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HYDRATION STATUS AND SWEATING RESPONSES OF BOYS PLAYING SOCCER AND FUTSAL

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Abstract

Introduction: Boys usually practice soccer (SC) and futsal (FS) for long and successive sessions and may become dehydrated.

Objective: To examine hydration status and sweating of prepubertal (PP) and pubertal (P) boys during SC and FS training.

Methods: Before and after training, 21 soccer (13PP (SCPP)), 8P (SCP)) and 26 futsal players (14PP (FSPP), 12P (FSP)) voided and body mass was measured. Urine was analysed for color and specific gravity (USG). Training lasted 1 to 1.6 h, and players could drink water as desired every 30-min. Sweat volume was calculated from body mass change corrected by fluid intake and urine output. Patches were attached in the scapula region to collect sweat for analyses of [Na^+].

Results: Urine markers indicated that boys arrived in the training slightly hypohydrated (color=4±1.42 and USG=1.021±0.006). In SC session, sweat volume and water intake (in mL) of the PP (465±287 and 207±192) were lower (*P*=0.024 and 0.033) than those of P (852±399 and 447±259). In FS, sweat volume 503±220 and 627±282mL and water intake (342±118 and 344±194 mL) were similar between PP and P. Individual and mean dehydration levels was not >1%. PP's sweat [Na^+] was 58.7±16.8 and P's, 65.0±24.5 $mmol{\cdot}L^{-1}$, and respective sweat Na^+ losses were 0.52±0.34 and 0.82±0.53 $g{\cdot}h^{-1}$.

Conclusion: Body water deficit was minimal in SC and FS, probably because boys could drink every 30-min break. Hydration opportunities during and following training are important to prevent further fluid deficits, especially when SC and FS players have successive training/competition sessions in the heat.

Key words: *hydration status, sweating, children exercise, sports*

Introduction

In Brazil, as well as in many countries, both soccer (SC) and futsal (FS) (indoor football) are very popular sport modalities among boys. These sports are often included in the physical education curricula and are practiced after-school and as recreational activities, regardless of seasonality. A FS match is shorter in duration (40 *vs.* 90 min) and has fewer players (5 *vs.* 11) than soccer, being played inside a gymnasium while soccer is played outdoors. Nevertheless, both sports have an intermittent pattern of effort and the training sessions are alike. The duration and intensity of training can cause considerable sweating in hot environments and lead to dehydration.

The maintenance of body hydration in children and adolescents during training sessions is a concern when they are practiced in the heat. A small degree of 2% of dehydration may impair performance [1] and health [2,3], even in children and adolescents [4,5].

Some studies [6-11] measured water loss and only three [7,8,12] measured electrolyte losses in sweat among children during exercise sessions in the heat. Most of these studies [8,9] were conducted in a laboratory setting, using protocols in which exercise intensity and environment conditions were standardized and well-controlled. Other studies [6,10,11] were performed outdoors, but still with a standardized and controlled exercise protocol. Regarding soccer, some studies [13-16] assessed sweating and hydration during training, but in adult players. With young athletes, there is one study, but the modality was American football [7].

The aim of this study was to examine hydration and sweating responses in prepubertal and pubertal boys in a training session of soccer and futsal during summer days.

Methods

***Participants*:** Twenty-one boys attending soccer (SC) and 26 attending futsal (FS) schools, both prepubertal (SCPP, n = 13 and FSPP, n = 14) and pubertal (SCP, n = 8 and FSP, n = 12), participated in this study. This study was conducted in Porto Alegre, south of Brazil during the summer (December and January). All participants provided verbal consent and one of their parents or guardians signed an informed consent form. The study was approved by the Ethics Committee of the Federal University of Rio Grande do Sul.

***Physical Evaluation Session*:** The boys came to the laboratory for the following evaluation session: health history, self-report maturational stage, anthropometry and peak aerobic test. They did not have any chronic disease or used any medication, as reported in a questionnaire applied in this session. The maturational degree was self-reported according to Tanner's classification [17], in which the PP corresponded to stage I and the P to stages 2-4. Body mass was determined using electronic scales with a precision of 0.05 kg (G-TECH model BALGLA 3C), and height with a wall stadiometer (Seca, 0.01 m). BSA was calculated according to DuBois and DuBois [18] (BSA = 0.20247 x height (m)$^{0.725}$ x body mass (kg)$^{0.425}$). Adiposity was determined by summing the 7 skinfolds (triceps, biceps, subscapula, suprailiac, abdomen, thigh and calf) using an adipometer (Lange, 1 mm). Peak oxygen consumption ($\dot{V}O_2$peak) was evaluated according to McMaster protocol [19] in a cycloergometer (Ergo Fit 167, Spain, 5 W). This protocol consists of a progressive 15-25 W increment every 2 minute depending on the height. Expiratory gases were analyzed by indirect calorimetry in open circuit (*breath by breath*) (Medgraphics model CPX/D), and of the futsal players were measured at every 10 sec (Medgraphics model VO 2000). The boys were instructed to keep the cadence of 60-70 rpm during the test that was interrupted when the boys met one of the following criteria: $\dot{V}O_2$plateau, heart rate (HR) >200 beats·min^{-1} (Polar S610, Polar Electro Oy, Finland, 1 bpm), RPE >19 [20], inability to maintain pace of 60 rpm, exhaustion despite verbal encouragement by researchers.

***Training session*:** This session was held with a 7-10 days interval from the physical evaluation session, according to the boys' training schedule. The environmental conditions and training duration are described by sport modality and maturational group in Table 2.

Evaluations comprised of six days as they were held on three training sessions in both SC and FS groups. Wet bulb globe temperature (WBGT) ranged from 21.7 to 24.1°C in SC, and from 24.6 to 26.8°C in FS. Wet bulb ranged from 20.2 to 23.5°C in SC, and from 21 to 25°C in FS.

Upon arrival at the field or gymnasium for the training, the boys were requested to empty their bladders and then they were weighed (G-TECH, 0.05 kg) wearing only shorts. A sample of urine was separated for urine specific gravity (USG) analysis (euhydration <1.020 and hypohydration ≥ 1.020 [3]) by refractometry (Refractometer Hand-Held, ATAGO 2722-E04) and the color was determined according to Armstrong et al. [21] by a 8-point scale that ranges from very pale yellow (#1) to brownish green (#8).

Each boy had his own individual bottle of water to drink *ad libitum* at each break (every 30-min) during

Table 1. *Boys' Physical Characteristics*

Modality	Tanner	*n*	Age (years)	Weight (kg)	Height (m)	Σ 7 skin folds^{a} (mm)	BSA (m^2)	$\dot{V}O_2$peak (mL·kg^{-1} ·min^{-1})
SCPP	1	8	9.5±1.1	37.4±7.2	1.37±0.4	131±72	1.86±0.10	40±8.5
SCP	2	7	13.1±2.1*	58.0±18*	1.59±0.1*	145±75	1.59±0.29*	45±9.5
FSPP	1	10	9.3±1.2^	34.7±6.4^	1.36±0.7^	104±56	1.14±0.12^	34±9.2
FSP	2	6	11±1.4	41.6±11.7$^+$	1.47±0.9$^+$	122±80	1.29±0.21$^+$	37±986

*P<0.001 between SCPP and SCP; ^+P<0.05 between SCP and FSP; ^P<0.001 between SCP and FSPP. a Triceps, biceps, subscapula, suprailiac, abdomen, thigh and calf). BSA= body surface area.

Table 2. E*nvironmental conditions and duration of each training session of soccer and futsal*

Modality	Training	Air temperature (°C)	% Humidity	Duration (h)		
Soccer	1	27.2±0.86	55.3±3	PP	1.3±0.4	(*n*=7)
				P	1.5±0.1	(*n*=5)
	2	23.1±0.56	85.7±3.1	PP	1±0.1	(*n*=6)
				P	1.2±0.4	(*n*=2)
	3	25.5±2.36	84.7±8.7	P	1.6	(*n*=1)
Futsal	1	28±0.22	69±1.83	PP	1.4±0.2	(*n*=5)
				P	1.3±0.2	(*n*=9)
	2	33	30	PP	1±0.1	(*n*=6)
	3	31	60	PP	1.2	(*n*=3)
				P	1.2	(*n*=3)

PP prepubertal; P pubertal. *n* = number of players. Values are mean ± SD.

the training, as this was the fluid that they used to take during their training sessions. The bottles were weighed (scale OHAUS model CS2000, 1g) before and after the training session in order to determine the total volume ingested.

Patches (Tegaderm + Pad 3M) were placed on the right region of the scapula (on the spine of scapula ~5cm lateral to the vertebrae), as described by Patterson et al. [22]. This site was chosen because it usually does not interfere with the body movements and it is difficult to be touched and contaminated. First, the skin was cleaned with deionized water and then the patches were attached. The patches were removed at the end of the training session and then transferred to a syringe where they were squeezed in order to obtain the sample, which was placed in microtubes. Five sweat samples were missed either because the patches were lost during training or because there was not enough volume for analysis (three in SCPP, one in SCP and two in FSP). At the end of training, the boys were dried with a towel, emptied their bladders and were weighed. A urine sample was separated again for color and USG evaluation.

Percentage dehydration was calculated by the change in body mass. Sweat volume was determined by the difference in body mass before and after the training plus the volume of fluid ingested minus urine output. Sweat volume was expressed per unit of time (in one hour – $mL \cdot h^{-1}$) and corrected by BSA and time in min ($mL \cdot m^{-2} \cdot min^{-1}$). Sodium ($[Na^+]$) and chloride ($[Cl^-]$) concentrations in sweat were analyzed by the electro-selective ion method (AVL 9180 – ROCHE). Na^+ sweat loss was calculated as the product of sweat $[Na^+]$ and volume. It was also corrected by body mass (measured just before the training session) and time, and expressed in $mmol \cdot kg^{-1} \cdot h^{-1}$ and $g \cdot h^{-1}$.

Statistical analysis

The results are expressed as mean ± SD. Analysis of variance (ANOVA) was used to compare physical characteristics, sweating responses (volume, $[Na^+]$ and $[Cl^-]$, and Na^+ loss), water intake and % dehydration between modalities and maturational stage. Tukey post hoc test was used when a difference was found. We used paired *t*-test to compare urine color and USG (before and after training). Analyses were performed using the Statistical Package for the Social Sciences (SPSS - version 13.0), and $P < 0.05$ was considered as statistically significant.

Results

Boys' characteristics by sport modality and maturation are shown in Table 1. Only in soccer the boys differed in weight, height and BSA.

Six boys (1 PP and 5 P) in the soccer and 9 in the futsal (4 PP and 5 P) missed the first *Physical Evaluation Session*; therefore, maturational and anthropometric assessments (except the $\dot{V}O_2$peak) were obtained at the start of the second (training session).

The findings from the training session are shown according to maturational group and sport modality. All the boys were considered as physically active because they trained the respective sport at least twice a week besides the regular practice of physical education classes at school. SC and FS training sessions were similar in both modalities and consisted of warm-up, technical practice with ball in pairs, game, and cooling; except for the duration which tended to higher in the P.

In soccer, the PP showed a lower sweat volume (P=0.024) and water intake (P=0.033) than in the P. Between futsal players, there was no difference in the sweat volume or water intake between PP and P. In both modalities and maturational groups, sweat rate was similar and dehydration was not higher than 1%.

Table 3 shows the volumes of water ingested and sweat amount, sweat rate, and % dehydration.

Table 4 shows the results of sweat $[Na^+]$ and the amount of Na^+ loss which were similar between sport modalities and maturational stages. Overall, the sweat $[Na^+]$ (in $mmol \cdot L^{-1}$) of PP boys was 58.7 ± 16.8 and of P boys was 65.0 ± 24.5, and respective sweat Na^+ loss (in $g \cdot h^{-1}$) was 0.52 ± 0.34 and 0.82 ± 0.53. A lower sweat $[Cl^-]$ was found in FSPP compared to SCP (38.7 ± 11.0 *vs.* 64.1 ± 26.9 $mmol \cdot L^{-1}$, P=0.043).

Urine markers indicated that boys arrived slightly hypohydrated (color = 4 ± 1.42 and USG = 1.021 ± 0.006) to the training session. Pre- and post-training urine color and USG are shown in Table 5. The SCP had a significant increase in urine color (P=0.044) and the FSP in the USG (P=0.001) after the end of the training.

Table 3. *Volumes of water ingestion and sweat, sweat rate and % hydration by modality and maturational group*

Modality	Ingested volume (mL)	Sweat volume (mL)	Sweat rate ($mL \cdot h^{-1}$)	Sweat rate ($mL \cdot m^{-2} \cdot min^{-1}$)	% Dehydration
SCPP	207±192	465±287	392±219	4.90±3.58	0.67±0.78
SCP	447±259*	852±399*	652±340	6.49±3.17	0.71±0.58
FSPP	342±118	503±220$^+$	423±160	5.56±2.42	0.43±0.69
FSP	344±194	627±282	494±237	6.73±2.68	0.54±0.46

Values are mean ± SD. SCPP soccer prepubertal; SCP soccer pubertal; FSPP futsal prepubertal; FSP futsal pubertal. *P<0.05 between prepubertal and pubertal in respective modalities. ^+P<0.05 between FSPP and SCP.

Table 4. *Sodium concentration ([Na^+]) in the sweat and Na^+ losses by sweat*

Modality	[Na^+] $mmol{\cdot}L^{-1}$	Na^+ loss	
		$mmol{\cdot}kg^{-1}{\cdot}h^{-1}$	$g{\cdot}h^{-1}$
SCPP (*n*=10)	58.5±24.5	0.49±0.57	0.44±0.44
SCP (*n*=7)	65.0±32.9	0.69±0.46	0.97±0.78
FSPP (*n*=14)	58.9±9.1	0.71±0.29	0.58±0.24
FSP (*n*=10)	65.1±18.7	0.64±0.15	0.71±0.25

SCPP soccer prepubertal; SCP soccer pubertal; FSPP futsal prepubertal; FSP futsal pubertal. *n* = number of sweat samples considered for scapula site. Values are mean ± SD.

Table 5. *Urine color and urine specific gravity (USG) by modality and maturational stage*

Modality	Pre-coloration	Post-coloration	Pre-USG	Post-USG
SCPP	4.09±0.94	4.18±0.98	1.021±0.001	1.023±0.003
SCP	4.16±1.72	4.33±1.50$^+$	1.021±0.002	1.024±0.007
FSPP	3.78±1.47	4.21±1.18	1.021±0.009	1.022±0.006
FSP	4.33±1.23	4.91±1.08	1.021±0.006	1.025±0.004*

SCPP soccer prepubertal; SCP soccer pubertal; FSPP futsal prepubertal; FSP futsal pubertal. *P<0.05 pre- and post- SCP; ^+P<0.05 pre- and post- FSPP.

Discussion

This study evaluated the sweating and hydration responses in boys during a training session of soccer and futsal, without the intention of interfering with the practice program. This "in field" study gave a more realistic approach although limited some technical aspects such as for sweat collection as some movements made few patches be lost.

This study was conducted in Porto Alegre, south of Brazil, during the summer (December and January). We thus assumed that the boys were acclimatized to the heat. Among the maturational groups and sport modalities, the boys had similar aerobic conditionings according to the $\dot{V}O_2$peak obtained.

Thermal conditions were similar between the boys of a given sport modality. One training session of SC (Table 2) occurred on a day in which the air temperature was not as high (23.1°C), RH was quite elevated (85.7%). The air temperature at the soccer field was relatively lower (23.1-27.2°C) than that in the gymnasium (28-33°C) (Table 2). We believe this was due to the gymnasium structure where heat tended to be retained. Anyway, such thermal conditions did not seem to affect the sweat volume of SC (612 ± 377 mL) and FS (560 ± 253 mL).

In both SC and FC training sessions, a break was given for the boys to drink every 30-min. In the present study, there was no difference between the volumes of water intake indoors and outdoors. The higher volume intake was in the SCP group (447 ± 259 mL), which was somewhat lower than those reported in previous studies [10,11].

Sun exposure may determine the volume of water ingested. Rodriguez Santana et al. [11] compared the voluntary consumption of water while exercising during three hours (four 20-min bouts alternating with 25-min rest) in the shade and under the sun and found lower consumption in the former (~450 mL and 900 mL, respectively). Rivera-Brown et al. [10] reported a water consumption of about 1500 mL, in protocol with the same duration as the previous study, by young athletes exercising outdoors under solar radiation. In these two studies, the volume of water consumed was ~2-4 times greater than that of our study. We believe that the lower water intake of the boys in the present study (~318 $mL{\cdot}h^{-1}$) could be due to no sun exposure and the shorter intermittent efforts of soccer and futsal training, as well the lower duration of training in this study, compare to previous studies (1-1.6 h *vs.* 3 h). Still, the boys of the present study rehydrated properly during their soccer and training sessions when water was available for them to drink as desired during the breaks.

Except for the two PP (one from the FS and one from the SC), all of the boys remained hydrated, with water loss below 1%. Even with no difference between the modalities, the soccer players, who exercised outdoors, lost more body mass than the futsal players did. Nevertheless, this little water deficit did not reach the one of about 1% in the boys studied by Rivera-Brown et al. [10], who cycled in the heat with solar exposure for 3 h, or when pubertal athletes practiced tennis for 2 h outdoors [6], probably because of the time difference, which in this study was 1-1.6 h.

As reported by Meyer et al. [8] and Falk et al. [23], in the present study we also observed a trend of smaller sweat rate in prebubertal (SC 40% and FS 15%) as compared to pubertal boys. The sweat rate was similar in the two training places (indoors vs outdoors). The means in the present study are similar to those found by Rodriguez Santana et al. [11], when he compares active, acclimated boys exercising with sun exposure (500 mL/h) and in the shade (400 mL/h) with voluntary ingestion of water.

In the studies by Meyer et al. [8] and Falk et al. [23] with prepubertal and pubertal boys and by Inbar et al. [24] with prepubertal boys exercising in an environmental chamber (40-42°C) and water consumption *ad libitum*, the boys presented a lower sweat rate than in our study. The reason for such difference might be that the boys had different heat acclimation levels.

Three studies [7,8,12] evaluated electrolytes concentrations in the sweat of children during physical exercise. One of these studies [8] tested non-acclimated children cycling in cycloergometer inside an environmental chamber (40-42°C, 18-20% RH), and the other [7] tested young American football players during training with air temperature of 25°C and RH of 70%. In the first study [8], the sweat [Na^+] from the scapula also in prepubertal and pubertal boys was about 40% lower than that reported in our study. In the second study [7], sweat [Na^+] from the forearm was about 50% lower, but only prepubertal boys were tested. Such distinctive results may be due to the heat acclimation status and sweat collection and analysis [7].

An important indication in the present study, consistent with other publications with adolescent tennis [25] and American football [26] players is that the boys were already slightly hypohydrated at the begining of training, independent of the sport modality or maturational stage. In the present study both urine color and USG [3] indicated that boys began the SC and FS training sessions at a mild hypohydration level and that it advanced to a moderate level. A recent study [27] also indicated that adult soccer players (~ 25 yrs-old) arrived not well hydrated over 7 consecutive days of training sessions. Therefore, attention should be given to the hydration habits between training sessions, especially under warm environments.

In conclusion, SC and FS practices from one to (1-1.6 h) in a warm environment resulted in minimal body water deficit (~277 mL) and an average Na^+ sweat loss of 0.64 $g{\cdot}h^{-1}$ in active boys. This acute fluid deficit is probably of no biological significance to impair performance or health. However, it is important to recover from such fluid deficits within successive training/competition sessions, especially because the boys started practices not fully euhydrated according to the urinary markers. Fluids should be available to drink during and after SC and FS practices to ensure that fluid intake is satisfactory to prevent further fluid deficits.

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Declaration of interest

The authors report no conflicts of interest.

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