A preliminary report on voluntary fluid intake of adolescent elite athletes during training: a cause for concern?

Frank E Marino & Michael Gard
School of Human Movement Studies
Charles Sturt University
Bathurst NSW 2795

P 61 2 6338 4268
F 61 2 6338 4065
E fmarino@csu.edu.au

The failure to thermoregulate or tolerate the ambient conditions during prolonged exercise remains a significant concern for sporting officials. The typical medical conditions that manifest during exercise heat stress are heat cramps, heat exhaustion and heatstroke [1]. Each of these conditions have related symptoms that a clinician identifies so that appropriate management and treatment is initiated. Whereas symptoms of heat related injury are well known, the underlying mechanisms that lead to these injuries or illnesses are less well understood. There is consensus that certain intervention strategies are able to reduce the incidence of thermal illness. In fact, event organisers and officials advocate that hydration, appropriate training and a level of acclimatisation are strategies that competitors should consider prior to engaging in long duration physical work, particularly when ambient temperatures are high. The basis of these intervention strategies are related to the common observation that a rise in rectal temperature to 39.5 – 40 °C is associated with a termination of exercise regardless of training or acclimation status of the individual [2-4] in addition to the findings that hydration provides less physiological strain [5-7]. All of these studies provide the evidence that leads to the overwhelming view that drinking is a safe and reliable way to avoid thermal illness and prevents a reduction in physical performance. This aspect has been seized upon by the sports drink industry which advocates that drinking enough fluid to replace sweat loss, or rather negate the reduction in body mass, is the preferred strategy. The intuitive response of athletes generally is to drink copious amounts of fluids containing electrolytes and carbohydrates developed by the sports drink manufacturers. The consequence of this behaviour is the increased risk of developing exercise associated hyponatremia (EAH); a condition which develops from over drinking and is potentially lethal. The death of Dr Cynthia Lucero in 2002 following her collapse in the Boston Marathon and the subsequent inquest which confirmed that she developed *hyponatremic encephalopathy* from ingesting large volumes of Gatorade, provides the catalyst for studying this potentially lethal condition and its prevention [8]. Finally, a recent finding confirms that athletes over-drink as 12.5% of 88 athletes competing in the 2006 London Marathon were found to have developed EAH even though the race conditions were favourable (9-12 °C, 73% relative humidity) [9].

It is becoming clearer that greater emphasis should be placed on educating the athletic community, especially junior athletes, about the possible consequence of over drinking so that long term health risks can be avoided or at least minimised. As far as we are aware there are no available studies which have examined the attitudes and knowledge base of young athletes about the use or misuse of hydration for exercise performance although one study has reported that adolescent males can gauge fluid intakes during treadmill running so that dehydration is avoided [10]. In addition, there are no studies that have effectively measured the consumption of fluids during training and competition of young elite athletes with a view to matching this practice to their knowledge base and attitudes. Any studies which can establish the understanding and current practice of young athletes with respect to drinking for maximising exercise performance would be well positioned to develop educational strategies to assist in the minimisation of health risks associated with hydration strategies.

Therefore, the purpose of this study was to ascertain junior athletes' knowledge about, and attitudes towards voluntary drinking; compare these data against junior athletes' observed voluntary drinking behaviour and; determine what proportion of junior athletes are in danger of under and/or overdrinking.

Methods

Subjects

The participants were recruited from the Western Region Academy of Sport in NSW across a Netball, Basketball, Hockey. This provided the opportunity to recruit athletes which were selected for their abilities to compete at state and national levels in their respective sports. The study was approved by the Ethics in Human Research Committee of the University before each participant and their legal guardian signed a letter of informed consent.

Design and measurements

Participant recruitment

The number of participants was 67 comprising 45 females aged 14.8 ± 0.9 years and 22 males aged 14.3 ± 0.7 years. As each squad undertakes a program of training over a sustained period, usually two days at a time before a major competition, the opportunity to monitor and measure the fluid consumption, attitudes and knowledge about hydration of elite junior athletes was invaluable. Prior to participating in the study, the researcher explained the study procedures and requested that participants not change their hydration habits.

Study design and procedures

The training day lasted approximately 6 h starting at 0900 and ending at 1500 with scheduled minor breaks throughout. In total the squads completed ~ 5 hours of training which included specific skill drills and small sided games. At each training venue the researchers provided all fluid to be consumed; plain water or commercially available sports drinks, which were available *ad libitum*. Each participant was permitted to fill his/her drink bottle at any time with the type, amount and frequency of fluid recorded. Prior to either discarding the fluid or filling the drink bottle it was weighed to the nearest 5g on a precision balance. In addition, body mass was recorded prior to commencing training, before and after each time the athlete emptied their bladder or voided and at the end of the training session. Body mass was measured whilst the subjects were dressed in their specific training uniforms which comprised singlet top and shorts or in the case of netball a once piece lycra uniform. Participants removed their shoes before being weighed. Urine specific gravity (USG) was used to assess the hydration status of subjects [11]. Urine samples were collected in a sterile container on each occasion the participant emptied their bladder. The sample was then given to the researcher for duplicate analysis of USG by pipetting a 1 mL sample onto an electronic refractometer which was cleaned and calibrated with deionised distilled water before each measurement.

Interviews

In addition to the collection of quantitative data, structured interviews with a random selection of participants was undertaken to determine the expectations, attitudes and knowledge base about drinking for exercise performance. The athletes were asked a series of predetermined questions about their drinking preferences, including the reasons why they drink, what they drink, how much they should drink and how much they actually drink. Interviews were conducted individually and lasted between 15 and 20 minutes. Variation in the duration of interviews occurred because different athletes had different levels of knowledge about sports hydration and, therefore, more or less to say.

Statistics and analysis

Descriptive statistics were generated for all quantitative data. Dependent and independent t-tests were used to compare commencing and finishing measurements for mass and USG for the entire sample and between males and females, respectively. Data are presented as means

± SD. Statistical significance was set at $P < 0.05$. Qualitative interview data were analysed using standard interview coding procedures. Specifically, responses were sorted into themes which were then used to identify similarities and differences between athletes. For example, identifying key concepts, words and ideas that seem important to respondents which are were then used to form summarising themes. At the same time, responses which diverge from the general view of the sample were also instructive as they may indicate a diversity of views and understandings.

Results

Body mass

The body mass at the commencement of the training session was 65.14 ± 12.17 kg and increased significantly by 0.84 ± 1.48 kg to be 65.97 ± 11.79 kg ($P = 0.0001$) at the end of the training session. The female participants commenced with a body mass of 64.17 ± 11.91 kg which increased significantly by 1.26 ± 1.89 kg to be 65.41 ± 10.95 kg ($P = 0.0005$) by the end of the session. Similarly, the males increased their commencing body mass from 69.17± 14.03 kg to 69.89 ± 14.15 kg ($P < 0.0001$) representing a difference of 0.72 kg. However, the difference in mass between males and females at the end of the session was not statistically significant.

USG and fluid consumption

The total fluid consumption over the training session was 1435.76 ± 848.84 mL. However, the males consumed 970 ± 530mL whilst the females consumed 1900 ± 800 mL ($P < 0.0001$). The USG at initial presentation was 1.021 ± 0.006 $g.mL^{-1}$ and was significantly different at the end of the training session USG value of 1.013 ± 0.010 $g.mL^{-1}$ ($P = 0.0001$). The females presented with a USG of 1.020 ± 0.007 $g.mL^{-1}$ which decreased to 1.014 ± 0.010 $g.mL^{-1}$ (P =

0.005). The males presented with a USG of 1.021 ± 0.006 g.mL^{-1} which decreased significantly to 1.012 ± 0.007 g.mL^{-1} (P = 0.002). The type of fluid consumed over the course of the training session changed so that sports drinks comprised only 5.4% of the fluid compared to plain water. This subsequently changed to be ~53% sports drink by the end of the training session.

Interview responses

The interviews revealed that hydration was an axiomatic dimension of being an athlete. In fact, they appear to see regular and, in some cases, continual hydration as a normal and unquestioned behaviour. Some interviewees reported drinking before, during and after training and most reported drinking continually while at school and at home. This is interesting for many reasons, not least because few, if any, of the athletes were able to offer clear reasons for, or benefits of, hydration beyond the prevention of what they called 'dehydration'. None of the athletes was able to say what 'dehydration' means. In two cases hydration was justified in terms of cramp prevention. In other cases, athletes tentatively suggested that hydration was something that improved 'stamina' or 'endurance'.

The issue of endurance also came up when athletes were asked about their choice of fluids. Approximately half reported that they did not use commercial sports drinks or at least used them rarely. Those that did use commercial sports drinks reported using them because a coach or parent had encouraged them to do so and because of a general belief that the extra carbohydrate in commercial sports drinks would provide a boost to endurance.

However, regardless of justification, all athletes reported that their hydration behaviour was the result of advice they received from parents or coaches.

All athletes described their hydration behaviour as ‘a little bit all the time’ rather than ‘a lot only when thirsty’. Two reported drinking to avoid the feeling of ‘dry mouth’. Observations of the athletes during training suggested that, at least in part, drinking was used as a behaviour to fill in time, something that is done when there is nothing else to do. Some of the athletes said that coaches encouraged them to drink during the breaks in training.

All athletes reported consuming significant amounts of fluid while training. They estimated consuming between approximately two and four litres for an extended training session (two hours or more) and some reported drinking up to three litres during the course of a normal school day where no sports training occurred.

In short, the practice of continual and significant hydration appears to have become a habit for the young athletes we interviewed. Hydration occurred despite little knowledge about its effects and was uniformly encouraged by parents and coaches. None of the athletes interviewed made any mention of the dangers or even the possibility of drinking too much.

Discussion

The intent of this study was to examine the drinking behaviour of young athletes during training with minimal interference by the researchers. Under the conditions of extended training, the novel finding is that young elite athletes drink excessively which is possibly related to the perception that dehydration will negatively affect their performance. The evidence for this is the significant body mass gain in the course of the training session so that in both males and females there was an increase of almost 1 kg. A USG of ≤ 1.020 g.mL^{-1} is regarded as representative of a euhydrated state [11-13]. The athletes in the present study commenced with a USG of 1.021 g.mL^{-1} which was similar among both males and females. The USG at the end of the training session decreased significantly to be 1.013 g.mL^{-1}. In a previous study, the USG following a 60 min treadmill run was reduced from ~ 1.025 $g.mL^{-1}$ to ~ 1.015 $g.mL^{-1}$ in males but in females the reduction was ~ 1.016 $g.mL^{-1}$ to ~ 1.009 $g.mL^{-1}$. This is not dissimilar from the present results which indicate that female athletes are at greater risk of drinking more than males (~ 1000 mL) [14, 15]. Although we did not directly measure sweat rate it is apparent that the increase in body mass reflects either an exercise intensity which did not elevate the body temperature in order to invoke a sufficient sweat rate for there to be a significant reduction in body mass. However, if this is the case, then this only compounds the problem of fluid intake as it suggests that the volume of fluid ingested over the course of the training session was not warranted at least on the basis of replacing fluid lost through sweat. On this basis, the interview data indicate that fluid intake is not necessarily related with thirst but rather the perception that “more fluid is best”.

Notably, recent research indicates that adolescent males may be better at estimating hydration needs and avoiding dehydration [10]. These authors showed that adolescent males were able to estimate the fluid ingestion irrespective of whether it was plain tap water, flavoured water or a 6% carbohydrate solution so that changes in body mass was not greater than about -0.66%. In the present study, the changes in body mass were positive and not significantly different between males and females although there was a trend for females to have greater increase in mass (1.26 vs 0.72 kg, respectively).

The interview data suggests that these young athletes consider dehydration as a serious condition warranting higher levels of fluid ingestion. However, dehydration is a condition that can be completely reversed and usually is not life threatening or even detrimental to performance given that the loss of body mass as high as 8-10% in elite runners has been shown not to compromise performance [16-20].

In summary, elite junior athletes seemingly over drink during extended training sessions which is likely associated with the perception that ‘over-hydrating’ will prevent dehydration and maintain exercise performance. There is also the real possibility that some junior athletes are at risk of developing EAH.

References

1. Noakes TD, Adams BA, Myburgh KH, Greeff C, Lotz T, Nathan M. The danger of an inadequate water intake during prolonged exercise. *Eur J Appl Physiol*. 1988;57:210-9.

2. Montain SJ, Coyle EF. Influence of the timing of fluid ingestion on temperature regulation during exercise. *J Appl Physiol*. 1993;75(2):688-95.

3. Nielsen B, Hales JRS, Strange S, Christensen NJ, Warberg J, Saltin B. Human circulatory and thermoregulatory adaptations with heat acclimation and exercise in a hot, dry environment. *J Physiol (London)*. 1993;460:467-85.

4. Sawka MN. Physiological consequences of hypohydration: exercise performance and thermoregulation. *Med Sci Sports Exerc*. 1992;24(6):657-70.

5. Nybo L, Jensen T, Nielsen B, González-Alonso J. Effects of marked hyperthermia with and without dehydration on VO2 kinetics during intense exercise. *J Appl Physiol*. 2001;90:1057-64.

6. González-Alonso J, Calbert JAL, Nielsen B. Muscle blood flow is reduced with dehydration during prolonged exercise in humans. *J Physiol (Lond)*. 1998;513(3):895-905.

7. González-Alonso J, Mora-Rodriguez R, Below PR, Coyle EF. Dehydration markedly impairs cardiovascular function in hyperthermic endurance athletes during exercise. *J Appl Physiol*. 1997 April 1, 1997;82(4):1229-36.

8. Smith S. Marathon runner's death linked to excessive fluid intake. Boston Globe. 2002 13 August.

9. Kipps C, Sharma S, Tunstall Pedoe D. The incidence of exercise-associated hyponatremia in the London marathon. *Br J Sports Med*. 2011;45:14-9.

10. Wilk B, Timmons BW, Bar-Or O. Voluntary fluid intake, hydration status, and aerobic performance of adolscent athletes in the heat. *Appl Physiol Nutr Metab*. 2010;35:834-41.

11. Sawka MN, Burke LM, Eichner ER, Maughan RJ, Montain SJ, Stachenfeld NS. ACSM Position Stand: Exercise and fluid replacement. *Med Sci Sports Exerc*. 2007;39:377-90.

12. Popowski LA, Oppliger RA, Lambert GP, Johnson RF, Kim J. Blood and urinary measures of hydration status during progressive acute dehydration. *Medicine and Science in Sports & Exercise*. 2001;33(5):747.

13. Armstrong LE, Maresh CM, Castellani J, Bergeron M, Kenefick R, LaGasse K, et al. Urinary indices of hydration status. *Int J Sport Nutr*. 1994;4(3):265.

14. Hew-Butler T, Almond C, Ayus JC, Dugas J, Meeuwisse W, Noakes T, et al. Consensus Statement of the 1st International Exercise-Associated Hyponatremia Consensus Development Conference, Cape Town, South Africa 2005. *Clin J Sport Med*. 2005;15(4):208-13.

15. Silva RP, Mündel T, Altoé JL, Saldanha MR, Ferreira FG, Marins JCB. Preexercise urine specific gravity and fluid intake during one-hour running in a thermoneutral environment – a randomized cross-over study. *Journal of Sports Science and Medicine*. 2010;9(3):464-71.

16. Sharwood KA, Collins M, Goedecke JH, Wislon G, Noakes TD. Weight changes, medical complications, and performance during an ironman triathlon. *Br J Sports Med*. 2004;38:718-24.

17. Noakes TD. Oral fluids: How pseudoscience gulls the gullible. *S Afr Med J*. 2008;98:410-2.

18. Noakes TD. Drinking guidelines for exercise: What evidence is there that athletes should drink "as much as tolerable", "to replace the weight lost during exercise" or "*ad libitum*". *J Sports Sci*. 2007;25:781-96.

19. Noakes TD, Speedy DB. Case proven: Exercise-associated hyponatremia is due to overdrinking . So why did it take 20 years before the original evidence was accepted? *Br J Sports Med*. 2006;40:567-72.

20. Noakes TD. Overconsumption of fluids by athletes. *Br Med J*. 2003;327:113-4.