequences are deleterious to health (Guezennec, 2011). In our study, it was found that 40% of players had a sweat sodium concentration ([Na+]) between 30-60mmol/L (called typical sweaters) versus 26.7% who had a [Na+] <30mmol/l (called low salt sweaters), and 33.7% had a [Na+] greater than 60mmol/l (called salty sweaters); their respective sweat rates were 1.4L/h; 1.6L/h, and 1.6L/h. The average amount of water drunk by the players during the training session was 1.36 ± 0.31L. It should be noted that the water ingested was a mineral water beverage called *Supermont* recognized as one of the most commercialized in the Cameroonian market, with a sodium content of zero. From these findings, we can say that this hydration could not compensate for the sodium losses recorded, thus explaining the relatively high proportion of participants (33.7%) with the "*salty sweater*" profile. With regards to the assessment of the players' fluid losses, we found that the JACY players experienced more fluid loss and a higher percentage of dehydration than the RENAIS players. Overall, almost all footballers (27/30, 90%) showed a percentage of dehydration greater than 2%. An excellent review (Nuccio et al, 2017) indicated that certain levels of dehydration (3-4%) as observed in the present study were sufficient to impact cognitive function, technical skills, and physical performance in team sport athletes. The study by Aragon-Vargas et al. (2009) found average dehydration levels (3.3%) similar to the present study in soccer players, but with greater hydration (1.9L). Furthermore, the percentage of dehydration observed among our athletes during this training session would be further exacerbated during official matches, which take place in extremely hot environments. Indeed, the study by Tarnowski et al. (2022) reported that sweat flows were doubled during an official match compared with a training session in young female soccer players. And if hydration is sodium-deficient, as in the present study, the associated discomforts (muscle cramps, eye irritation) would manifest themselves very early in these athletes. Moreover, McCubbin (2023) has shown that sodium supplementation is very important in disciplines such as soccer, where sweat rate is high. It should be emphasized that the responses to questions providing information on hydration habits could possibly justify the hydro-electrolytic data observed. Although the respondents were few, some reported discomforts such as muscle cramps or sweat-induced eye irritation. Eighty percent of them admitted to hydrating only every 30 minutes. This attitude conformed to the instructions given by the coaches, who prescribe this time interval in an attempt to prevent stomach fluid overload. This however gives us a clue about the coaches' ignorance concerning good hydration strategies.

Evaluation of hydro-electrolyte responses after a training session in some Cameroonian soccer players showed significantly high sweat rates associated with inter-individual variations in sweat markers, with a "*salty sweater*" profile present in more than one-third of the participants. The environmental conditions in which each of these two sessions took place provided information on the observable variation in hydro-electrolyte losses, which would be exacerbated in real-time competition settings. The hydration of Cameroonian soccer players is qualitatively and quantitatively inadequate, suggesting the need for appropriate and individualized hydration strategies.

The present study has a number of limitations. We worked with a very small number of soccer players, all male, in two different environmental conditions. Several soccer club managers were reluctant to allow their players to take part in our study. Even though sweat collection is a non-invasive procedure, these managers didn't really understand the value of sweat analysis. This susceptibility is linked to our culture and tradition. These kind of challenges are even more frequent during implementation of protocols involving invasive measures (blood sampling) in our context. Thermoregulatory responses can also vary according to gender. It would have been wiser to include an equal number of players per field position and possibly gender for a better comparative approach. The assessment of hydro-electrolyte losses carried out during a single standardized training session at the end of the sports season, cannot allow for generalizations of results.

AUTHOR CONTRIBUTIONS

Conception and design: PBAN, WRG, ELBL. Acquisition of data: JMN, VNDM, PBAN, SB, CNNG. Analysis and interpretation of data: PBAN, JMN, WRG, ELBL. Drafting the article: PBAN, SB, CNNG. Reviewed submitted version of manuscript: all authors. Statistical analysis: PBAN, JMN, ECBL. Study supervision: AT, BB, SHM, LSEN. All authors read and approved the final version of the manuscript.

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