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Pre-race characteristics and race performance in hyponatremic and normonatremic finishers of Czech ultra-races

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Background: Exercise-associated hyponatremia (EAH) is used to describe hyponatremia occurring during or up to 24 hours after physical activity. **Objective:** The aim of the study was to compare pre-race characteristics, race performance and plasma sodium [Na^+] levels of hyponatremic and normonatremic ultra-endurance athletes and chosen variables in all finishers ($N = 138$). We assessed age, gender, club membership, pre-race training history and experience, pre-race body mass and body mass index (BMI) in 138 finishers of ultra-races (stage mountain bikers, 24 hours mountain bikers, 24 hours ultra-runners and 100 km ultra-runners) and post-race plasma [Na^+] in a subgroup of 113 ultra-athletes. **Methods:** The 138 participants completed a pre-race questionnaire survey and underwent body mass measurement, of those, 113 provided blood samples pre and post-race. **Results:** There were no group differences between hyponatremic and normonatremic ultra-athletes in age, gender, club membership, pre-race BMI, regular training, experience or race placement. Pre-race body mass and BMI related to race placement in the normonatremic group ($r = .30$, $p < .01$; $r = .43$, $p < .01$). Faster finishers were older ($r = -.28$, $p = .001$) and more experienced ($r = -.19$, $p = .02$) than slower finishers ($N = 138$). Lower pre-race body mass and BMI ($r = .28$, $p < .01$; $r = .49$, $p < .001$) was associated with lower absolute order; however, did not related to age ($N = 138$). A higher weekly training volume was associated with a lower pre-race body mass ($r = -.49$, $p < .01$) in female racers; however, it did not relate to pre-race BMI ($r = -.21$, $p = .41$) or race placement ($r = -.20$, $p = .56$). **Conclusion:** Pre-race characteristics did not distinguish those finishers developing EAH from those not developing EAH.

Keywords: runners, mountain bikers, endurance

Introduction

Exercise-associated hyponatremia (EAH) is used to describe hyponatremia occurring during or up to 24 hours after physical activity (Hew-Butler et al., 2015). It is defined by a serum, plasma or blood sodium [Na^+] concentration below 135 mmol/L (Hew-Butler et al., 2008). Athletes with symptomatic EAH can present with lightheadedness and nausea, headache, vomiting, altered mental state resulting from cerebral edema or noncardiogenic pulmonary edema (Hew-Butler et al., 2015). The major clinical relevance of asymptomatic EAH lies in its potential for quick progress into symptomatic EAH (Hew-Butler et al., 2015). The major risk factors for the development of asymptomatic and symptomatic EAH are overdrinking, weight gain during exercise, exercise duration more than 4 hours, event inexperience or inadequate training, slow running or race performance, high or low BMI and readily available fluids during a race (Hew-Butler et al., 2008). Given that excessive fluid consumption is a primary etiologic factor in EAH, prevention of EAH requires broad educational programs with emphasis on the importance of appropriate hydration practices, recognition of EAH and appropriate treatment protocols (Hew-Butler et al., 2015).

Participation in ultra-endurance races in the Czech Republic has risen in recent years (Chlíbková et al.,

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2015). Despite an increasing number of participants and events, there is limited information relating to the EAH in this country. Racers, event staff and emergency medical service personnel should be educated about proper recognition and treatment of EAH (Bennett, Hew-Butler, Hoffman, Rogers, & Rosner, 2013; Hew-Butler et al., 2015; Wegelin & Hoffman, 2011). Recently, it was reported that in 2012/2013 11.5% of 113 ultra-endurance athletes from a number of different sports developed post-race hyponatremia (Chlíbková et al., 2015). This was an increase from previous research on this population in the Czech Republic in 2012 (5.7% of the 53 finishers) (Chlíbková, Knechtle, Rosemann, Žákovská, & Tomášková, 2014). It is important to examine the risk factors for EAH (Bennett et al., 2013; Hew-Butler et al., 2015; Hoffman, Fogard, Winger, Hew-Butler, & Stuempfle, 2013). Risk factors such as overdrinking water, sport drinks, and other hypotonic beverages; weight gain during race, race fluid intake of finishers and pre and during a race habits were investigated in detail in our recent publications (Chlíbková et al., 2015; Chlíbková et al., 2014; Chlíbková, Rosemann, Posch, Matoušek, & Knechtle, 2016). Little is known; however, about selected pre-race characteristics and risk factors such as training experience, gender, age, pre-race BMI and race performance between those ultra-athletes developing EAH and those not developing EAH. Large-scale studies describing demographic and other characteristics of racers with EAH are rare (Hoffman et al., 2013; Hoffman, Stuempfle, Rogers, Weschler, & Hew-Butler, 2011; Winger, Dugas, & Dugas, 2011; Winger et al., 2013). To the best of our knowledge, no previous studies have investigated the demographic or other pre-race characteristics and race performance of Czech ultra-athletes. In the present study we hypothesized that hyponatremic ultra-athletes would be middle-aged (Hoffman, 2010; Hoffman & Fogard, 2011; Hoffman & Fogard, 2012; Hoffman et al., 2013) and less experienced (Hoffman & Fogard, 2012; Hoffman et al., 2013; Hoffman et al., 2011) and that there would be no differences in age, gender or finish time (Hoffman et al., 2013; Hoffman et al., 2011) compared with normonatremic finishers.

Methods

The data were collected from seven ultra-endurance races over two years (2012 and 2013). We contacted athletes before the start of each race via an e-mail and informed them about the investigation. Information about the finish time or number of kilometers completed was available for each entry from each race website. The study was approved by the Ethics Committee of the Institute of Experimental Biology at Masaryk University, Brno, Czech Republic and volunteers provided their informed written consent.

The races

The "Czech Championship 24 hours Mountain Bike race" took place during the second weekend of June 2012 and 2013. The course comprised a 9.5 km single-track with an elevation of 220 m. The "Bike Race Marathon Rohozec 24 hours" took place on June 9th 2012 and finished on June 10th 2012. The course comprised a 12.6 km track with an elevation of 250 m. The "Sri Chinmoy Self-Transcendence Marathon 24 hours race" took place from July 21st 2012 to July 22nd 2012. The lap was 1 km, situated around an athletic stadium with 1 m ascension. The "Trilogy Mountain Bike Stage Race" took place during the first week of July in 2012 and 2013. The prologue covered 3 km with 300 m difference in elevation, the first stage covered 66 km with 2,200 m of altitude to climb, the second stage was 63 km in length with 2,300 m difference in elevation and the third stage was 78.8 km with 3,593 m difference in elevation. The "Czech championship 100 km running race" was held on March 9th 2013. The ultrarunners had to run 66 laps of a 1,500 m circuit. Other details of the races are provided elsewhere (Chlíbková et al., 2014).

Procedures

All ultra-athletes were invited via e-mail to complete a web-based pre-race questionnaire about demographic information including age, gender, club membership and pre-race training history/experience approximately three weeks prior to each race ($N = 138$). Every participant underwent body mass measurement prior to the start of the race ($N = 138$). All participants were measured using a calibrated commercial scale (Tanita BC-351, Tanita, Tokyo, Japan) to the nearest 0.1 kg. Body height was determined using a stadiometer (Harpenden Stadiometer, Baty International Ltd, Crosswell, United Kingdom) to the nearest 0.01 m. BMI was calculated from pre-race body mass and height. Blood samples were drawn from an antecubital vein. One Sarstedt S-Monovette (plasma gel, 7.5 ml) for chemical analysis was cooled and sent to the laboratory and was analysed within 6 hours ($n = 113$). Blood samples were obtained to determine pre and post-race plasma [Na^+] using biochemical analyzer Module SWA, Module P + ISE (Hitachi High Technologies, Tokyo, Japan; Roche Diagnostic, Rotkreuz, Switzerland). Characteristics were compared between study participants with EAH ($n = 13$) and those not developing EAH ($n = 100$). We compared chosen variables and race performance in all ($N = 138$) finishers. Pre-race testing took place during the event's registration in the morning before the race between 7:00 a.m. and 11:00 a.m. in the morning for 24 hours races, between 7:00 a.m. and 8:45 a.m. for the 100 km race and three hours before the start of the prolog for the multi-stage race. Post-race measurements were taken immediately after the races and were finished within two hours. The data on race placement were obtained from statistics for each race and race websites.

Statistical analysis

Data are presented as mean ± standard deviation. The Shapiro-Wilk test was applied to check for normal distribution of data. Two-sample *t*-tests were used for comparison of age, a chi-square test of the male proportion and club membership. A Welch ANOVA for unequal variables was used to determine differences in the average number of finished ultra-marathons, the average number of years as an active biker/runner and weekly training hours between the race types and between the group of all 138 and of 113 ultra-athletes with blood samples. Because of unequal sample sizes (normonatremic versus hyponatremic group) we chose the nonparametric Mann-Whitney *U* test or chi-square test in case of proportion comparisons of pre-race characteristics or race performance. In order to identify possible relationships between continuous variables, scatter plots and Spearman's rank correlation coefficient were also used. Race performance was identical to relative placement in percentiles in each race despite of the connection of runners, mountain bikers and various disciplines (24 hours race, stage race, 100 km race) in the present study. For example in a 24 hours race we considered better race performance such as a higher number of achieved kilometers during 24 hours. Statistical significance was set at $p < .05$. The data was evaluated in the program STATISTICA (Version 7.0; Statsoft, Tulsa, OK, USA).

Results

A total of 138 ultra-athletes (110 men and 28 women) underwent measurement of pre-race body mass and reported demographic, training and experience-related characteristics (Table 1). Of these, 113 (81.8%) (88 men and 25 women), (twelve 24 hours ultra-runners, fifty 24 hours ultra-mountain bikers, thirty-two stage mountain bikers and nineteen 100 km ultra-runners) finishers also provided blood samples (Table 2). There was no difference in the average age ($p = .44$), gender ($p = .82$), pre-race body mass ($p = .76$), club membership ($p = .45$), an average number of finished ultra-marathons ($p = .71$), the average number of years as an active biker/runner ($p = .67$) and weekly training hours ($p = .53$) between the group of all 138 and of 113 ultra-athletes with blood samples. Considering all pre-race entries, there was no significant difference in age ($p = .07$), gender ($p = .40$), the average number of finished ultra-marathons ($p = .07$), the average number of years as an active biker/runner ($p = .18$), total weekly training hours ($p = 0.43$), or total weekly cycling/running hours ($p = 0.07$) among finishers from all types of races; the group was homogeneous. The majority of racers were members of some club and the only difference was that everyone within the group of 24 hours runners had a club membership, which was not true for other types of races ($p = .004$). However, club membership was not related to plasma [Na^+] ($p = .80$) or BMI ($p = .85$) or race placement ($p = .09$).

Table 1
Pre-race characteristics of the athletes who underwent blood measurements. Data are reported as mean (SD) except where indicated to be a percentage.

	All finishers (N = 113)	Normonatremic finishers (n = 100)	Hyponatremic finishers (n = 13)
Age (y)	38.7 (8.3)	38.6 (8.5)	39.5 (6.9)
Male sex (%)	70	71	69
Pre BMI (kg/m^2)	23.0 (2.1)	23.1 (2.2)	23.0 (1.8)
Number of finished ultra-marathons	8.7 (11.1)	8.5 (11.1)	10.2 (11.4)
Years as an active cyclist/runner	9.3 (6.6)	9.3 (6.7)	9.2 (6.1)
Average total training volume (h/week)[a]	10.7 (4.4)	10.4 (4.1)	13 (5.8)
Average cycling/running training volume (h/week)[a]	9.7 (4.1)	9.5 (3.8)	10.9 (5.5)

Note. [a]During the 3 months prior to the event.

Table 2
Demographic, pre-training and experience-related characteristics of all finishers (N = 138) in each type of race. Data are reported as mean (SD) except where indicated to be a percentage.

	24 hours MTB (n = 75)	24 hours RUN (n = 12)	100 km RUN (n = 19)	MTB stage (n = 32)
Age (y)	36.9 (8.9)	38.3 (7.3)	42.6 (8.9)	37.2 (6.1)
Male sex (%)	80	67	74	88
Club membership (%)	53	100*	79	72
Number of finished ultra-marathons	7.1 (5.7)	15.6 (18.4)	12.8 (17.4)	5.3 (4.9)
Years as an active cyclist/runner	7.9 (5.2)	9.8 (6.9)	10.4 (9.1)	10.5 (6.1)
Average total training volume (h/week)[a]	10.5 (4.5)	10.5 (3.9)	8.8 (3.5)	11.0 (4.9)
Average cycling/running training volume (h/week)[a]	9.8 (4.4)	8.1 (3.2)	7.4 (2.8)	10.1 (4.1)

Note. MTB = mountain biking; RUN = running. [a]During the 3 months prior to the event. *Statistically significant difference between groups.

Comparison of hyponatremic (EAH) and normonatremic (non-EAH) finishers (n = 113)

In total, 13 of the 113 investigated athletes developed post-race hyponatremia, equal to 11.5%, nine (69.2%) men and four (30.8%) women (Chlíbková et al., 2016). Of the 113 athletes, female pre-race plasma [Na^+] was 138.6 (2.7) mmol/L, post-race 137.0 (2.2); male pre-race plasma [Na^+] 139.9 (2.7) mmol/L and post-race 138.2 (2.9) mmol/L (Figure 1). There were no differences between hyponatremic and normonatremic finishers in terms of age (p = .67), sex (p = .42), pre-race body mass (p = .84), BMI (p = .99), club membership (p = .48), total weekly training hours (p = .16), total weekly cycling/running hours (p = .42), average number of finished ultra-marathons (p = .62) and average number of years as an active biker/runner (p = .93), or race placement (p = .21) (Table 2). Race placement was not related to gender (EAH: p = .74, non-EAH: p = .20), age (EAH: r = .15, p = .62; non-EAH: r = –.03, p = .72), club membership (EAH: p = .58, non-EAH: p = .67), average number of finished ultra-marathons (EAH: r = .17, p = .57; non-EAH: r = –.09, p = .33), or average number of years as an active biker/runner (EAH: r = .33, p = .26; non-EAH: r = –.05, p = .59) within the hyponatremic or normonatremic athletes. Pre-race BMI and pre-race body mass related to race placement in the normonatremic group (r = .43, p = .01; r = .30, p = .01), but not in the hyponatremic group (r = .17, p = .51; r = .11, p = .46).

Age, gender, pre-race body mass, BMI and race performance (N = 138)

The mean age of all competitors was 37.9 (8.4) years [men 37.9 (8.8), women 38.0 (6.9) years]. There was no difference in age between male and female ultra-athletes (p = .66) (Figure 2). The youngest finisher was twenty-three, the oldest one was sixty-two years old. Race performance (absolute order in each race) showed a significant negative correlation with age of all racers (N = 138) (r = –.28, p = .001) without gender differences (p = .60). This finding means that older racers were faster than younger racers.

Pre-race body mass was 72.7 (SD 10.2) kg in all finishers (N = 138), 60.9 (5.7) kg in women (n = 28) and 75.7 (8.8) kg in men (n = 110). The average BMI was 23.6 (2.2) kg/m^2 for male and 21.5 (1.6) kg/m^2 for female finishers, respectively. Logically, male ultra-athletes showed a significantly higher pre-race body mass compared with female ultra-athletes ($p < .001$). There were also significant differences in pre-race BMI between genders ($p < .001$). Pre-race BMI was not related to post-race plasma [Na^+] (r = .10, p = .74). We found a significant correlation between pre-race BMI and race placement (r = .49, $p < .001$) and between pre-race body mass and race performance (r = .28, $p < .01$) within all ultra-athletes (N = 138) such that faster racers had a lower pre-race body mass and BMI. Other select pre-race variables such as the average number of finished ultra-marathons (women: r = –.24, p = .15; men: r = –.09, p = .66) and the average number of years as an active biker/runner (women: r = –.30, p = .27; men: r = .04, p = .84), total weekly training hours (women: r = –.21, p = .41; men: r = –.16, p = .32), or total weekly cycling/running hours (women: r = –.09, p = .59; men: r = –.12; p = .78), were not associated with pre-race BMI. Age was unrelated to BMI in all 138 athletes (r = .01; p = .81), in women (r = –.07, p = .47), in men (r = .04, p = .65).

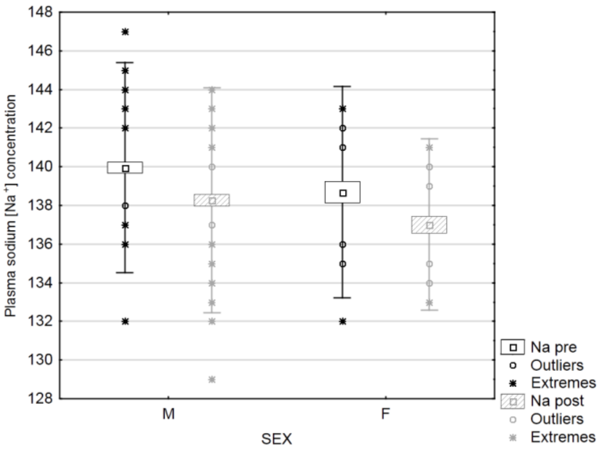

Figure 1. Pre and post-race plasma sodium [Na^+] concentrations in the female and the male groups (n = 113).

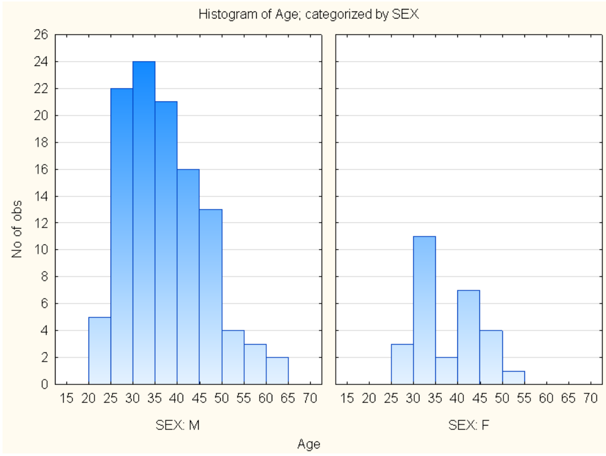

Figure 2. Histogram of age categorized by sex (N = 138).

Pre-race training experience and race performance (N = 138)

Pre-training history of finishers is shown in Tables 1 and 2. A negative correlation was reported between race placement and years as an active biker/runner (r = –.30, p < .001). Faster racers reported more years of training experience as active bikers/runners than the slower finishers. We also found a very weak negative correlation, although statistically significant, between race placement and the number of finished ultra-marathons (r = –.19, p = .02). Total weekly training hours (r = –.08, p = .30) or total weekly cycling/running hours (r = –.13, p = .12) three weeks prior each race did not relate to race placement. Total weekly training hours in female racers (r = –.20, p = .56) and male racers (r = –.04, p = .39) were not associated with race placement. Pre race body mass related to the number of hours spent by training per week in female ultra-athletes (r = –.49, p < .01), but not in male finishers (r = –.04, p = .34).

Discussion

The primary finding of this study was that we did not find any group differences between hyponatremic and normonatremic ultra-athletes in age, gender, club membership, pre-race BMI, regular training, experience or race performance. Pre-race body mass and BMI related to race placement only in the normonatremic group.

Another finding was that faster finishers were older and more experienced than slower finishers. Lower pre-race body mass and BMI were associated with lower absolute order; however, they did not relate to age. On the contrary; gender, club membership, total weekly training or cycling/running hours did not relate to race placement. A higher weekly training volume was associated with a lower pre-race body mass in female racers; however, it did not related to pre-race BMI or race placement.

Comparison of hyponatremic and normonatremic finishers

Recent studies sought to identify characteristics that could distinguish those finishers developing EAH from those not developing EAH in a 161 km running ultra-marathon (Hoffman et al., 2013). We hypothesized that hyponatremic ultra-athletes would be middle-aged (Hoffman, 2010; Hoffman & Fogard, 2011; Hoffman & Fogard, 2012; Hoffman et al., 2013) and less experienced (Hoffman & Fogard, 2011; Hoffman & Fogard, 2012; Hoffman et al., 2013) with no differences in age, sex or finish time (Hoffman & Fogard, 2011; Hoffman et al., 2013) compared with normonatremic finishers. Both groups were middle-aged and we found no group differences between hyponatremic and normonatremic ultra-athletes in age, sex, pre-race BMI, regular training, experience or race performance. On the contrary, being female is considered as a risk factor for developing EAH (Bennett et al., 2013; Dugas & Noakes, 2005; Hew-Butler, Chorley, Cianca, & Divine, 2003; Sawka et al., 2007). However, the incidence of EAH in the present study was not higher in the male than in the female group. This fact seems to be in contrast to previous studies (Almond et al., 2005; Hew-Butler et al., 2003), where the incidence of EAH was greater in women adjusted for BMI and their racing time (Hew-Butler et al., 2015). However, the apparent gender difference was not statistically significant (Almond et al., 2005). Our hypothesis that there were no gender differences between hyponatremic and normonatremic ultra-endurance athletes was confirmed; hyponatremic ultra-athletes did not differ in sex compared to normonatremic athletes. Nevertheless, in other studies, the risk of developing EAH was also not related to age and sex (Hoffman et al., 2013; Winger et al., 2013). Moreover, the recent Hew-Butler et al. (2015) did not state gender as a risk factor for the development of EAH.

A major risk factor for developing EAH is high or low BMI (Almond et al., 2005; Bennett et al., 2013; Hew-Butler et al., 2015). According to recent studies, racers with smaller body size show lower sweat rates and lower metabolic rates (Sawka et al., 2007); they probably follow fluid intake guidelines for larger individuals (Bennett et al., 2013; Noakes, 2012; Rosner, 2009) and they are also more prone to overhydration (Hew-Butler et al., 2015). In Almond et al. (2005) study EAH was more developed in women. The difference between female and male athletes was not significant. Nevertheless, when we compared pre-race BMI between the EAH and the non-EAH group, the hyponatremic group had a lower pre-race BMI; however, the difference was not significant. Moreover, pre-race BMI did not relate to post-race plasma [Na^+] in the present study. The results suggest that body size did not explain the incidence of EAH with regard to BMI differences in present ultra-athletes.

Inexperience is one of multiple risk factors reported with EAH (Hew-Butler et al., 2015; Noakes, 2012). In Hoffman and Fogard (2011) and Hoffman et al. (2013), experience at ultra-marathons was also significantly lower among those with EAH. On the contrary, the risk of developing EAH was not related to weekly training distance in an Almond et al. (2005) study. We did not confirm the hypothesis that hyponatremic finishers were less experienced or less trained than normonatremic finishers. This is in contrast to studies, where slower and less experienced runners were more prone to have a lower plasma [Na^+] and developed EAH (Almond et al., 2005; Hoffman et al., 2013). However, the experience was about completions of 161 km marathons, and there was no evidence that EAH was associated with regular training experience and training level. Moreover, the risk of developing EAH was not related to race performance either (Hoffman & Fogard, 2011; Hoffman et al., 2013).

Between present hyponatremic and normonatremic group we found differences in post-race plasma [Na^+] and percentage change in plasma [Na^+] (Chlíbková et al., 2016). In summary, the primary etiology and pathophysiological mechanism underlying EAH in the present ultra-endurance athletes group was presumably overconsumption of hypotonic fluids in likely combination with non-osmotic arginin vasopressin secretion as we stated in our previous studies (Chlíbková et al., 2014; Chlíbková et al., 2015; Chlíbková et al., 2016). Also drinking habits pre- and during the race could influence the prevalence of EAH in the present group (Chlíbková et al., 2016). None of the present pre-race variables were helpful in identifying of EAH, similarly as in a Wegelin and Hoffman (2011) study. These findings indicate that measurement of blood [Na^+] concentration remained the only viable means for determining EAH in ultra-endurance athletes (Hew-Butler et al., 2015).

Age, pre-race body mass, BMI, pre-race training, experience and race performance

Present faster ultra-athletes were significantly older than slower ultra-athletes. However, finish times were slower with advancing age above 38 years in the Wegelin and Hoffman study (2011) of 161 km ultra-runners. On the contrary, there was no trend of slowing down for older athletes in a recent study of the 100 km ultra-runners athletes in the age group 18–24 years (Rüst, Rosemann, Zingg, & Knechtle, 2015). Also in a study of ultra-runners in the "Marathon des Sables" – the world's largest multistage ultra-marathon (Jampen, Knechtle, Rüst, Lepers, & Rosemann, 2013) in contrast to women, men aged 35 to 44 years improved running speed between 2003 and 2012. Performance improved in women aged 40–44 years but decreased in male runners aged 18–49 years in the 78 km "Swiss Alpine Marathon", the largest mountain ultra-marathon in Europe (Rüst, Knechtle, Eichenberger, Rosemann, & Lepers, 2013). Future studies are needed to investigate the reasons for an improvement of masters' athletes in endurance performance (Jampen et al., 2013).

Another finding was that present faster athletes showed a lower pre-race BMI. Sharwood, Collins, Godecke, Wilson, and Noakes (2002) and Dietrick (1991) also found that starting body weight in triathletes predicted performance in the cycle and the run leg so that lighter athletes were faster. The current study demonstrates that 76.4% men and 100% women had BMI values under 25 kg/m^2. In Hoffman and Fogard (2012) study 77.6% men and 100% women had values between 18.5 and 25 kg/m^2, as the optimal range for the general population. Similarly, as in a study mentioned above (Hoffman, 2010) or in other Hoffman studies, we found no significant relationship of BMI with age (Hoffman, 2008; Hoffman, 2010). That means, finishers maintain a healthy body weight with advancing age. Furthermore, logically, male ultra-athletes had significantly higher pre-race body mass and BMI compared to female ultra-athletes. The interesting fact was that present female ultra-athletes with a lower pre-race body mass trained more than female athletes with a higher body mass; however, they were not faster in the race. The inverse association of absolute order with pre-race training was expected since the importance of training for these events is well recognized (Hoffman & Fogard, 2012). Finish time was negatively associated with the highest weekly training volume in Hoffman and Fogard (2012) study. Nevertheless, this fact was confirmed neither in the male, nor in the female group in the present study. A higher training volume probably helps female athletes to maintain lower pre-race body mass. However, it is necessary to mention that association of higher weekly training volume with BMI was not confirmed.

In addition, the present study found that the more experienced ultra-athletes, with more years of training and a higher number of completed ultra-marathons were faster than less experienced ultra-athletes. The number of ultra-marathons completed by the present participants ranged from 5.3 (4.9) (mountain bike stage racers) to 15.6 (18.4) (24 hours ultra-runners). The number was even higher than in 161 km ultra-marathon runners (Hoffman, 2010) with an average of 4.7 (6.9) finished similar races and 4.6 (7.8) races (Winger et al., 2013), or 3.3 finishes (Hoffman, 2010), respectively.

Limitations

Surveys were completed by a rather small percentage of finishers with EAH. Moreover, in each race there was a different number of finishers due to the field nature of research and the difficulty of such types of races, so future work during races in the Czech Republic is warranted. High or low BMI as one of the risk factors for the development of EAH with possible association with female gender needs to be verified in other races with a higher number of female finishers in the Czech Republic. Future studies are needed to determine if EAH increases the risk of long-term health problems, and to evaluate the variability in plasma [Na^+] and body weight in the days prior to a race, at the event start and during the event (Hew-Butler et al., 2015).

Conclusion

The primary focus of this study was to find any association between the occurrence of EAH and pre-race characteristics or race performance in the present group of ultra-endurance athletes. There were no group differences between hyponatremic and normonatremic ultra-athletes in age, gender, club membership, pre-race BMI, regular training, experience or race placement. Pre-race body mass and BMI related to race performance only in normonatremic ultra-athletes, not in hyponatremic athletes. In summary, pre-race characteristics did not distinguish those finishers developing EAH from those not developing EAH.

Overall, faster finishers were older and more experienced than slower finishers. Athletes with lower pre-race body mass and pre-race BMI developed better race performance. On the contrary, gender, club membership or total weekly training or cycling/running hours did not influence race performance. A higher weekly training volume was associated with a lower pre-race body mass in female racers; however, it did not relate to race performance or pre-race BMI. It seems that experience plays a more important role in ultra-endurance races than the volume of hours or kilometers spent training. However, in the case of female racers, it helps them to maintain lower pre-race body mass.

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Conflict of interest

There were no conflicts of interest.

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