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Acute effects of a basketball match on urine protein/creatinine ratio in sub-elite women players in a sub-Saharan environment

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**Posthumous*

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Abstract

Renal function is commonly evaluated by estimating glomerular filtration rate and proteinuria testing. A disturbance in the functioning of the kidneys may occur in top-level athletes during training and competition due to the associated high workloads and/or high water loss. This context requires the search for evaluation criteria more specific to athletes. In an effort to assess renal function during acute physical activity, this study evaluated the effects of a basketball match on urine protein/creatinine ratio (PCR_{urine}) of women players in a sub-Saharan environment. An experimental study was conducted with 20 sub-elite female basketball players from the Republic of Benin. Urine proteins (UProt) and creatinine (UCrea), PCR_{urine} and urine specific gravity (USG) were determined before, at the end and 24 hours after an experimental basketball match. Prior to the match, all players had normal values of each studied parameters, except for USG. UProt and UCrea increased by 64% ($p = 0.0005$) and 70% ($p = 0.0006$), respectively at the end of the match, but declined by 50% ($p = 0.0001$) and 51.5% ($p = 0.0005$), 24 hours later. The decrease in PCR_{urine} during and 24 hours after the match was not significant ($p > 0.05$). Under the study's conditions, the basketball match induced transient proteinuria assessed by PCR_{urine} in female sub-elite players. This non-invasive method could be used for frequent assessment of renal function in athletes with recourse to the invasive method if there was a strong suspicion of renal damage.

Keywords: Proteinuria, urine protein/creatinine ratio, basketball match, women players, Republic of Benin.

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Introduction

In clinical practice, renal function is usually assessed by estimating glomerular filtration rate (GFR) and urine protein screening (NKF, 2021). Glomerular

filtration rate estimation is the invasive reference method and proteinuria is often associated with it to assess the extent of renal dysfunction (KDIGO, 2021; NKF, 2021). Proteinuria is a higher-than-normal amount of protein in the urine (Haider & Aslam, 2021). According to Haider and Aslam, proteinuria can be an early sign of latent kidney disease if the situation persists, but it can sometimes be observed among healthy people, prone to transient proteinuria.

Urine albumin assay and/or urine albumin/creatinine ratio (ACR) calculation is the non-invasive reference method used to detect proteinuria (KDIGO, 2021). Urine protein and protein/creatinine ratio (PRC_{urine}), can however be determined instead of albumin or ACR, on 24-hour urine or on a urine sample (Isaza, de Seigneux & Martin, 2012; Sumida *et al.*, 2020). PCR_{urine} is an accurate indicator of proteinuria, a reliable marker used in the detection of kidney damage and monitoring the progression of kidney disease, because the higher the ratio, the earlier end-stage renal disease will appear (NKF, 2021). In addition, strenuous physical exercise is one of the most common causes of proteinuria in the general population in addition to diet, hydration and a predisposition to kidney disease (Haider & Aslam, 2021; NFK, 2021).

Research has shown that most urine markers of kidney function such as proteins tend to increase at the end of a strenuous physical exercise (Bongers *et al.*, 2018; Wołyniec *et al*., 2020). The increase in urine proteins, especially in albumin after acute physical exercise, is a well-known phenomenon called post-exercise proteinuria (PEP), whose main risk factors are age, athlete's competition level (beginner or top level), sex, intensity and duration of exercise, posture (standing), heat stress level, altitude, as well as health status (Poortmans, 1984; Shephard, 2016). In most studies on athletes, total proteins and albumin were the main parameters studied with the reported data indicating that the values of these parameters increased significantly at the end of physical exercise and the increase was persistent for six days in 18-100% of the athletes (Poortmans, 1984; Shephard, 2016; Wołyniec *et al.*, 2016). Most of the studies in this area have involved individual sports such as athletics, cycling and swimming, all of which were at a high level of competition (Rojas-Valverde *et al.*, 2020; Wołyniec *et al.*, 2020).

During a 40-min basketball match (FIBA, 2020), actions are brief, lasting less than five seconds, but intense, and performed at an average heart rate greater than 85% of maximum heart rate (HRmax), with a lactatemia of 3 to 11 mmol (Stojanović *et al.*, 2018; Milanović *et al.*, 2020). There are few data available on the acute effects of sport participation on renal function, particularly in sub-elite basketball players who compete in hot and humid environments. The few studies conducted on team sports players such as basketball (Gouthon *et al.*, 2009), football (Vigan *et al.*, 2017) and handball (Tonon *et al.*, 2020), used the invasive method based essentially on estimation of GFR from serum creatinine. Although this approach

could provide more precision, PCR_{urine} may indeed yield information that can enhance the reliability of the results obtained. The use of urine analysis is a non-invasive approach that has received little attention when examining the evolution of renal parameters during exercise in basketball players. Therefore, this study was undertaken to evaluate the effects of a basketball match on the PCR_{urine} in sub-elite level players from the Republic of Benin.

Methodology

Study design and sample

An experimental study was conducted with sub-elite level women players who participated in basketball match. Data were collected before, at the end of the match and after 24 hours of play. The day before the match, each player provided information on her sociodemographic characteristics, personal and family history of cardiovascular and kidney disease, number of years of participation in basketball competition and number of training sessions per week. Two hours before the match, measurements of the players' rectal temperature (Trec) were taken, and 15 minutes before the match, urine samples were collected from each player. After a 15-minute warm-up, an experimental basketball match was played in regulation time of four quarters of 10-minute (FIBA, 2020). Immediately after the match (within 5-min), and then 24 hours later, the same measurements were made, including the collection of urine samples.

Before, during and at the end of the match, the players were allowed to drink tap water *ad libitum*, i.e. without specific instructions on quantity and frequency. The last training session for the players took place 72 hours before the match and the last meal was taken at least four hours prior to the commencement of the game.
The study sample consisted of 20 sub-elite level female basketball players, three of whom participated for several years in the Afrobasket Zone 3 playoffs and the others were involved in the Division 1 National Championship. Only players who held a validated sports license for the 2017 - 2018 sports season were selected. Players on anti-hypertensive, anti-malaria or antidiuretic medicines, or who had a history of any other conditions that could affect normal renal function, were excluded from the study sample. All participants were initially combined, but subsequently randomly assigned to one of two teams (A: n=10; B: n=10) for the experimental match.

Ethical approval

Ethical approval for the study was granted by the ethics committee of the Scientific Sectorial Committee of Science and Technology, Physical and Sports Activities of the University of Abomey-Calavi, Republic of Benin (Ref. no.: 038-17/CSS-STAPS/SG/22/08/17). The study was carried out in accordance with the recommendations of the Helsinki Convention 1964, as amended in 2016 (World

Medical Association, 2016) and all the female players willfully gave signed informed consent to participate in the experiment.

Measurements, urinalyses and calculated parameters

The players' body mass (BM) and height (H) were respectively measured to the nearest 100 g and 0.1 cm with an electronic weight scale EF901 (Xiangshan, China) and a 206 M stadiometer (Seca-Bodymeter, France). For each variable, three successive measurements were taken and the average was recorded. Ambient temperature and relative humidity were measured using a Multifunction Meteostar TH-100 (LCD-Thermo, Germany) at the beginning and during the match. The extreme variations (minimum and maximum) values were noted. Rectal temperature (Trec) was measured with individual electronic thermometers MT 101R (China), cleaned before and after each use, with alcohol-soaked cotton. Normal Trec was between 34.4 and 37.8°C (Sund-Levander *et al.*, 2002). Any Trec value ≥ 40 °C should be suspected as effort hyperthermia and considered abnormal (Chin, 2020). Match data (playtime per player, faults, points scored, etc.) were recorded using FIBA LiveStats v7 software (Genius Sports, United Kingdom). Urine samples were collected- in 30 mL dry tubes and immediately sent to the university's laboratory for analysis by certified technicians. Urine creatinine (UCrea) and protein (UProt) concentrations were respectively determined by the Jaffe method (Jaffé, 1886), involving colorimetric technique, and then by the kinetic and turbidimetric method, using a BS-200 automatic analyzer (Mindray, Switzerland). Normal values of UCrea vary between 20 and 275 mg/dL i.e. 1.768 and 24.31 mmol/L (Mathew, 2021). Urine specific gravity (USG) was measured with a 30PX refractometer (Mettler Teledo, Switzerland). In this study, well-hydrated normal value was USG < 1.010, but any player with USG ≥ 1.020 was considered dehydrated (Casa *et al.*, 2000).

Height and BM measurements were used to calculate the body mass index (BMI) with the formula: BMI = weight (kg)/height^2 (m). Any player with a BMI ≥ 25 or 30 kg/m^2 was categorised as overweight or obese (World Health Organization, 2020). PCR_{urine} was also calculated using the formula: PCR_{urine} (mg/mmol) = (UProt [mg/L] x 8.84/UCrea [mmol/L] x 1000) (Isaza *et al.*, 2012). Normal PCR_{urine} was under 15 mg/mmol (Sakai *et al.*, 2019). In this study, any player with PCR_{urine} ≥ 15 mg/mmol or 150 mg/g, was regarded as having proteinuria (Haider & Aslam, 2021).

Statistical analysis

The data were processed with Statistica Stat Soft Inc. (version 8.0 software) and presented, as mean (m) ± standard deviation (s) for dependent (UProt, UCrea and PCR_{urine}) or independent (USG and BM) and confounding (Trec, playing time and seniority) variables as appropriate or absolute frequencies (fr) followed by the corresponding percentages (%) for the hydric status. The normality of the

distribution of the quantitative variables was verified, using the Kolmogorov-Smirnov test. A one-way analysis of variance (ANOVA) or Friedman's ANOVA, depending on whether the distribution of the variable was normal or not, was performed in each group to test the time of measures effect (before the match, at the end of the match and 24 h after the match). When a significant ANOVA result was found, Tukey's post hoc or Wilcoxon's rank test was used to determine which of the groups was substantially different from each other. The McNemar test compared the frequencies of dehydrated and non-dehydrated players at the different measurement times, using data from the 2 x 2 contingency table (Before the match versus At the end of the match; At the end of the match versus 24 hours after the match and Before the match versus 24 hours after the game). After observing that the mean data of individual playtime, UCrea, UProt and PCR_{urine} for both teams A and B showed no significant difference before, at the end, and even 24 hours after the match, the data from all players were pooled for further analysis. The level of significance for the statistical tests was set at $p \leq 0.05$.

Results

The socio-demographic and anthropometric characteristics of the studied players, five of whom were overweight, are presented in Table 1. They trained on average six hours per week, for at least seven years. None of the players was on antimalarial, antihypertensive or antidiuretic medication that could affect the renal parameters studied.

Table 1: Sociodemographic, anthropometric and sport history of the basketball players (n = 20)

Variable	Mean ± SD
Age (years)	21.65 ± 2.69
Height (cm)	164.95 ± 8.66
Body mass (kg)	64.68 ± 14.80
Body mass index (kg/m²)	23.62 ± 4.43
Seniority in competitive basketball practice (years)	7.00 ± 3.78
Weekly training hourly mass (hours)	2.40 ± 0.59
Rectal temperature (° C)	37.58 ± 0.31

Values in the table are the mean values (m) ± standard deviations (SD); n: study sample.

None of the players had any personal or family history of kidney and/or cardiovascular disease. The basketball match took place outdoors, between 4:00 and 6:00 p.m., at the ambient temperature and relative humidity of 28-31 °C and 69-72%, respectively. There was no significant difference between the average playing time of the players in either team A or B (26.0 ± 4.5 min *versus* 23.0 ± 3.4 min, $p = 0.11$). The average playing time spent by all the players of both teams on the ground during the experimental match was 24.5 ± 4.2 min (20 min - 35 min), corresponding to 61.2% of the regular time. Before the match, USG was abnormal,

i.e. USG > 1.020 in 16 players (80% of the study sample) but, at the end of the game, all the 20 players (100%) were dehydrated (Table 2).

Table 2: Changes in hydric status, induced by a basketball match among sub-elite female players from Benin (n = 20)

Variable		**At the end of the match**		**χ 2 of Mc Nemar**	**P**
		Normo-hydrated	**Dehydrated**		
Before the match	Normo-hydrated	04	00	9.38	0.002
	Dehydrated	16	20		
24 hours after the game					
At the end of the match	Normo-hydrated	00	04	14.06	0.0002
	Dehydrated	20	16		
24 hours after the game					
Before the match	Normo-hydrated	04	04	6.05	0.01
	Dehydrated	16	16		

After 24 hours of recovery, the number had decreased from 20 to 16, i.e. 80% of the study sample.

Before the match (Table 3), the value of Trec (average Trec = 37.5 ± 0.31 °C), UCrea, UProt and PCR_{urine} were normal for all the players.

Table 3: Changes in anthropometric, physiological and biochemical parameters induced by the basketball game in the studied players (n = 20)

Variable	**Before the match**	**At the end of the match**	**24 hours after the match**
Body mass (kg)	64.68 ± 14.80	63.63 ± 14.92 ***	64.80 ± 14.65 †††
Rectal temperature (° C)	37.58 ± 0.31	38.45 ± 0.34 **	37.35 ± 0.23 ††
Urine creatinine (mmol/L)	20.47 ± 12.16	34.83 ± 13.73 **	16.87 ± 8.62 ††
Urine protein (g/L)	2.50 ± 1.19	4.10 ± 1.55 **	2.05 ± 8.87 ††
PCR_{urine} (mg/mmol)	1.24 ± 0.53	1.31 ± 1.08	1.25 ± 0.58
Urine specific gravity	1.024 ± 0.006	1.029 ± 0.004 *	1.022 ± 0.004 ††

Values indicated in the cases are mean values (m) ± standard deviations (s); n: study sample; PCR_{urine}: urine protein/creatinine ratio; *: difference with pre-match value, significant at $p < 0.05$; **: difference with pre-match value, significant at $p < 0.01$: ***: difference with pre-match value, significant at $p < 0.001$; †† : difference between the values at the end of the match and those 24 hours later, significant at $p < 0.01$; ††† : difference between the values at the end of the match and those 24 hours later, significant at $p < 0.001$.

Trec increased to a maximum value of 39°C in a player at the end of the match, without the registration of any case of effort hyperthermia and dropped to 37.8°C (the highest value), 24 hours later. The players had lost an average of 1.7 ± 1.4% ($p < 0.001$) of their BM at the end of the match (Table 3) but between the mean values recorded before the match and those 24 hours after, the differences were not significant ($p = 0.05$).

At the end of the basketball match (Table 3), UCrea and UProt increased respectively by 70% ($p = 0.0006$) and 64% ($p = 0.0005$), while changes in PCR_{urine}

were non-significant ($p > 0.05$), thereby indicating that that there was no case of proteinuria. UCrea and UProt decreased 24 hours later, below the pre-match value, respectively by -51.5% ($P = 0.0005$) and -50% ($p = 0.0001$). The mean values of all parameters recorded before and 24 hours after the match did not show any significant difference ($p > 0.05$).

Discussion

The objective of this study was to examine whether the urine protein/creatinine ratio can be used to assess renal function during a basketball match in sub-elite women players from the Republic of Benin. As the participants were all motivated to give their best during the match, the results obtained were reliable and valid for the group of players studied. Although the players were instructed to drink *ad libitum*, the amount of water drunk during the match and their diet during the study were not been assessed, thereby constraining the interpretation of the results. The temperature and relative humidity recorded during the match suggest that the players exerted effort under low thermal stress, which probably did not impose additional stress on their renal function during the match.

Our results showed that the players' UCrea and UProt increased at the end of the match, but decreased 24 hours later. The PCR_{urine} ratio varied non-significantly at the different measurement times. Regardless of the parameters measured, the changes observed between pre-match and 24-hour post-match values were also not significant. The number of dehydrated players increased at the end of the match, before returning to pre-match levels after 24 hours of recovery.

A high percentage of dehydrated players was observed before, at the end and 24 hours after the match. This finding is not surprising, as previous studies in the same environment on female basketball (Gouthon *et al.*, 2009) and handball (Tonon *et al.*, 2015) players have reported a similarly high level of dehydration in the groups. These authors attributed the high rate of dehydrated players to the hot and humid environment, as well as the inadequate hydration before, during and after training sessions and matches. Therefore, it is necessary for the players who participated in this study to hydrate well before, during, and after training sessions and matches, in order to reduce the risk of dehydration and heat stroke.

Urine creatinine excretion increased at the end of the match, before decreasing 24 hours later. Dehydration, strenuous exercise, a diet with plenty of meat and proteins, ingestion of creatine, pregnancy, early diabetes, arterial hypertension, obesity, polycystic kidney disease and sickle cell anemia, are the main factors that induce increased creatinine in the urine (Landry & Bazari, 2020). Preliminary investigation of the players revealed that none of them was obese, had consumed any creatine supplements and had a history of any disease that could cause renal

dysfunction. Since UCrea values were normal in all the women before the match, the increase in UCrea excretion observed at the end of the match could be attributed to dehydration and the effects of the physical workload. The physical workload associated with the basketball match might have resulted in increased creatine metabolism and reduced renal blood flow. However, this increase has been transient as it returned to pre-match levels after 24 hours. Similar results were observed after 150 min of competitive effort in professional swimmers (Moreira *et al.*, 2020) and in healthy non-athletic subjects, after various exercise tests (Bongers *et al.*, 2018).

Urine protein excretion also increased at the end of the match, before declining 24 hours later. Benign and transient proteinuria is often caused by hemodynamic and hormonal changes, fever, dehydration, emotional stress, an inflammatory process, as well as intense physical exercise (Shephard *et al.*, 2016; Koçer *et al*., 2018). No case of fever associated with hyperthermia, before or at the end of the match was reported in this study. Since total proteins and urine protein/creatinine ratio were normal before the match, the most likely causes of the increased urine protein excretion observed in players were the dehydration and relatively high physical workload associated with the high intensity actions during the basketball match. Intense physical exercise often induces hemodynamic (reduction in renal blood flow, increased glomerular capillary permeability to proteins and/or partial inhibition of the capacity for tubular reabsorption of plasma proteins) and hormonal (renin-angiotensin system and prostaglandins) changes, which are all factors that may increase renal protein excretion (Poortmans, 1984). Mild dehydration induces renal hyperfiltration caused by increased secretion of vasopressin, which may precipitate multiple adverse effects on the kidneys, including transient proteinuria (Clark *et al.*, 2016). The high percentage of dehydrated players in our study could therefore be explained by the increased excretion of proteins.

The present study did not show any significant difference in the players' PCR_{urine} despite increased urine creatinine and protein excretions. The lack of change in this ratio may be attributed to a level of urine protein excretion similar to that of creatininuria, i.e. almost in the same proportions, both at the end of the experimental match and after the 24-hour recovery. It should be noted that UProt excretion did not substantially modify the players' urine protein/creatinine ratio. The intermittent nature of the actions during the basketball match could then be cited as a plausible explanation for the lack of change in the PCR_{urine}, since post-exercise proteinuria is much more associated with moderate or high intensity physical exercise (Poortmans, 1984). This ratio, calculated on a urine sample as it was the case in this study, makes it possible to rule out the hypothesis of the presence of significant or persistent proteinuria. Indeed, the protein/creatinine ratio of a random urine sample provides evidence to rule out or confirm the

presence of persistent proteinuria, as defined by the 24-hour urinary excretion measurement (KDIGO, 2021). In the context of the current study, the non-significant variation in the PCR_{urine} does not provide any new information compared with previous studies on the functioning of the kidneys during a basketball match. A non-invasive method could be used for frequent assessment of renal function in athletes with recourse to the invasive method if there was a strong suspicion of renal damage.

Study limitations

This study had some constraints. First, the participating players were instructed to drink *ad libitum*, but the amount of water drunk during the match, their diet as well as the wetbulb globe temperature (WBGT) during the study were not assessed, thus making interpretation of the results somewhat difficult. Second, as the players were women, their menstrual status should have been checked to examine the plausible effects of menstrual cycle on urinary proteins. However, this was not feasible as it was beyond the scope of the study.

Conclusions

This study evaluated the effects of a basketball match on urine protein/creatinine ratio to assess renal function in women players. It confirmed the onset of post-exercise proteinuria during a basketball match in a hot and humid environment. The results revealed that the basketball match induced a transient increase in creatininuria, but had little effect on the urine protein/creatinine ratio. It is reassuring to note that the basketball match staged in a hot and humid environment did not greatly and permanently affect the renal function the basketball players. Research carried out in other sports, with men and/or different age categories will be required to assess the relevance of the PCR_{urine} for the assessment of renal function in athletes and to validate the present findings.

Practical implications for Sports Science and Coaching

Excessive training loads, overtraining, incomplete recoveries, poor hydration and/or regular consumption of nonsteroidal anti-inflammatory drugs may cause kidney failure in athletes over time. It is therefore necessary to regularly assess the athlete's kidney function to rule out any underlying problem and/or prevent any kidney damage. $PCR_{urine,}$ a non-invasive method, could be used biannually to assess renal function in athletes with recourse to the invasive method if there was a strong suspicion of renal damage.

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