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Sweat rate and fluid intake in young elite basketball players on the FIBA Europe U20 Championship

Stepen znojenja i unos tečnosti kod mladih elitnih košarkaša na Prvenstvu Evrope FIBA U20

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Abstract

Background/Aim. Previous investigations in many sports indicated that continued exercise, especially in hot environments, can cause high sweat rate and huge water and electrolyte losses, thus impairing the performance of athletes. Most these studies were conducted during training sessions, but rarely during an official competition. Therefore, the aim of our study was to determine pre- and post-competition hydration, fluid intake and sweat loss of young elite basketball players during the FIBA Europe U20 Championship. **Methods.** The study included 96 basketball male players, (19 ± 0.79 years) of eight national teams. Ambient temperature was 30 ± 2ºC, humidity 55 ± 4% and the mean playing time in game 18.8 ± 10.5 min. The following parameters related to hydration status were measured: fluid intake, urine output, sweat rate, percent of dehydration, urine parameters (specific gravity, color and osmolarity), body mass and body surface area. **Results.** We found that the mean fluid intake was 1.79 ± 0.8 L/h, sweat rate 2.7 ± 0.9 L/h, urine output 55 ± 61 mL and the percentage of dehydration 0.99 ± 0.7%. According to urine osmolarity more than 75% of players were dehydrated before the game and the process continued during the game. The difference in body mass (0.9 ± 0.7 kg) before and after the game was statistically significant. There were statistically significant correlations between the sweat rate and fluid intake, urine osmolarity, body mass loss, body surface area and percentage of dehydration. Fluid intake correlated with the percentage of dehydration, body mass loss, urine specific gravity and urine color. The sweat rate, which varied between the teams, was the highest for centers when this parameter was calculated on the effective time in game. **Conclusion.** Most of the athletes start competition dehydrated, fail to compensate sweat loss during the game and continue to be dehydrated, regardless what kind of drink was used. These results suggest that hydration strategies must be carefully taken into account, not only by the players, but also by the coaches and the team doctors.

Key words:
basketball; water-electrolyte balance; sweating; dehydration; europe.

Apstrakt

Uvod/Cilj. Prethodna istraživanja u mnogim sportovima ukazuju da kontinuirano vežbanje, posebno pri visokim temperaturama, može da prouzrokuje obilan stepen znojenja i gubitak vode i elektrolita, smanjujući na taj način sportsku sposobnost. Mnoge od ovih studija sprovedene su u toku treninga, ali retko za vreme nekog zvaničnog takmičenja. Cilj ove studije bio je da se odredi stepen hidracije pre i posle utakmice, unos tečnosti i gubitak tečnosti putem znojenja kod mladih košarkaša tokom šampionata Evrope za mlađe od 20 godina. **Metode.** Studija je sprovedena na 96 košarkaša, starosti 19 ± 0,79 iz osam nacionalnih timova. Ambijetalna temeratura iznosila je 30 ± 2ºC, vlažnost 55 ± 4%, a prosečno aktivno vreme u utakmici 18,8 ± 10,5 minuta. Praćeni su sledeći parametri hidracije: količina popijene tečnosti, količina izlučenog urina, stepen znojenja, procenat dehidracije, parametri urina (specifična težina, boja i osmolarnost), telesna masa i površina tela. **Rezultati.** Našli smo da je prosečni unos tečnosti iznosio 1,79 ± 0,8 L/h, stepen znojenja 2,7 ± 0,9 L/h, količina izlučene tečnosti 55 ± 61 mL, a procenat dehidracije 0,99 ± 0,7%. Na osnovu osmolarnosti urina, više od 70% igrača bilo je dehidrirano pre utakmice i taj proces se nastavio u toku utakmice. Razlika u telesnoj masi (0,9 ± 0,7 kg) pre i posle utakmice bila je statistički značajna. Postojale su statistički značajne korelacije između stepena znojenja i količine unete tečnosti, osmolarnosti urina, gubitka telesne mase, površine tela i stepena dehidracije. Količina unete tečnosti korelisala je sa stepenom dehidracije, gubitkom telesne mase, specifičnom težinom urina i bojom urina. Stepen znojenja, koji se razlikovao između timova, bio je najviši kod centara kada je izračunovan u odnosu na efektivno vreme u toku igre. **Zaključak.** Većina košarkaša započinje takmičenje dehidrirana, ne uspeva da kompenzuje gubitak znoja u toku utakmice i nastavlja da bude dehidrirana bez obzira na vrstu unete tečnosti. Ovi rezultati ukazuju da strategija hidracije mora biti pažljivo razmatrana, ne samo od strane igrača već i od trenera i timskih lekara.

Ključne reči:
košarka; voda-elektroliti, balans; znojenje; dehidracija; evropa.

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Introduction

Sweat rate can be influenced by few factors such as environmental conditions, choice of clothing and exercise intensity and also can be significantly different between individuals. Exercise can stimulate high sweat rates and large water and electrolyte losses during continued exercise, particularly in warm-hot weather [1].

Individual characteristics, such as body weight, genetic predisposition, heat acclimatization state, level of aerobic fitness, hydration status and metabolic efficiency may influence sweat rates for a certain activity [2–5]. Heat acclimatization enhances an individual to reach higher and more sustained sweating rates. Also, aerobic exercise training has a moderate effect on enhancing sweating rate responses [2].

Continuous intensive or strenuous exercise in a hot environment presents a bigger challenge to the body's homoeostatic mechanisms than any other factor. The volume of consumed fluids should be greater than the volume of sweat lost in order to make provision for the ongoing obligatory urine losses [6]. In team sports, a number of factors such as awareness about the loss of fluid, fluid availability, the ability to intake the liquid, palatability liquid, gastrointestinal comfort, awareness of the hypohydration problems, fear of weight gain, fear of urge to urinate, affects the internal mechanisms that regulate fluid intake [7].

In its position stand, the American College of Sports Medicine (ACSM) recognized that consumption of beverages containing electrolytes and carbohydrates can help to sustain fluid electrolyte balance and exercise performance. Rehydration beverage should contain certain level of sodium (at least 10–20 mmol/L), potassium and, also, certain amount of carbohydrates (30–60 g/L) [8]. The water alone is sufficient for rehydration when food contains a sufficient amount of electrolyte which is lost through sweat [6].

Specific individual recommendations for fluid intakes should be calculated based on sweat rates, sport dynamics, and individual tolerance. Casa et al. [9] suggested a general rehydration protocol for basketball players: 200 mL at quarter breaks, 400 mL at half time and 100 mL at one timeout/half.

Tournament conditions in many team sports involve a daily schedule of matches played over a specified time culminating in grand finale. Failure to replace sweat losses during and between matches could lead to the situation of chronic or progressive hypohydration at the same time when optimal performance becomes more critical [7].

Up to now, most studies focused on the problems of dehydration in sport games have been performed during a training period, but rarely during an official competition. Therefore, our study was designed to investigate pre and post-competition hydration, fluid intake and sweat loss of young elite basketball players during the FIBA Europe U20 Championship. All these results should help to optimize and encourage fluid replacement for athletes during tournaments and to provide teams with feedback about their fluid intake habits.

Methods

Subjects

A total of 96 basketball players, the members of 8 national teams were assessed during the official FIBA Europe U20 Championship. The players were informed in writing about the aims of this study and the procedures performed during the project. Each of them signed consent for participation in the study.

Measurements

We measured weight and body composition of all the players pre-game and post-game by a Tanita, Body Composition Analyzer BC-418MA. Their anthropometric characteristics are given in Table 1. During the pre-game measurements the participants were dressed in minimal clothing. For the post-game measurements all of them had identical dry clothes. After the pre-game weight players were given labeled bottles containing fluid and instructed to drink until the post-game weighting, in order to calculate total water consumed. Players were advised to continue with the normal routine of fluid intake and to drink only from their bottles. Before the match, we measured the empty bottles and bottles full of liquid. In addition, during the game, the bottles before filling of liquid and after refueling were measured. Only after the measurement basketball players were returned bottles to continue with drinking. In half time, sterile urine vessels were provided in every toilet in the dressing rooms in order to measure the volume of urine. Three mornings urine samples were collected from each player as well as an urine sample after the game.

Full statistic data on each game was provided by official organizer. Temperature and humidity were measured with a UPM wireless weather station (model: ws290c), BIOS Weather™, (model: 312BC-RX).

Table 1

Anthropometric characteristics of the basketball players (n = 96) involved in the study

Parameters	$\bar{x} \pm SD$	Range
Age (years)	19 ± 0.79	16–20
Weight (kg)	90.6 ± 12.4	62–144
Height (cm)	196.3 ± 8.18	177–214
Body mass index (kg/m^2)	23.3 ± 2.56	10.9–34.4
Body surface area (m^2)	2.27 ± 0.19	1.91–2.83
Body fat (%)	9.4 ± 3.8	3–27
Muscle mass (kg)	81.8 ± 9.53	57–110

Hydration status was evaluated by the following parameters: urine specific gravity (USG) for which we used reagent strips (Combur 10 Test, Roche) and a refractometer (Atago Pal – 10s). Cut off value was 1.02 [10]; urine color (UC) by using a scale of eight colors (10) (cut off value was 4[10]); urine osmolality (UO) with a laboratory osmometer – UriSedilabUMAT, cut off value was 700 mOsm[8]). Sweat rate (SwR) was calculated using the change in mass adjusted for fluid intake and urine production: SwR = (pre-exercise body weight – post-exercise body weight + fluid intake – urine volume)/exercise time in hours percentage of dehydration (DEH) during the practice was estimated as the net body mass loss (kg) during the practice divided by the pre-practice body mass: we also measured % DEH = (body mass loss/pre exercise body mass) × 100, fluid intake (FI) and urine output (UO).

Statistical analysis

All data were presented as the mean ± SD. Associations between variables were investigated using Pearsons correlation analyses. In order to define statistically significant differences among the groups we used one-way ANOVA test. Statistical significance was accepted at $p < 0.05$.

Results

Hydration status

Hydration status was evaluated before and after the game by USG, UO and UC parameters. The results are presented in Figure 1A. Pre-game evaluation of all the players showed that the mean USG was 1024 ± 0.6, mean UO 883 ± 229 mOsm and mean UC 5.67 ± 1.12. According to cut-off values given in the methods, 80%, 75%, and 95% of studied subjects, respectively, were hypohydrated before the game. When these urine parameters were evaluated after the game, dehydration increased further based on increased USG (1026 ± 6) and UC (5.97 ± 1.37) but not UO (852 ± 228 mOsm) and accordingly the percentages of dehydrated players increased to 85% and 95%, respectively. However, statistical analysis did not confirm that these pre-post differences in any of the examined parameters were statistically significant.

When hydration status was analyzed depending on the team, it can be seen (Figure 1B) that all the hydration parameters of the team 6 were statistically significantly lower compared to other teams, indicated that the players of this team had lowest dehydration.

Other parameters associated with hydration including significantly body mass loss (0.9 ± 0.7 kg), percentage of dehydration (0.99 ± 0.7%) and urine output (55 ± 61 mL) are shown in Table 2.

Sweat rate

The mean sweat rate (Table 2) was 2.7 ± 0.9 L/h (range 0.23 L/h – 5.54 L/h). Figure 2 illustrates the distribution of sweat rate among players based on an arbitrary division. The highest percentages of players had sweat rate between 2 L/h and 3 L/h. There was no statistically significant difference in the sweat rate between various positions of players in the team during the complete period of game (Figure 3A). How-

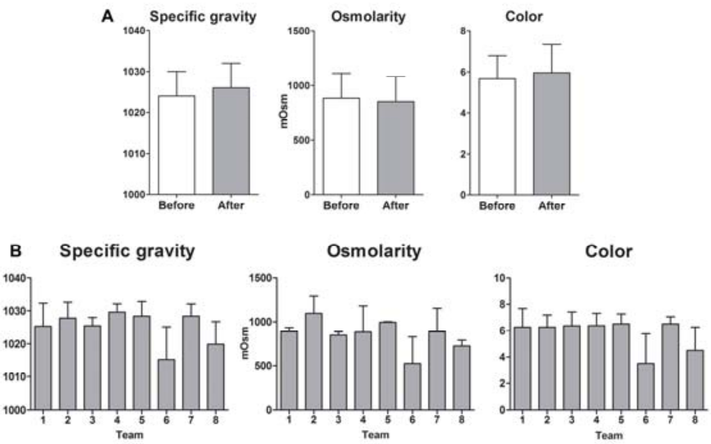

Fig. 1 – Urine parameters related to young elite basketball players before and after the game for all participants (A) and *per* teams (B).

Table 2

Parameters related to hydration assessment

Parameters	x̄ ± SD	Range
Body mass loss (kg)	0.9 ± 0.7	-1.0–2.9
Percentage of dehydration (%)	0.99 ± 0.7	-1.25–2.95
Total fluid intake (L)	1.87 ± 0.82	0.38–3.98
Fluid intake (L/h)	1.79 ± 0.8	0.4–19
Sweat rate (L/h)	2.7 ± 0.9	0.23–5.54
Urine output (mL)	55 ± 61	0–240
Temperature (°C)	30 ± 2°C	27.2–32.5
Relative humidity (%)	55 ± 4	48–58
Playing time in game (min)	18.8 ± 10.5	0.15–40

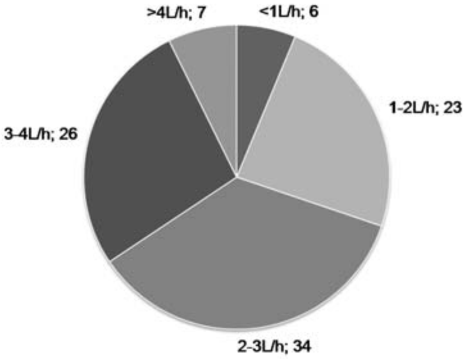

Fig. 2 – Distribution of sweat rate (L/h) among players (n = 96) based on arbitrary division.

ever, when sweat rate was analyzed by the team position in a playing time, it can be seen (Figure 3B) that the highest sweat rate was for center and the lowest for point guard and the difference was statistically significant.

Fluid intake

The mean total fluid intake was 1.87 ± 0.82 L and relative fluid intake 1.79 ± 0.8 L/h (Table 2). Total fluid intake and its composition in team is presented in Table 3. Figure 4 ilustrates the distribution of players depending on the quantitiy of drank fluid and shows that the largest percentages of players were in the group between 1 and 2 L/h of intaken fluid. No significant difference was seen in the quantitiy of drank fluid depending on the team position of the players (data not shown).

Correlations

The statistically significant correlations between sweat rate and: fluid intake ($p = 0.001$) are shown in (Figure 5), UO ($p = 0.001$), body mass loss ($p = 0.001$), (body surface areal-BSA) ($p = 0.001$) and percentage of dehydration ($p = 0.001$) were found.

The statistically significant correlations between fluid intake and: percentage of dehydration ($p = 0.001$), body mass loss ($p = 0.000$), USG ($p = 0.035$) and UC ($p = 0.004$) were

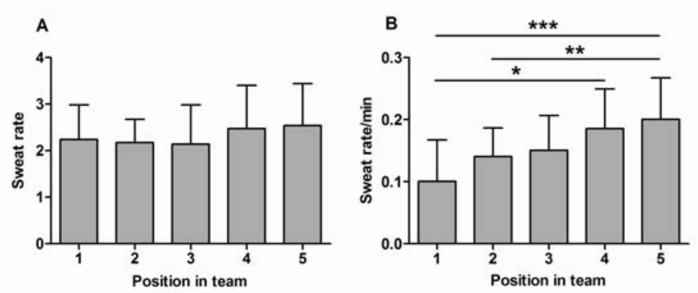

Fig. 3 – A) Sweat rate, and B) relative sweat rate/min depending on the position in team.
1. Point guard; 2. Shooting guard; 3. Small forward; 4. Power forward; 5. Center.

Table 3
Composition of beverages that players drink during the game

Team	Total fluid intake (L)	Water (L)	Isotonic drink (L)
1	1.55	1.55	0
2	1.35	1.35	0
3	1.52	1.15	0.37
4	1.19	0	1.19
5	2.44	1.66	0.77
6	2.11	1.18	0.93
7	2.07	2.06	0
8	1.96	0.85	1.11

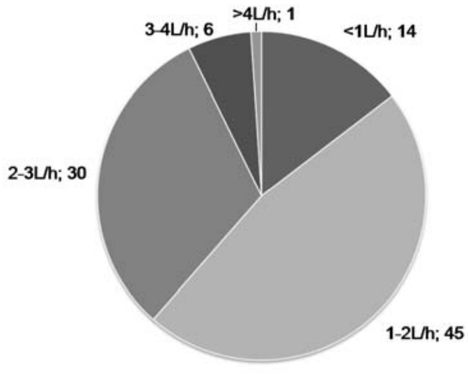

Fig. 4 – Distribution of fluid intake (L/h) among the players (n = 96) based on arbitrary division.

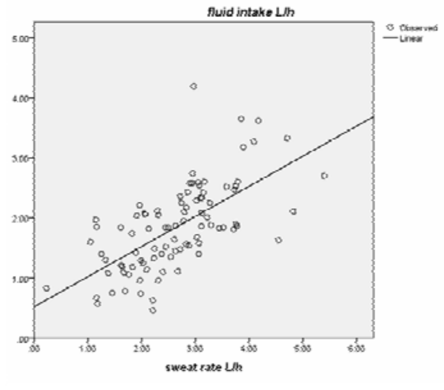

Fig. 5 – Correlation between fluid intake and sweat rate of young elite basketball players during the game.

obtained. No statistically signficant correlations between sweat rate and USG and between fluid intake and BSA in m^2 and UO were found.

Discussion

Basketball is a sport defined by bursts of high-intensity activity with intermittent rest periods and coupled with the large body sizes. This type of stop-and-go action is associated with heavy sweat losses and dehydration [11, 12]. Tournament could involve even the greater risk of dehydration since players may have difficulty to obtain fully rehydration between and after games. One study suggests that approximately 50% of individual and team-sport athletes are hypohydrated at the start of competition [13]. In our study 75–95% of all the basketball players were hypohydrated on the beginning of the competition and after the games, depending on the used urine parameters for evaluation of hydration status [8, 10]. Thus, one of the main feedbacks to the teams was that dehydration during competition is very high and because of that they should take care about their fluid intake habits.

Having in mind that basketball is playing in sport halls, under possible high, both, temperature and humidity, potential dehydration should be taken seriously [7]. During a regular basketball match maximal time of physical activity can be 80 min (warm up period 30 min, effective time in the game 40 min and warm up on the halftime 10 min). The mean playing time in our study was 18.8 minutes, but according to our results the players sweated not only during the time spent in the game but also while sitting on the bench, especially in such a warm environment.

In the sport of basketball, even though players have opportunities to drink during time-outs and when players are substituted, they may still be unable to maintain fluid balance [14]. Most athletes in the present study did not intake enough fluids to match sweat losses during the game and they were significantly dehydrated.

Sweat rates of athletes have been analysed in different studies and sports, and a wide range of results have been recorded. Average sweat rates from the scientific literature in athletes can vary from 0.5 L/h to more than 2.5 L/h[9]. The high sweat rate of 2.7 ± 0.9 L/h in our study could be caused by several reasons: high temperature of 30°C in sport hall, duration of competition (two weeks), day-to-day games and high exercise intensity.

The sweat rate in our study (2.7 ± 0.9 L/h) was higher than in a study of Broad et al. [15]. They studied the competition with a group of basketball players of similar ages to participants in our study. The sweat rate was 1.6 ± 0.37 L/h and fluid intake 1.08 ± 0.64 L/h. This study was conducted in summer conditions at the temperature of 23ºC and the humidity of 41%. A big difference between our and that study was temperature and humidity in sport hall where the games were played (in our study 30 ± 2°C, 55 ± 4%).

The sweat rate in our study was also close to the study of Bergeron et al. [5]. In that study sweat rates between 1.7 L/h and 2.4 L/h were recorded for single three set tennis matches in warm conditions (31.9 ± 0.5°C, RH 55 ± 0.2%).

In a report of Maughan et al. [16], during a training session, the sweat rate in 24 premiership soccer players, at 24–29°C was 1.35 ± 0.275 L/h. Shirreffs et al. [1] analysed 26 soccer players using the same methodology with the same duration of training session, but in much warmer conditions (32°C), and found out a mean sweat rate of 1.46 L/h, with a range from 1.12 to 2.09 L/h. Our results showed a higher sweat rate, compared to the previous studies. The main reason for that could be the fact that our study was conducted during competitions on tournament, not on trainings.

We found that centers had the biggest sweat rate when this parameter was calculated per min of the effective game. Similar results were obtained when we analysed sweat rate *per* BSAm^2. The highest sweat rate for a center could be explained with a high BSAm^2 and a bigger number of sweat glands, and therefore higher rates of sweating compared with smaller BSA athletes [17].

A total fluid intake of players in our study was 1.87 ± 0.82 L, which was not sufficient to compensate sweat losses. Despite of insufficient rehydration, mean percentage of dehydration was only 0.9%. During the competition fluid intake of our participants included sport drinks as well as water. There are few studies on fluid intake and sweat rate of basketball players on competition. Much more of them investigate those parameters during training sessions.

Our study found a statistically significant positive correlation between sweat rate and fluid intake. Such a correlation was previously identified by Palmer and Spriet [12]. and Silva et al. [18]. Different studies show that athletes are better hydrated when taking more sports drinks than water [19, 20]. In our study, out of 8 teams, only one used sport drink, 3 used water and 4 used a mix of water and sport drinks. There was a statistically significant difference for all the three urine parameters between the team 6 compared to other teams. The difference could be explained by the fact that the team 6 took a proper balance of water and sport drink during the game.

The fluid intake of young basketball players in our study was higher than in studies of Australian Institute of Sport during competition in summer season (23°C) in which fluid intakes were from 0.465 to 1.69 L [21] and in the studie of Broad et al. [15] who reported fluid intake 1.079 ± 0,615 L/h in male basketball players during practices and competitions. The fluid intake we found was also higher than in a study of Osterberg et al. [22] (1.0 ± 0.6 L) and Palmer and Spriet [12] (1.0 ± 0.1 L/h). One of the reasons for that could be the temperature in the venue and the level of competition.

Conclusion

Most of the athletes start competition dehydrated, fail to match sweat losses during the game and continue to be dehydrated. Quantity of water given to the teams is not adequate, having in mind the sweat rate and hydration status of the players. These fact must be considered seriously, not only by players, but also by the coaches and the team doctors. A hydration strategy, involving proper fluid and electrolyte replacement should be planned on an individual base and monitored carefully during practice or competition.

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