Journal of Human Sport and Exercise *online*
J. Hum. Sport Exerc.
Official Journal of the Area of Physical Education and Sport.
Faculty of Education. University of Alicante. Spain
ISSN 1988-5202 / DOI: 10.4100/jhse
An International Electronic Journal
Volume 4 Number 3 October 2009

Research Article

SIGNIFICANT SODIUM PLASMA REDUCTION AFTER HALF-IRONMAN TRIATHLON IN BRAZILIAN TRIATHLETES

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Received: 12 February 2009; received in revised form: 15 April 2009; accepted: 20 June 2009

ABSTRACT

Hypontremia defined as a serum concentration below 135 mmol/L (1 mmol/L - 1mEq/L). The aim of the present study was to analyze the effects of half-ironman triathlon on serum sodium concentration in Brazilian triathletes. Significant changes after triathlon completion was found pre = 141.72± 0.75 mmol/L; post= 138.37± 0.72 mmol/L (P=0.018). Was not found significant correlation between sodium plasma concentrations after the competition with the finishing time. In conclusion, the results presented herein, showing significative reduction in the sodium plasmatic concentrations remain between normal ranges.

Key words: *hyponatremia, electrolytes, half-ironman, triathlon, ultra-endurance.*

Reference Data: Bürger-Mendonça M, Bielavsky M, Retondaro-Barbosa FC. Significant sodium plasma reduction after half-ironman triathlon in brazilian triathletes. *J. Hum. Sport Exerc.* 2009; 4(3):246-253.

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DOI:10.4100/jhse.2009.43.06

INTRODUCTION

Hyponatremia defined as a serum concentration below 135 mmol/L (1 mmol/L - 1mEq/L) (Almond et al., 2005; Montain, Sawka, & Wenger, 2001; Souba et al., 2006). Severe hyponatremia and critical hyponatremia were defined as serum sodium concentration of 130 and 120 mmol/L or less respectively (Almond et al., 2005). Signs and symptoms of hyponatremia include confusion, disorientation, mental obtundation, headache, nausea, vomiting, aphasia and muscle weakness (Siegel, 2006; Souba et al., 2006). Complications of severe and rapidly evolving hyponatremia include seizures, coma and pulmonary edema (Souba et al., 2006).

The incidence of hyponatremia in endurance athletes participating in ultra-endurance events such: triathlons (half-ironman, ironman) marathons and ultra-marathons have been well documented over the past two decades (Siegel, 2006; Vrijens & Rehrer, 1999). In fact hyponatremia has been stated to be one of the most common medical complications of ultra-endurance events and is an important cause of race-related fatalities (Rosner & Kirven, 2007) occurring in athletes during or after extraordinary physical efforts, especially in the heat (Vrijens & Rehrer, 1999).

As triathlon competitions evolves three different disciplines, each of them with their particular physical effort demands, thermoregulatory adaptations, field environment and opportunities for fluid and energy sources ingestions (Jeukendrup, Jentjens, & Moseley, 2005), several studies regarding sodium balance in triathlon (ironman and half-ironman) competitions were performed to improve performance, avoid physical fatigue and avoid complications related to hyponatremia during and after exercise (Bentley, Cox, Green, & Laursen, 2008). The aim of the present study was to analyze the effects of half-ironman triathlon on serum sodium concentration in Brazilian triathletes.

MATERIAL AND METHODS

Subjects

Six well-trained male amateurs' triathletes with 27.33 ± 5.78 years; 72.17 ± 9.82 kg; 177.50 ± 9.65 cm; 22.84 ± 1.98 kg/m^2 who completed the 2004 half-ironman triathlon in Cabo-Frio, Brazil participated in the study. The athletes had all completed a minimum of one prior half-ironman triathlon distance event in less than 7 h. Each subject provided written informed consent, and the investigation was approved by the medical research ethics committee of The Estácio de Sá University (protocol nº 307/2006), were in accordance with the norms of the Brazilian National Health Council, under resolution n° 196, promulgated on 10 October 1996, referring to scientific research on human subjects. Athletes were allowed to eat and drink *ad libitum* during their race and no particular guidance was given to them as to what quantities or types of fluids and fuels they should consume.

Race conditions

The event consisted of a 1,9km swim, followed by a 90 km cycle, and completed with a 21 km half-marathon run. Environmental conditions ranged from 18–23°C according local airport. Performance times for the swim, cycle, and run phases, and the total time are shown in table 1.

 ISSN 1988-5202

Table 1. *Performance time in the half-ironman triathlon race.*

Swim time	0:23:13 ± 0:03:12
Cycle time	2:51:15 ± 0:05:57
Run time	1:43:50 ± 0:22:21
Total race time	4:58:19 ± 0:28:04

Data are mean ± SD (N=6). Values expressed hours:minutes:seconds).

Blood sampling

Blood samples (≈15 mL) were obtained from the antecubital vein on morning day of the competition after eight hours dietary restriction between 6-7 am, and immediately before the race. Post race blood samples were taken within 5 min of athletes finishing the race, with the athlete lying supine in the medical tent. For sodium analyzed was used tubes contained without addictive and for hematological parameters analyzed was used tubes with EDTA K_3.

For hematological parameters the samples were homogenate during 20 min, after were stored at ambient temperature (≈ 20° C), with other blood samples, until arrival in the laboratory for posterior analyze in the same day using auto analyzer Coulter STKS blood cell counter (Beckman-Coulter, Miami, Florida, USA). For Sodium samples were centrifuged during 10 min with relative centrifugal force of 1200G (2600 rpm). Serum samples had been stored 4° C for posterior analyze in the same day, were measured using flame photometer model 410 (Sherwood, United Kingdom).

Statistical analysis

Data were tested for normality using the Shapiro-Wilk (SW) test, with all data sets found to be normally distributed. Values are presented as means ± standard deviation (M ± SD). Pre and post race values were compared by paired t-tests. Pearson`s product–moment correlation coefficients (PC) were used to examine potential relationships between of finishing time with serum Sodium concentrations after the competition. Significance was set at the 0.05 level of confidence. All statistical analyses were performed with version 13.0 of the SPSS statistical software package (SPSS Inc., Chicago, Illinois, USA).

RESULTS

A significant reduction in sodium plasma concentrations were found after triathlon competition (Individual values are present in table 2). The means obtained were Na-pre= 141.72 ± 1.85 mmol/L; Na-post= 138.37 ± 1.75 mmol/L (P=0.018). This reduction, even significative after the competition, presented values in normal sodium plasma concentrations range (135-145 mmol/L) according to Souba, Fink et al. (2006).

Were not found significant alteration in hematocrit (HCT) values after competition (Individual values are present in table 2). The means obtained were HCT-pre= 44.58 ± 2.26 %; HCT-post= 45.00 ± 2.84 % (P=0.697). All hematocrit values stayed in normal range (41-53%) according to Souba et al. (2006) and below the normality, specifically for male triathletes (52%) (O'toole, Douglas, Hiller, & Laird, 1999).

Mean corpuscular hemoglobin (MCH) were MCH-pre= 30,23 ± 1,12 pg/cell MCH-post= 30,07 ± 1,35 pg/cell (P=0.233) and Mean corpuscular volume (MCV) MCV-pre= 88,15 ±

 ISSN 1988-5202

2,71 µm³; MCV-post= 87,55 ± 2,99 µm³ (P=0.195) both parameters stayed in normal range according to Souba et al. (2006) (Individual values are present in table 2).

Also, was not found significant correlation between sodium plasma concentrations after the competition and finishing time (PC= -.339; P=.511) possibly due to type β error.

Table 2. *Individual values sodium and Hematological parameters.*

	Na pre (mmol/L)	Na post (mmol/L)	HCT pre (%)	HCT post (%)	MCV pre (µm³)	MCV post (µm³)	MCH pre (pg/cell)	MCH post (pg/cell)
1	140,90	136,90	43,30	47,70	87,80	87,90	30,50	30,00
2	138,80	138,10	45,50	43,30	89,30	89,50	30,70	30,80
3	143,90	137,60	44,60	44,80	84,50	84,10	28,90	28,60
4	143,40	138,70	44,70	42,50	92,30	92,20	32,00	32,30
5	142,00	141,70	48,10	49,20	88,90	86,50	30,10	29,80
6	141,30	137,20	41,30	42,50	86,10	85,10	29,20	28,90
M ± SD	141,72 ± 1,85	138.37± 1,75	44,58 ± 2,26	45,00 ± 2,84	88,15 ± 2,71	87,55 ± 2,99	30,23 ± 1,12	30,07 ± 1,35
SW	0,818	0,087	0,919	0.198	0,965	0,878	0,792	0,675
P	0,018#		0,697		0,195		0,233	

Data are M ± SD (N=6). Na- Sodium; HCT- Hematocrit; MCH- Mean corpuscular hemoglobin; MCV- Mean corpuscular volume; Pre- before the race; Post- after the race; SW- Shapiro-Wilk; #significant different from before race (P> 0.05).

DISCUSSION AND CONCLUSIONS

In this study we examined the behavior of plasmatic sodium concentrations before and after in half-ironman triathlon competitors. All volunteers presented a significant reduction in sodium plasma concentration, but this reduction still was in the normal range values (from 135 to 145 mmol/L), thus not characterizing even mild and/or severe hyponatraemia, a dangerous condition possibly resulting from overfluid intake and/or dehydration and/or inadequate electrolyte replacement with a possible fatal outcome.

In 1991, Irving et al. (1991) collected data of several biochemical plasma markers and electrolytes, also evaluated urine output and renal function markers in marathon runners who collapsed due to hyponatremia after the 1988 Comrades Marathon and compared to values obtained from normonatremic runners. The authors observed that each of the runners who collapsed was fluid overloaded (6L total fluid intake), and the sodium loss was not larger than those of normonatremic runners.

Fluid ingestion during endurance events is largely recommended to suppress body water and salts losses due to sweat, a normal thermoregulatory mechanism. In the literature there is controversial findings regarding the type and amount of fluid an athlete should take during competitions and trainings to avoid dehydration, electrolyte losses and body weight alteration during exercise (Noakes, 1992a, 1992b; Noakes, Goodwin, Rayner, Branken, & Taylor, 1985; Speedy et al., 1999).

Also it is important to consider that half-ironman and others ultra-endurance athletes experience a wide range of environmental conditions, and mostly half-ironman competitions are completed between 4 – 8 hours, with the athlete running in a significant state of dehydration and fatigue (Dallam, Jonas, & Miller, 2005).

At this point, it is important to note that all volunteers in our study were free to ingest any fluid that they were used to, no matter if it was water or any sport drink at a free rate; that

 ISSN 1988-5202

means the athletes followed their own physiological needs for hydration and/or electrolyte, considering the theory that overload of fluids is strongly related to exercise induced hyponatremia, the non-hyponatremic sodium plasma reduction observed in our study.

We can assume that this personal fluid intake was directed mostly by body´s plasma osmolality defense mechanisms. This internal regulation occurs by the secretion of antidiuretic hormone and thirst stimulation when osmolality rises 5 to 10 mOsmol/ kg H_20, thus not leading to a clinical sodium plasma reduction due to fluid overload (Robertson, 1984).

Speedy et al. (2001) reported that ironman athletes, with fluid intake estimated by recall, showed no significant pre- and post race plasma sodium alterations, with a relative inverse relationship between change in sodium plasma concentration and weight loss, similarly to results obtained from the same author in 1999, were the relative body change of severely hyponatremic athletes was increased during the event, thus associating this condition to a fluid overload.

Noakes et al. (2005) observed that excessive fluid consumption was the principal cause of a reduction in serum sodium concentrations after exercise. The author analyzed 2135 athletes in endurance events and observed that 89% completed the races in euhydrated state and presented normal or elevated serum sodium concentrations. The portion of athletes who gained weight after the events (11%), 70% of them was normonatremic or hypernatremic.

As there is an intimate correlation between sodium plasma concentrations and water movement from intra- and extracellular spaces (Hew-Butler, Sharwood, Collins, Speedy, & Noakes, 2006; Speedy et al., 2001; Verbalis, 2003), measuring of sweat and urine production is one parameter that indicates how the organism manages hydroelectrolic equilibrium. In our study we could not measure these parameters as all athletes were under competition situation, thus, the less we interfere in their performance strategies and concentration during the competition the more “real’ and accurate results we could obtain from blood samples.

To establish a correlation between plasma sodium concentration and fluid homeostasis in an attempt to understand if the sodium reduction was due to fluid overload or an intensive water loss from sweating, we focused in hematocrit values.

Hematocrit reflects the blood proportion occupied by red cells, it is a common and reliable exam that can diagnoses abnormal states of hydration and anemia. One could suspect that an reduced plasma sodium concentration and an reduced hematocrit should be related to hemodilution, thus indicating overfluid ingest, even the athletes were free to follow their own fluid ingest plan; or an elevated hematocrit could indicate a dehydration status due to sweating and losing of electrolytes in sweat.

All hematocrit values, before and after competition in all volunteers in our study were between normal ranges (for adult men 42 to 52%), although four of our six volunteers showed a very mild increase in hematocrit. This result indicates that even presenting a reduced sodium plasma concentration, water mobilization between intra- and extra-cellular compartments was perfectly managed by athletes’ organism to maintain a normal hydration status, including normal sweat rates to regulate body temperature and also an ideal fluid ingest. This correlation indicates that the reduced sodium plasma was not related to overfluid

 ISSN 1988-5202

ingestion nor to dehydration, as stated above, this sodium reduction was not clinically important or characterizing even a mild hyponatraemia.

Hematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and thus plasma deficit values are parameters evaluated in the literature concerning electrolyte and hydration alterations in athletes performing long-duration sport modalities.

Loss of red cell volume was associated with a linear increase in serum sodium concentration, thus evidentiating a response of the erythrocyte to alterations in body osmolality (Kolka, Stephenson, & Wilkerson, 1982).

MCV is the relation between hematocrit and erythrocyte counting, expressing its mean size and considering that circulating plasma volumes consists of all the fluid located within the vascular space, except that contained in red blood cells, and this volume is less than 10% of total body water (Maw, MacKenzie, Comer, & Taylor, 1996; Verbalis, 2003), alterations in MCV could reflect a change in osmolality due to alteration in fluid balance (i.e. water and/ion concentrations).

MCH reflects the content of hemoglobin inside the erythrocyte. Gastman et al. (1998) reported an increase in plasma volume during ultra distance triathlon and postulated that water movement from the intracellular space to extracellular space is favored during exercise by the decrease in cellular osmolytes and intravascular hemolysis associated to hemodilution due to salt losses.

This result confirms those observed by Reid et al. (2004) in a observational cohort study in runners completing a standard 42,2 km marathon, where post race sodium plasma concentrations were directly related to body weight changes, evidentiated by a significative alteration in hematocrit values, but with no clinical cases of hyponatraemia in 155 of 296 athletes.

Also, Hew-Butler et al. (2007) observed results similar to ours in 181 male athletes competing the 2000 South African ironman triathlon, where both plasma volume and sodium concentrations were maintained despite a 5% body weight loss. Among other parameters studied, the authors concluded that the individuals could manage fluid and electrolyte homeostasis.

In our study, we did not observed any difference between both MCH and MCV pre and post competition, all values remained between normal ranges in all volunteers thus confirming indirectly that plasma volume, which can be assumed indirectly by hematocrit, MCH and MCV alterations, could be maintained during the endurance exercise even with a reduced plasma sodium concentration, which in turn, if excessive could alter those hematological values.

In conclusion, our study demonstrates that all volunteers were able to maintain water and ionic balance during the competition and also confirms previous studies regarding drinking policies, as all volunteers were free to ingest any fluid at any rate.

ISSN 1988-5202

ACKNOWLEDGEMENTS
The authors wish to thank Corrêas Clinical laboratory (especially Dr. Denisvaldo Silveira) and Danilo Amaral for technical support and all the participants for their valuable time and effort.

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