

Hydration and Perceptual Responses Resulting from a Training Session Involving Female Rhythmic Gymnastics Athletes

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Abstract

Young rhythmic gymnastics (RG) athletes engage in long training sessions that can lead to dehydration, especially on very hot days. Hydration status can affect the sporting performance and health maintenance of these young gymnasts. To evaluate the sweat volume, fluid balance and perceptual responses of young female RG athletes during a training session in the heat, fourteen female RG athletes (11.3±2.6 years) with a body fat percentage of 17.35±4.85% participated in this study. Body weight was measured and a urine sample collected for color analysis, both before and after the training session. The workout lasted 2.5 h in environmental conditions of between 29 °C and 50% relative humidity (RH), and 30 °C and 59% RH. Water was made available for consumption *ad libitum* and sweat volume was calculated from the change in body weight, corrected for water intake. The rate of perceived exertion, thermal sensation, thermal comfort, and irritability were measured every 30 minutes using categorical scales. Sweat volume was 1146.6±412.6 mL and water consumption was 825.2±368.1 mL. The negative fluid balance was between 1-2% in 50% and 1% in 42.8% of the athletes. Twelve athletes began the training session hypohydrated (urine color between 3 and 7), and 92.3% were hypohydrated after training (urine color between 4 and 6). There was an increase in thermal sensation (8±1) and discomfort (3±1) over the course of the workout. The RG athletes were unable to adequately replace their fluid losses, despite water being available for drinking *ad libitum*, which may reflect on the perceptual responses to heat.

Keywords: Sweating; Hydration; Exercise in the heat; Gymnastics; Children

Abbreviations

RG: Rhythmic Gymnastics; BSA: Body Surface Area; RPE: Rate of Perceived Exertion; VO_{2max} : Aerobic Fitness

Introduction

Rhythmic gymnastics (RG), practiced mainly by girls, is a long duration sport with training sessions lasting around 3-4 hours daily. This may lead to dehydration, especially in hot weather conditions when sweating is more intense. The necessary skills that a gymnast requires are: strength, power, flexibility, agility,

dexterity and stamina. The biotype of slenderness, desired in RG, causes many athletes to manipulate and restrict their intake of food and fluids to reduce body weight [1], which can compromise hydration status [2].

RG and other sports (judo, football, futsal) demand high aerobic fitness, strength, balance, coordination, perception and cognition [3,4], skills that can be compromised when accompanied by a negative fluid deficit >2% [5]. Young athletes from different sports (rhythmic gymnastics, tennis, football, futsal, judo), frequently begin training sessions and competitions hypohydrated and are unable to recover from one training session to the next [3,6-9], often using restricted fluid intake for the maintenance and loss of body weight [3,9]. A chronic state of hypohydration may decrease performance, motivation and physical effort during training and competitions [10].

The restriction of fluid intake combined with losses from sweating can be of concern both for performance and health. Physical training can affect the sweat responses in athletes [11]. No studies were found that evaluated the hydration and sweating status of RG athletes during a training session in the heat. The majority of studies evaluating hydration status, sweating and fluid intake in young athletes have focused on males [3-5] and a few studies have involved females, which involved protocols conducted in the laboratory [12-14].

Studies carried out in the field under normal training conditions are important in order to reflect specific training situations, such as heat stress and the availability of liquids. The aim of this research was to evaluate the hydration and sweating responses, and perceptual responses of young RG athletes during a training session conducted in the heat.

Methods

Participants

Fourteen female RG athletes, aged between 8-16 years, from the competition team of the Gymnastics Society of Porto Alegre (*Sociedade de Ginástica Porto Alegre - SOGIPA*) participated in

the study. The physical characteristics of the athletes are shown in Table 1. The participants had no musculoskeletal injuries and none were taking medications that could affect the cardiovascular system and/or thermoregulation. All athletes had been training a minimum of four days a week for at least six months, with each training session lasting at least 2 hours 30 minutes. This study was approved by the Research Ethics Committee of the Pontifical Catholic University of Rio Grande do Sul, number CEP 11/05549, and those parties responsible for the athletes signed a consent form and the athletes signed a statement of consent for minors, agreeing to participate in the research. The study consisted of two sessions: one preliminary assessment and an evaluation training session.

Preliminary assessment

The first assessment was conducted three days prior to the training session and included an evaluation of maturational stage and anthropometry. The maturity level was assessed by a female researcher through observation of the breast region and pubic hair development, and classified using the Tanner criteria (1962). The height (Sanny portable stadiometer, model ES2040, 210cm, 0.1cm, Sao Paulo, Brazil) and body weight (G-TECH model 3 Glass control, Guangdong, China, 0.05 kg) of athletes were measured whilst wearing a bathing costume only, and the body surface area (BSA) was calculated [15] using the following equation: $BSA = 0.20247 \times \text{height (m)}^{0.725} \times \text{weight (kg)}^{0.425}$.

Triceps and subscapular skinfold measurements were taken using Lange skinfold calipers (Cambridge, USA, 1 mm) and the % fat was estimated by the Slaughter et al. [16] equation. The athletes were instructed to consume ~375-500 mL of water, 30 minutes prior to the training session to try to balance the initial state of hydration.

Training session

The training session was conducted during an afternoon at the end of November 2011, a predominantly hot month in southern Brazil, and took place in a gymnasium (temperature $29.2 \pm 0.5^\circ\text{C}$ and $59.3 \pm 2.8\%$ relative humidity). It lasted a total of 2.5 h and consisted of 20 min of warm-up (stretching and light running with jumping), 1h 50 min of technical and choreographed exercises, followed by 20min of recovery (stretches).

Each athlete was asked to urinate and then body weight was measured. A sample of urine was collected for evaluation of the color; used as an indicator of the initial state of hydration [17].

During training, individual bottles containing water were available and positioned within easy access, for ingestion *ad libitum*. The bottles were weighed (Ohaus scale, model CS2000, New Jersey, USA, 1g) before and after the training session in order to calculate the total volume of liquid consumed. Body weight was again measured at the end of the training session to determine the hydration status of the athletes. The sweat volume (mL) was estimated by the difference between pre- and post-training body weight, corrected for the volume of water ingested during exercise. The sweat volume was divided by kg and time ($\text{mL}\cdot\text{kg}^{-1}\cdot\text{h}^{-1}$) to express the sweat rate.

The following perceptual variables were evaluated every 30 minutes: rate of perceived exertion (RPE) [18], thermal sensation, thermal comfort [19] and irritability [20]. The categorical scale for thermal sensation consisted of nine points ranging from very cold (1) to very hot (9); thermal comfort scale consisted of six points ranging from very comfortable (1) to very uncomfortable (6); and the irritability scale with five points ranging from nothing noticeable (1) to strong intensity (5).

Table 1: Physical characteristics of the athletes.

ID	Maturational stage	Age (yrs)	Weight (kg)	Height (cm)	Body Surface Area (m ²)	Fat %
1	1	11	27.2	139.1	1.05	12.5
2	1	9	34.3	141.8	1.17	21.7
3	1	8	27.8	136.8	1.04	19.4
4	1	9	39.9	153.1	1.32	13.5
5	2	10	38.4	156.5	1.32	13.8
6	2	12	38.0	148.2	1.26	16.3
7	2	8	25.4	128.0	0.96	15.7
8	3	15	42.4	160.9	1.41	10.9
9	3	11	37.5	153.1	1.29	16.9
10	3	12	45.2	156.3	1.41	17.5
11	3	11	35.0	145.9	1.21	11.2
12	3	11	44.5	153.3	1.38	22.8
13	4	15	48.6	160.4	1.49	26.0
14	5	16	59.6	165.8	1.66	24.1
Mean		11.3	38.2	153.1	1.31	16.6
SD		2.6	9.2	10.6	0.19	4.9

Statistical analysis

The variables were analyzed by means of descriptive statistics and presented as mean± standard deviation. The change in body weight was analyzed using the Student’s t-test for paired samples and perceptual scales were analyzed by the Friedman test. Correlations were performed using the Pearson test. The analyses were carried out using the program GraphPad InStat version 3.00 for Windows, GraphPad Software, San Diego California USA, and the level of significance adopted was 5%.

Results

The results for hydration status and sweat response during the training session are presented individually in Table 2.

Figure 1 illustrates the coloration of the urine pre- and post-training for each athlete. Twelve (92.3%) athletes began the session hypohydrated (color between 3-7) and only one (7.69%) athlete (ID 11) began training euhydrated (color 2). At the end of the training session, ten (76.92%) of the girls showed significant

Table 2: Body weight variations, % of hydration, water intake, sweat volume and sweat rate during one training session.

ID	Δkg (mL)	% of hydration	Water itake (mL)	Sweat volume (mL)	Sweat rate (mL.kg ⁻¹ .h ⁻¹)
1	200	0.74	499	299	4.40
2	-100	-0.29	661	761	8.88
3	-200	-0.72	675	875	12.59
4	-600	-1.50	438	1038	10.41
5	-500	-1.30	1000	1504	15.67
6	-400	-1.05	1113	1513	15.93
7	-400	-1.57	231	631	9.94
8	-400	-0.94	766	1166	11.00
9	-100	-0.27	865	965	10.29
10	-200	-0.44	1518	1718	15.20
11	-600	-1.71	833	1433	16.38
12	-500	-1.12	619	1119	10.06
13	-100	-0.21	1510	1610	13.25
14	-600	-1.01	820	1420	9.53
Mean	-0,32	-0,81	825,18	1146,61	11,68
SD	0,24	0,66	369,06	412,60	3,36

Δkg = Body weight variations.

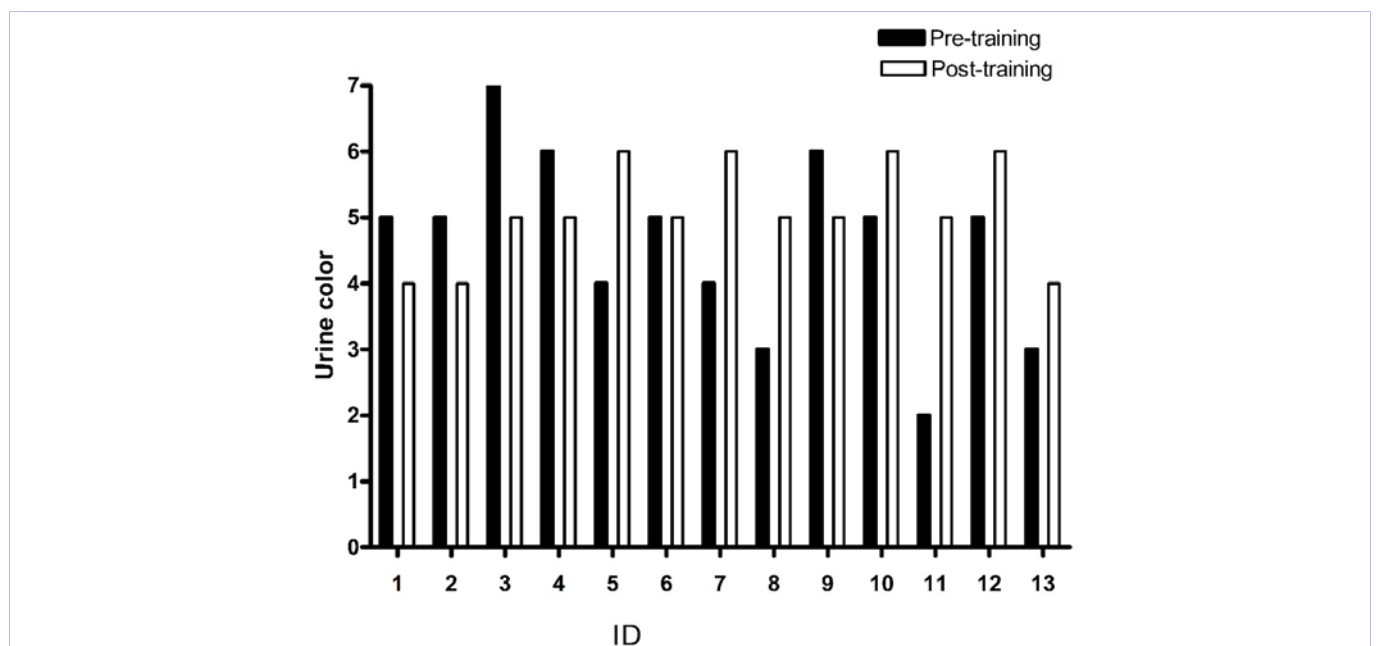


Figure 1: Coloration of the urine pre- and post-training for each athlete.

hypohydration (color between 5-7), and the remaining three (23.07%) were slightly hypohydrated (color 4). The urine color of the athlete identified as ID 14 was not evaluated due to her menstrual cycle. The mean for pre- and post-training urine color did not present a difference (color 5 for both).

Thirteen girls had a reduction ($p < 0.001$) in body weight (-321.4 ± 242.4 g). The mean percentage of dehydration was $-0.81 \pm 0.67\%$ and the greatest loss observed was 1.57%. Water intake was 825.18 ± 368.06 mL. The mean for sweat volume and sweat rate were 1146.61 ± 412.60 mL and 11.68 ± 3.36 mL·kg⁻¹·h⁻¹, respectively. The data for sweating and hydration related to the variation in body weight, % hydration, fluid intake, sweat volume and rate of sweating of the young RG athletes during the training session are shown in Table 2.

No correlation was found between the state of hydration, according to urine color, prior to exercise and the volume of fluid ingested (mL) ($R = -0.24, P = 0.44$). In addition, no correlation was found between the state of hydration prior to exercise, with respect to the urine color, and the % of dehydration ($R = 0.269, P = 0.23$).

Table 3 shows the response rate for perceived exertion, thermal sensation, thermal comfort and irritability during the training session, measured every 30 min. No significant difference was observed in perceived exertion ($P = 0.69$) and irritability ($P = 0.18$) over the course of the workout. A non-significant increase in thermal sensation was observed ($P = 0.08$) and a reduction in thermal comfort ($P = 0.08$) during the 90th minute of the training session.

Discussion

The principle findings of this study were: (1) the athletes began the training session hypohydrated; (2) the percentage of body weight loss during the training session indicated that the RG

athletes did not hydrate themselves adequately, despite having drinking water available *ad libitum*; (3) the prior hydration status was not related to the hypohydration seen post-training; and (4) the athletes presented an increased thermal sensation and decreased thermal comfort related to the training duration.

Despite the recommendation of hydrating with 375-500 mL of water 30 minutes prior to the beginning of the training session, 12 of the 13 athletes were classified as hypohydrated, with other studies having also observed this initial state [3-5]. The intake of 250-300 mL of water at the beginning of an activity and the further intake of around 150 mL every 20 minutes during the exercise is known to be among the recommendations for ensuring hydration [9], however, the athletes taking part in our study showed themselves to be commencing training already in a worrying state of hypohydration. The findings of this study reinforce the importance of encouraging hydration in the young RG athletes by prescribing fluid intake before, during and after training sessions, as they can fail to adequately recover from the dehydration suffered due to their daily training and competition schedules.

In the present study, one athlete hyperhydrated, six dehydrated less than 1%, and seven dehydrated between 1-2%, despite having water easily and readily available for drinking *ad libitum*. This result is in agreement with the study by Bar-Or, O [21], involving children aged between 10-12 years who presented hypohydration during prolonged exercise in the heat, even with fluids available. The American College of Sports Medicine [10] shows that hypohydration exceeding 1% is already detrimental to the performance and health of young athletes, and may cause a greater increase in body temperature, heart rate and fatigue, as well as a reduction in aerobic fitness (VO_{2max}) [20]. Moreover, the study by Dougherty et al. [5] demonstrated that hypohydration in excess of 2% affects the performance related to the specific skills of basketball players.

Table 3: Rate of Perceived exertion (RPE), thermal sensation (TS), thermal comfort (TC) and irritability (IR) during the training session.

ID	RPE				TS				TC				IR			
	30"	60"	90"	120"	30"	60"	90"	120"	30"	60"	90"	120"	30"	60"	90"	120"
1	11	15	15	16	7	8	8	8	3	4	4	4	3	3	3	3
2	15	15	13	15	8	8	8	8	3	3	3	3	3	1	3	3
3	11	13	11	13	8	8	7	7	4	5	5	4	1	1	1	1
4	17	17	17	17	5	5	8	8	3	2	5	5	2	3	3	1
5	13	13	11	11	8	8	9	8	2	2	2	3	1	3	3	3
6	11	11	11	11	7	8	8	8	5	3	3	4	2	2	2	2
7	11	9	9	9	8	8	9	8	3	2	3	2	1	1	1	1
8	9	9	15	17	9	8	7	9	2	2	5	5	2	2	2	2
9	15	15	17	13	7	7	8	4	4	4	5	3	3	3	3	2
10	9	7	9	11	5	5	5	7	1	2	2	3	1	1	1	1
11	15	7	7	7	8	8	9	9	2	1	2	2	3	4	1	1
12	11	15	15	15	8	8	9	8	3	4	4	4	3	3	4	3
13	11	9	9	9	8	8	9	7	3	2	4	2	1	1	3	1
14	11	9	9	9	8	9	9	7	3	4	4	3	1	1	1	1

The volume of water consumed by the athletes in the 150 minutes of training was on average 71% (825.18 mL) of the volume of sweat produced (1146.61 mL). Rivera-Brown et al. [13] evaluated 12 young athletes (10.6±0.2 years) in an environmental chamber, using a protocol of 180 minutes of cycling with an intensity of 60% of VO_{2max} in heat (30.9±0.2°C); the voluntary water intake was 90% (950 mL) of the sweat volume (1050 mL). In the present study, the athletes presented a greater percentage of hypohydration than in the study by Rivera-Brown et al. [13], however, sweating responses are related to individual factors (genetics, activity level, aerobic fitness), linked to the activity or sport (evaluation site, physical exercise intensity), as well as external conditions (temperature, relative humidity) [9].

In the present study, perceived exertion and thermal sensation remained constant during the training session, being as the mean reported perceived exertion related to the intensity of the training session was 13, considered slightly tiring. The volume and intensity of the training session and the environmental conditions were similar for all the athletes. In regards to the thermal sensation of the athletes, the mean observed was 8 to 9 points, considered "warm to hot", and corresponding with the ambient temperature of the day. Thermal comfort reduced during training with a mean of 3 points, considered "just comfortable". The increased feeling of heat and reduced thermal comfort during training may be related to the reduction in performance and/or motivation of the athletes [19]. Also, the irritability of the athletes was classified as low and it is believed that this result is an outcome of adaptation to the training and environmental conditions.

Conclusion

Training sessions for RG are intense and continuous and we stress the importance of encouraging fluid intake prior to and during these workouts, especially when conducted in the heat, which may compromise performance and health. Moreover, we believe that further research involving RG athletes should be carried out, verifying the impact of hypohydration on the performance of specific skills and the use of other forms of drink for fluid replacement.

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