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Estimate of Glomerular Filtration Rate among Players of A West African Football Team During A Competition

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Abstract

Introduction: A football match could cause transient adverse effects in the players' kidney function. The purpose of this study is to determine the development of glomerular filtration rate among football players during a match and a competition in Benin.

Methods: It was a cross-sectional and descriptive study conducted from November 2015 to May 2016. Participants included black footballer, aged above 17 years, who has been residing in Benin for at least one year, attending regular training sessions and having given his informed consent to participate in the study. During a series of 4 matches, blood sampling was regularly carried out before, just at the end and 24 hours after each match. Glomerular filtration rate (GFR) was estimated by CKD-EPI formula from blood creatinine.

Results: A total of 14 players were included in each match. The participating players were averagely aged 23 ± 2.21 years and had 2 years of experience in first division football. The estimate of the players' medium GFR during the 1st match was 129.35 ± 17.39 ml/min/1.73m² before the beginning, 90.31 ± 17.39 ml/min/1.73m² at the end and 123.96 ± 18.72 ml/min/1.73m² 24 hours later. During a 4-match competition, the GFR declines at the end of each match and rise up again in the next 24 hours.

Conclusion: The glomerular filtration rate declines drastically and transiently during a match of football competition in a hot and humid climate. There is need for players to rehydrate before, during and after each match.

Keywords: Benin, CKD-EPI, Glomerular filtration rate, Football, Hot and humid climate

Introduction

Physical activity is associated with disruptions of the body's homeostasis. These disruptions can cause the development of adaptive responses which, in the long term, are translated into the physical condition. However, the maintenance (and most often the improvement) of the individual's health condition requires that constraints due to the physical activity are perfectly tolerated by the body [1].

The benefits of regular physical activity are reflected through an improvement of the well-being, a reduction in the incidence of cardio-vascular diseases and a longer lifespan [2].

Kidneys allow maintaining their own normal value of the individual's vital signs. They are involved in the elimination of many substances, the control of acids-bases balance and blood pressure regulation [3,4].

Kidneys play multiple and complex roles, however the Glomerular Filtration Rate (GFR) is the best evidence of all these functions [5]. GFR is the quantitative variable which best defines kidney function, and it is a vital parameter in the assessment of renal function [6]. In clinical practice, the glomerular filtration rate is estimated from blood biomarkers of which the most used is the determination of serum creatinine [7].

Physical activity leads to significant changes in the renal hemodynamics and in the urinary excretion of electrolytes and proteins [8,9].

During physical effort, the increase in blood flow to the muscles leads to a decline of the splanchnic and renal perfusion. This decline is directly proportional to the degree and duration

of the effort. During intense exercises, renal blood flow can drop up to 25% of its value at rest [10]. This gradual decline of renal blood flow can cause ischemia in renal function, thus disrupting or slowing their normal function [11]. The decline in Glomerular Filtration Rate (GFR) is one of the most frequent malfunctions observed during and after an intense physical effort [12,13].

Football is a collective sport characterized by long-term efforts with variable intensities interspersed with periods of incomplete recovery, which could cause serious changes in kidney function. Few studies conducted on collective sports practiced by children and adolescents, revealed that football recorded most of the post-effort kidney damage (62% of various kidney damage) [14,15].

In southern Benin, collective sports are practiced, regardless of the sport season. Nevertheless, the exposure to heat and relative humidity can cause dehydration which may worsen GFR. That is why we decided to study the development of GFR among football team players during a competition.

General Objective

To study the development of estimated Glomerular Filtration Rate (eGFR) among football team players during a competition in a sub-equatorial climate of Southern Benin.

Specific Objectives

- Determine the development of eGFR during a match.
- Determine the development of eGFR during a competition among football team players.

Methods

The framework of the study was:

- The stadium of Project Goal FIFA (International Federation of African Football) training center located in Misséréte within AKPRO MISSERETE district, in eastern part of Porto Novo.
- Biomedical analyzes lab of MAHOUNA Polyclinic.

It was a cross-sectional study of experimental and descriptive type conducted from November 2015 to May 2016.

The study population included senior players of a football team in Benin 1st division. They were from OUSSOU SAKA (ASSOS) sports club of Porto-Novo, a team that has been in Benin first division for several years. The consecutive sampling is not probabilistic. We received the approval of the team's managers and the informed consent of the players who agreed to make themselves available to follow all procedures in compliance with the Declaration of Helsinki.

Participants included were black footballer, aged above 17 years, who has been residing in Benin for at least one year, holding a sports license validated for the first division of the ongoing championship, duly registered to compete at different levels and having given his informed consent to participate in the study.

Those excluded in the study were homozygous players with sickle cell anemia SS; vegetarian, hypertensive, diabetic subjects; subjects with impaired kidney function; subjects with a gradually-developing intercurrent condition and subjects undergoing antihypertensive, diuretic, anti-inflammatory therapy or any other therapy which is likely to influence renal parameters.

Any player who does not play at least forty-five (45) minutes of a match was excluded from the study.

The Glomerular Filtration Rate is the dependent variable, and it was estimated on the basis of the equation CKD-EPI (Chronic Kidney Disease Epidemiology). This equation is considered as one of the most valid and reliable formulas because it is more accurate for creatinine clearance values above 60 ml/min/1.73m² (Table 1).

Table 1: CKD-EPI formula [16].

| Africa ns | Serum Creatinine $\mu\text{mol/L}$ (mg/dL) | Formulas |
|-----------|--|---|
| Men | ≤ 80 (≤ 0.9) | $\text{GFR} = 163 \times (\text{Creat}/0.9)^{-0.411} \times (0.993)^{\text{age}}$ |
| | > 80 (> 0.9) | $\text{GFR} = 163 \times (\text{Creat}/0.9)^{-1.209} \times (0.993)^{\text{age}}$ |

The dosage of serum creatinine levels has been carried out through enzymatic method after calibration by reference technique: Isotopic Dilution Mass Spectrometry (IDMS). A standard quality control and pathological control were conducted at the beginning and end of handling. The device used for this dosage is the automated biomedical analyzer "flexor Junior".

The independent variables were:

Socio-demographic characteristics: Age, sex, level of education, occupation, origin and number of years of experience in 1st Division football.

Anthropometric variables: Body mass, height, Body Mass Index (BMI) or Quetelet index which is an individual's body weight divided by the square of his/her height; the Body Surface Area (BSA) is calculated using Boyd formula:

$$\text{BSA} = 0.0001 \times (3,207) \times (P \ 0,7285 - 0,0188 \log P) \times (T \ 0.3)$$

$$P = \text{Weight in g}, T = \text{Height in cm and BSA in m}^2.$$

Clinical data: The internal temperature (IT), blood pressure (BP) and heart rates (HR) at rest and after effort are recorded with an automatic upper arm blood pressure monitor certified by the European Society of Hypertension. Three successive measurements were carried out and the average was selected for the BP. The measurements were recorded before the kick-off of the match while respondents were at rest for at least 15 minutes; they were recorded again at the end of the match and 24h later.

We used a previously designed survey questionnaire including the socio-demographic characteristics, anthropometric, clinical and biological variables. Data collection was carried out by a

team made up of a doctor, a research Master student in the field of science and technology of physical activities and sports, a state registered nurse and a lab technician.

Based on the list of players (number, name and surname) selected by the coach for the match, the different tubes were previously labelled. For the 1st match, we met the players on their lodging site 3h prior to the kick-off of the match. After a brief interview, they were called upon one after the other to be administered the questionnaire. The identity and medical history are then documented. Then we recorded the body mass, height, the internal temperature, blood pressure (BP) and heart rate (HR) at rest. After this step, 4mL of venous blood were taken from the back of the hand or from the bend of the elbow in a dry tube. A compression and a dressing of the puncture site were made and the player was thanked for participating. All players selected for this match were attended to equally. Two people were in charge of filling the forms and measuring the different vital signs while the other two took care of blood samples.

At the end of the match, the different vital signs (BP, HR, internal temperature) were recorded once again. The tubes were labelled with the names and numbers of those who actually played for at least 45 minutes. Another 4mL of venous blood sample was taken from these latter. Pre and post-match blood samples were stored in a cooler equipped with accumulators. They were immediately sent to MAHOUNA Polyclinic lab and processed the same day.

The following day i.e. 24h after the match, we met the players to record their vital signs and the same blood samplings were carried out.

In the 2nd, 3rd and 4th matches, we used the same procedure for data collection except for the identity and medical history which were already recorded during the 1st match.

During the study period, the ambient temperature varied between 36°C and 31°C at the beginning and 28°C to 30°C at the end of the matches. Relative humidity varied between 80 to 68% at the beginning and 63 to 70% at the end of the matches.

Data entry was carried out using Epi-DATA 3.1. For all the processing, the significance level of statistical tests was set at $p < 0.05$ and confidence interval at 95%.

Results

Globally, fifteen (15) players met our inclusion criteria. Later on, one (01) of them refused the blood sampling, so our sample size was reduced to fourteen (14) players.

General characteristics of the sample

Socio-demographic characteristics: The players' average age was 23.14 ± 2.21 years with extreme values of 20 and 28 years. The most represented age range was 23 to 26 years. All respondents were educated, and 10 out of 14 had a university education level. Most of the players were students but all were professional footballers. Half (7 out of 14) or 50% of the total number of these players lived in urban area. Over half or 57.14%

(8 out of 14) of the players had less than 2 years of professional football experience in Benin 1st division. The rest of the general characteristics is outlined in table 2.

Table 2. Socio-demographic characteristics of the sample 4.1.2- Anthropometric characteristics of football players.

| | | Total (N=14) | Rate (%) |
|--|-------------------------|--------------|----------|
| Age | | | |
| | [20; 23] | 6 | 42.9 |
| | [23; 26] | 7 | 50.0 |
| | [26; 28] | 1 | 7.1 |
| Level of education | | | |
| | Secondary education | 4 | 28.6 |
| | University education | 10 | 71.4 |
| Profession | | | |
| | Artisan | 1 | 7.1 |
| | Cook | 1 | 7.1 |
| | Pupil | 2 | 14.3 |
| | Student | 10 | 71.4 |
| | Professional footballer | 14 | 100 |
| Place of origin | | | |
| | Urban areas | 7 | 50.0 |
| | Suburban areas | 7 | 50.0 |
| Experience in 1st division football | | | |
| | < 2 years | 8 | 57.2 |
| | 2 - 5 Years | 4 | 28.6 |
| | 5 - 10 years | 1 | 7.1 |
| | ≥ 10 years | 1 | 7.1 |

The medium body weight was 66.14 ± 7.33 kg, medium height was 1.73 ± 0.05 m and medium body mass index was 22.12 ± 1.57 kg/m² (Table 3).

Table 3. Anthropometric characteristics of the players. BM=Body Mass; BMI=Body Mass Index; BSA=Body Surface Area.

| | Medium | Standard deviation |
|--------------------------|--------|--------------------|
| BM (kg) | 66.14 | 7.33 |
| Height (m) | 1.73 | 0.05 |
| BMI (kg/m ²) | 22.12 | 1.57 |
| BSA (m ²) | 1.08 | 0.01 |

Clinical data of the players: The players' medium internal temperature did not vary significantly between the beginning and the end of a match. Except for the first match, the medium systolic and diastolic blood pressure slightly declined from the beginning to the end of the match. The players' heart rate

slightly increased from the beginning to the end of the match. Table 4 highlights the different variations of these clinical data.

Table 4. Distribution of players according to clinical data during the competition. IT=Internal Temperature; SBP=Systolic Blood Pressure; DBP=Diastolic Blood Pressure; HR=Heart Rate.

| | IT (°C) | SBP (mmHg) | DBP (mmHg) | HR (beats/min) |
|------------------|--------------|----------------|---------------|----------------|
| 1st Match (n=14) | | | | |
| Pre-match | 36 ± 0.5 | 126.14 ± 14.82 | 75.71 ± 9.20 | 71.71 ± 10.18 |
| Post-match | 36.5 ± 0.52 | 127.14 ± 9.24 | 78.64 ± 5.93 | 94.71 ± 6.96 |
| 2nd match (n=14) | | | | |
| Pre-match | 36.5 ± 0.52 | 127.79 ± 11.74 | 75 ± 8.39 | 68.64 ± 12.24 |
| Post-match | 36.5 ± 0.52 | 121.14 ± 10.20 | 73.14 ± 9.17 | 95 ± 10.55 |
| 3rd match (n=14) | | | | |
| Pre-match | 36 ± 0.5 | 131.14 ± 16.64 | 76.79 ± 0.87 | 62.86 ± 11.03 |
| Post-match | 36.29 ± 0.47 | 117.07 ± 9.21 | 73 ± 11.93 | 99.35 ± 8.02 |
| 4th match (n=14) | | | | |
| Pre-match | 36.14 ± 0.36 | 132.64 ± 7.52 | 79 ± 13.60 | 70.35 ± 11.99 |
| Post-match | 36.21 ± 0.43 | 120.57 ± 11.13 | 70.29 ± 13.63 | 101.93 ± 5.78 |

Development of the players eGFR during the 1st match

During the 1st match, the players medium eGFR value declined drastically from 129.35 mL/min/1.73m² before the match to 90.31 mL/min/1.73m² at the end of the match representing a significant decline of 30.18% with p<0.001. It rises back to 123.96 mL/min/1.73m² 24 hours after the match. The development of the estimated GFR is shown in Table 5.

Development of eGFR during a Competition

The data of the first match are shown above. During the 2nd match, the players medium eGFR value declined drastically from 128.19 mL/min/1.73m² before the match to 85.17 mL/min/1.73m² at the end of the match representing a significant decline of 33.55% with p<0.001. It rises back to 127.88 mL/min/1.73m² 24 hours after the match.

During the 3rd match the players medium eGFR value declined drastically from 116,13mL/min/1.73m² before the match to 89.78 mL/min/1.73m² at the end of the match representing a significant decline of 22.69% with p<0.001. It rises back to 127.61 mL/min/1.73m² 24 hours after the match.

During the 4th match, the players medium eGFR value declined drastically from 133 mL/min/1.73m² before the match to 100.42 mL/min/1.73m² at the end of the match representing a significant decline of 24.94% with p<0.001. It rises back to 129.61 mL/min/1.73m² 24 hours after the match.

During the competition (set of four matches) the eGFR declined drastically at the end of matches and rises back 24 hours after matches to nearly reach pre-match value (Figure 1).

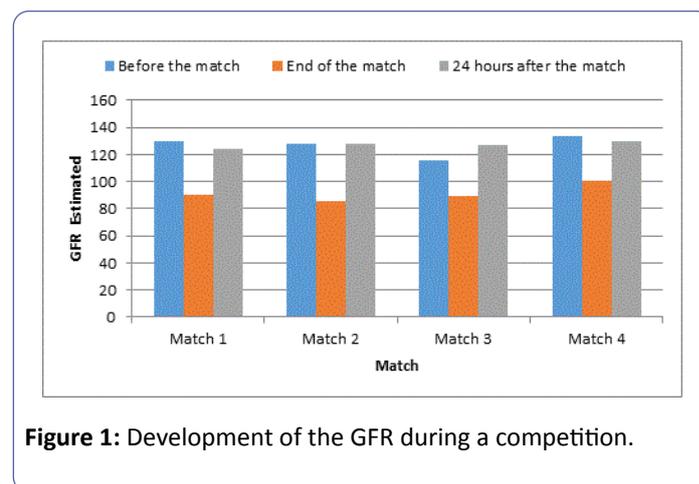


Figure 1: Development of the GFR during a competition.

Discussion

The purpose of this study is to identify renal function disruptions in southern Benin climatic environment among 1st division football players.

Intense physical exercises induce a decline in renal hemodynamic in relation with greater burdens on active muscle tissue and the skin [17].

At the end of the matches, the drastic eGFR decline varied between 22.69% and 33.55%. A similar observation was made by Gouthon and al in 2009, on female basketball players in sub-Saharan Africa, where at the end of the match, the eGFR declined drastically in the winning team (-27.32%, p=0.046) and the losing team (-35.45%, p=0.020) [18]. Similarly, a decline of 19% (p=0.017) of the eGFR was observed at the end of a series of two matches among female handball players in Benin 1st division in 2012, in the same environment as in this study [19]. In Italy, in 2011, Tian and al also recorded among adolescent semi-marathon runners a decline of GFR values estimated by MDRD formula ranging from 101.2 ± 10.0 mL/min/1.73m² at the beginning of the race to 78.0 ± 11.1 mL/min/1.73m² 2 hours later and 77.6 ± 12.7 mL/min/1.73m² after 4 hours race. Therefore, there was a 20% decline in the eGFR [20].

The football played in the climate of southern Benin certainly creates kidney function disruption due to the substantial eGFR decline. The eGFR decline at the end of matches is the consequence of kidney blood flow decline to the benefit of active muscles, as a result of cardiac output redistribution [2,13].

Table 5. Development of the players eGFR during the 1st match.

| Players | Beginning match | | End match | | 24 hours after the match | |
|--------------------|--------------------------|-----------------------------------|--------------------------|-----------------------------------|--------------------------|-----------------------------------|
| | Serum creatinine (mg/dl) | eGFR (ml/min/1.73m ²) | Serum creatinine (mg/dl) | eGFR (ml/min/1.73m ²) | Serum creatinine (mg/dl) | eGFR (ml/min/1.73m ²) |
| 1 | 0.73 | 145.93 | 1.19 | 95.52 | 0.84 | 137.68 |
| 2 | 0.76 | 149.95 | 1.28 | 91.66 | 0.76 | 149.87 |
| 3 | 0.95 | 131.74 | 1.25 | 94.36 | 0.98 | 126.42 |
| 4 | 1.20 | 96.67 | 1.58 | 69.09 | 1.07 | 110.81 |
| 5 | 1.02 | 121.31 | 1.65 | 68.21 | 1.14 | 106.65 |
| 6 | 0.75 | 149.80 | 1.17 | 100.99 | 0.75 | 149.88 |
| 7 | 0.89 | 137.44 | 1.32 | 86.06 | 1.01 | 118.95 |
| 8 | 0.83 | 142.58 | 1.06 | 112.74 | 0.83 | 142.58 |
| 9 | 1.00 | 122.96 | 1.26 | 92.80 | 1.26 | 92.89 |
| 10 | 1.15 | 102.82 | 1.28 | 90.30 | 1.15 | 102.82 |
| 11 | 0.86 | 141.16 | 1.18 | 99.65 | 0.89 | 139.32 |
| 12 | 1.13 | 107.34 | 1.29 | 91.83 | 1.13 | 107.34 |
| 13 | 0.97 | 125.06 | 1.70 | 63.61 | 1.05 | 114.02 |
| 14 | 0.92 | 136.18 | 1.12 | 107.56 | 0.92 | 136.18 |
| Average | 0.94 | 129.35 | 1.31 | 90.31 | 0.98 | 123.96 |
| standard deviation | 0.15 | 17.39 | 0.19 | 14.48 | 0.16 | 18.72 |

The next day, or 24 hours after matches, the eGFR recorded values rose back to nearly pre-match values. The same observations were made among female Benin handball players as 26h after matches, the eGFR values rose back to nearly pre-match values [19]. In the 24 hours following the end of the basketball match, the eGFR increased progressively up to a significantly higher value than the one recorded at rest in the winning team (+11.75%, $p=0.02$) [18]. Therefore, the kidney disruption created by football disappears 24 hours after matches. This observation is consistent with observations made by several authors [2,13,20] confirming that: kidney function disruption induced by physical effort is transient and disappears within few hours after the end of the effort, or 24h later [20]. These results reflect a transient kidney burden in relation with the dehydration which is inadequately compensated by the players during matches [21,22]. Scientists are much concerned with football players' hydration conditions. Barbosa reported in 2012 that an official football match significantly impairs players' hydration and this is correlated with the time spent in the match [23]. Similarly, Williams showed among young football players that 14 out of 21 were already dehydrated before the beginning of the training. He concluded that there was a wide variation of hydration conditions among these players and suggested adequate hydration during training sessions [24].

Conclusion

During a football match, particularly in a hot and humid environment such as southern Benin, players present a

significant decline in glomerular filtration rate. This decline is transient and repetitive at each match throughout the competition. These results can be explained by inadequate players' hydration during matches.

It is therefore important to persuade players on the need for adequate hydration before, during and after matches during a competition.

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