SSE #246

Sports Science Exchange (2024) Vol. 37, No. 246, 1- 6

GATORADE SPORTS SCIENCE INSTITUTE

THE HEALTHY YOUTH ATHLETE – REINFORCING THE ROLE OF HYDRATION

Michael F. Bergeron, Ph.D., FACSM
Hydration Health Center, University of Hartford, West Hartford CT

KEY POINTS

- Sound daily hydration management for a youth athlete extends beyond just sport performance to also facilitating academic achievement and overall health.
- Establishing sensible hydration behaviors as a youth athlete can be instrumental in underpinning healthy hydration habits as an adult that enable wellness and help to maintain long-term health.
- As youth develop and advance through sport, they need to develop personal initiative and autonomy to make healthy and ethical decisions about their involvement in sport, including managing their own hydration needs and strategies.
- Contemporary approaches utilizing multi-domain, complex systems and state-of-the-art tools and methods will be instrumental in fully recognizing the wide-ranging role and contribution of hydration to youth athletes' health and sustainable sport participation and performance.

INTRODUCTION

Youth sport participation can be enjoyable and highly rewarding. Beyond the recognized psycho-social benefits and improvements in overall health and fitness, positive impacts can extend to academic achievement and even career success later in life (Eime et al., 2013, Kniffin et al., 2015, Silva et al., 2013, Singh et al., 2012, Trudeau & Shephard, 2008). Whereas numerous diverse factors can interfere with or assist in achieving these objectives, daily hydration management and one's resulting habitual hydration status are notable contributing aspects that frequently are not given their due attention. Moreover, establishing sound hydration behaviors early can be instrumental in underpinning healthy hydration habits that are maintained and possibly even carry over as an adult (Rodger & Papies, 2022).

With youth athletes, daily water intake patterns, including varying frequency and overall volume, profoundly impact and shape countless physiological processes aligned with normal growth and development, as well as engaging in sport. The ensuing functional support or consequent strains from these fluctuations in hydration status, in turn, can acutely influence a wide range of one's mental, physical and thermoregulatory capacities. If sustained or repeated routinely, the impact can extend to other aspects of wellness, morbidity and long-term health. In this Sports Science Exchange (SSE) article, the focus is on three key interrelated domains that are integral to this hydration-based paradigm for all youth participating in sport – a) cognition, learning and academic achievement, b) heat safety and sport performance and c) chronic health. Whereas performance is the predictable emphasis for youth athletes (and many around them), consistent and apt daily hydration management can likewise facilitate academic achievement and acute and long-term health. Correspondingly, these complementary attributes are fundamental and mutually reinforcing to athletic development, sustainable sport success and lifelong physical activity and well-being.

COGNITION, LEARNING AND ACADEMIC ACHIEVEMENT

As youth athletes grow and develop, there are extensive structural and functional changes and ongoing neural reorganization in the brain that parallel the dynamic patterns and non-linear continuum of individualized cognitive development (Yates et al., 2021). Notably, across adolescence, the cognitive, cognitive control and socio-cognitive processes involving attention, memory, planning, self-regulation, reasoning and motivation are rapidly refined and integrated to enable thinking and behaving in more complex and abstract ways (Kilford et al., 2016).

The effects of inadequate hydration on cognition in children and young adults have been examined in the context of sport, though the supporting extant literature is not robust. Correspondingly, at least with team sport, the impact on cognitive performance remains unclear, despite the potential contributing adverse effect on selected relevant subcomponents (Nuccio et al., 2017). More generally, a thorough review of the integral contributive role of water intake and hydration status in basic and higher-order healthy cognitive functioning reinforces this understated association even at mild levels of dehydration that are characteristic of children (Merhej, 2019). However, more recently, an exploratory systematic review on hydration and cognitive function in children primarily in school settings only further underscored the limited extent of evidence. Nonetheless, acute fluid consumption was consistently shown to enhance short-term cognitive task performance (Almalki et al., 2022, Drozdowska et al., 2020). However, these effects may be somewhat moderated by overall daily hydration status (Perry et al., 2015).

The demonstrated effects of water intake and hydration on cognitive skills and performance in children have corresponding potential implications on school behavior and learning (D'Anci et al., 2006). Although, while the connection between hydration and learning is not, to date, well-established in developing youth athletes and other

children, more inclusive longitudinal research across the involved domains will no doubt be more revealing. Yet, regular exercise and participation in school sport can indeed have clear positive effects on cognitive skills, performance and academic achievement (Donnelly et al., 2016, Singh et al., 2012, Trudeau & Shephard, 2008) and appropriate routine hydration is fundamental to sustainable physical activity. Likewise, consistent learning and academic performance generally open opportunities for youth to participate in sport.

HEAT SAFETY AND SPORT PERFORMANCE

Acute and habitual water intake can markedly impact risk to an athlete's well-being and health during sport participation, exercise and other physical activity in the heat, as largely aligned with the pronounced cardiovascular and thermoregulatory demands (Bergeron et al., 2011, Sawka et al., 1998). Moreover, hydration status can have a measurable bearing on exercise/sport performance, especially in the heat, as cardiovascular stability, thermoregulation, neuromuscular control and fatigue, heat tolerance and perception of effort are often considerably challenged (Cheung & Sleivert, 2004, Cheuvront & Kenefick, 2014, Nuccio et al., 2017, Sawka et al., 2001). More broadly, proper preparation for activity and recovery hydration strategies are likewise integral to exercise/sport performance and well-being, especially with long duration activities or same-day repeated bouts where drinking voluntarily and regularly to thirst during or between each session may not be sufficient to avert a significant body water deficit (Bergeron, 2003, Capitan-Jimenez & Aragon-Vargas, 2022, Suh & Kavouras, 2019).

There had been a long-standing perspective that children are less effective than adults in regulating body temperature, correspondingly less tolerant to a hot environment, and thus inherently at greater risk for incurring exertional heat illness during sport participation in the heat (American Academy of Pediatrics, 2000). More current research indicates, however, that amply hydrated youth have sufficient cardiovascular capacity, effective thermoregulation and thus adequate exercise-heat tolerance in a wide range of environmental conditions (Falk & Dotan, 2011, Leites et al., 2016, Rowland, 2008). Therefore, the emphasis on sensible and effective heat safety guidelines and policies for youth athletes participating in sport in hot and/or humid weather should focus on practical and readily modifiable corresponding risk factors. As local environmental conditions warrant, these would include adjusting the intensity and duration of activity, frequency and duration of breaks, feasible cooling interventions, recovery time between sessions and contests and hydration management (Bergeron, 2013, Bergeron et al., 2011, Bongers et al., 2015).

Adolescent athletes sweat at rates that can readily exceed 1.0 liter per hour (L/h) during sport participation, whether in practice or during competition, especially with late pubertal boys and girls and in hot and/or humid conditions (Bergeron et al., 2006, Rivera-Brown & Quiñones-González, 2020). Whereas sweating capacity is generally much lower in younger boys and girls (e.g., 9-14 years) (Aragón-Vargas et al., 2013, Bergeron et al., 2009, Falk et al., 1992, Rowland et al., 2008). Notably, as a youth athlete grows and physically, physiologically and athletically develops and matures, individual sweating levels in older adolescents progressively increase and can reach 2.5 L/h or more (Bergeron, 2003, Falk et al., 1992, Nuccio et al., 2017). In addition, sweat loss will be markedly greater for all youth athletes when they are wearing protective equipment and uniforms that do not facilitate heat exchange, thus exacerbating the risk of incurring a measurable body water deficit (McDermott et al., 2009, Yeargin et al., 2021). The cumulative effect can be particularly evident when participating in multiple same-day sessions over successive days (Bergeron et al., 2009, Stover et al., 2006).

Generally, the emphasis for all youth athletes should be to be well-hydrated prior to each practice and competition. Further, it is essential to avoid (to the extent feasible) incurring any appreciable body water deficit (e.g., any level greater than 2% or 3% of body mass from a euhydrated state), as this can impose greater cardiovascular and thermal strain and perception of effort, thus lowering corresponding exercise-heat tolerance, performance and safety (Bergeron, 2015).

CHRONIC HEALTH

The beneficial effects of hydration on acute and selected aspects of long-term health in the general population have been widely examined and, in some regards, purportedly well-established. However, the evidence-based impact of routine hydration behavior, water intake and thus sustained typical hydration status across the lifespan on these and noted other key clinical expressions of chronic health is not robust or consistently corroborated (Liska et al., 2019). Whereas, for example, the evidence for kidney stones and type 2 diabetes/hyperglycemia being associated with daily water/fluid consumption is strong (Cheungpasitporn et al., 2016, Janbozorgi et al., 2021), the effectiveness of ample water intake interventions on the progression of other diseases (e.g., chronic kidney disease) is not well-supported (Clark et al., 2018).

More specific to this SSE article, how early in life such risk can be mitigated and what level of habitual hydration can make a lasting positive difference are questions that remain to be answered. Correspondingly, the respective lack of a supporting evidence base is likely largely due to incomplete or limited research approaches that are not fittingly designed to reveal the impact of maintaining (or not) routine daily hydration on chronic health. Thus, more comprehensive rigorous investigations that include youth and continue tracking key broad metrics of health through adulthood are likely to be far more informative in highlighting these connections.

For youth athletes, linking proper hydration management to supporting acute health and wellbeing and performance during sport is clear. The fitness and health benefits of exercise and sport participation is also widely recognized. These two perspectives can thus be justifiably merged and extended to underscore how proper hydration management, by acutely supporting sustainable exercise and sport engagement, in turn, helps to fundamentally enable a more sustainable pathway for enhanced overall and chronic health. Moreover, with suitable regular

hydration habits and practices as a youth athlete potentially underpinning hydration beliefs and behaviors after sport as an adult, the stage may be set for long-term health by mitigating the risk or impeding early onset or progression of certain chronic diseases (Clark et al., 2016, Tasevska et al., 2016). Being healthier (with the support of habitual proper hydration) can enable and inspire a reciprocally beneficial more active lifestyle as an adult (Hargreaves, 2021).

WHO IS RESPONSIBLE?

Nutritional strategies to enhance individual athletic performance and recovery during training and competition have been well-described, and ample and proper hydration is clearly underscored in many recognized authoritative statements and comprehensive reviews (McCubbin et al., 2020, Thomas et al., 2016). Nonetheless, many youth athletes (more often characteristically with adolescent boys) strive for a performance advantage by taking supplements over well-timed and appropriate healthy food and fluid intake (Diehl et al., 2012). Therefore, the fundamental emphasis to all youth in sport needs to consistently stress the overwhelming inherent value to health and performance from a nourishing balanced diet with ample energy and proper and timely individualized hydration to support growth and maturation and their respective sport demands (Desbrow et al., 2014).

Beyond the inherent education, guidance and oversight roles of parents, healthy hydration practices can be reinforced to youth athletes through demonstrated examples of their lifestyle behaviors and by making water and other healthy beverages readily available and an encouraged daily priority (Suh & Kavouras, 2019). Pediatricians, sports dieticians and other health professionals can also be instrumental in educating youth athletes and those providing supervision on sport health and safety including sound hydration management strategies. Moreover, these professionals can actively participate as school team health providers and serve on school wellness committees or school boards to widely reach parents, coaches and administrators (Bergeron et al., 2011, Thomas et al., 2016).

In youth sport, the coaches' interactions with their athletes are decidedly among the most powerful influences on the athletes (Erickson et al., 2011). However, the ultimate responsibility for maintaining hydration lies with each youth athlete. Of course, by virtue of being 'young', youth athletes are not independent. Accordingly, there is considerable ongoing oversight, management and control by adults throughout each day (including at school) that can either facilitate or limit hydration opportunities and consumption (Bottin et al., 2019). This is especially relevant with coaches during sport practices, travel and competitions. Still, as youth develop and advance through sport, these pivotal relationships and interactions with adults should also facilitate the athletes developing personal initiative, autonomy and character that compel healthy and ethical decisions about their involvement in sport (Fraser-Thomas & Côté, 2009), including recognizing and managing their own hydration needs and strategies (Chia et al., 2015). This can be seen as a contributing piece in establishing a healthy and more sustainable balance between the provision of support and measured autonomy in the evolving process to equip and encourage each youth athlete to act more independently (Li & Julian, 2012). With high-level athletes, this is especially impactful in gaining confidence and assurance in their overall abilities and competition readiness.

ASSESSING HYDRATION IN YOUTH

Over the past decade, there has been a seemingly spontaneous evolution of advanced technology and personal monitoring devices, including a wide assortment of popular wearables and athlete/sport applications. This rapidly emerging category is aimed to help athletes, coaches and performance analysts instantaneously collect and assess a vast array of data corresponding to various physiological responses, athletic movements and load during training and sport competition, along with selected aspects of health, to purportedly achieve a performance advantage. Some instruments and platforms are explicitly designed to noninvasively monitor hydration status via direct measurement from sweat, saliva or urine. These tools and applications are designed and promoted to aid in defining, interpreting and tracking one's hydration-related signatures across sport-specific and various other non-clinical scenarios and environmental conditions. Such individualized responses and profiles could be notably useful in regularly monitoring youth athletes, as inherent and behavioral hydration-related patterns unpredictably change with the timing and tempo of growth and maturation across adolescence. In many instances, however, the specific metrics are not reliably consistent, and the automated data management, one-dimensional interpretations and ensuing recommendations provided to users are frequently biased and/or oversimplified, and thus potentially erroneous. These limitations readily undermine any accompanying hydration status insights, practical decision support and meaningful gains for the athletes (Gray et al., 2023, Shei et al., 2022).

Accordingly, hands-on and simple methods for estimating hydration needs and status in youth athletes by the athletes and their parents, coaches and athletic training and medical support teams remain acceptable estimation standards. Assuming any acute change in body weight during strenuous physical activity is primarily due to changes in total body water, this difference can be conveniently used to assess sweat loss during practice and competition in the heat and thus estimate any remaining rehydration needs (Cheuvront et al., 2015). Subsequently, to check the adequacy of rehydration, first morning urine – implicitly through observing color – is a viable complementary method for generally confirming sufficient water consumption or revealing potential underhydration (Munoz & Bergeron, 2023, Perrier et al., 2017).

THE FUTURE FOR HYDRATION HEALTH IN YOUTH SPORT

It is essential to appreciate the key complex psychobiological systems that are central to managing the ongoing interplay between maintaining water balance and the numerous concomitant factors challenging hydration status in youth sport. Respectively, the corresponding relationships and risks to performance and health (acutely and long-term) cannot be accurately interpreted or anticipated by solely evaluating discrete hydration metrics, especially when the youth athletes under

observation are removed from the natural sport environment for testing and assessment. Accordingly, to fully recognize the extensive role and contribution of hydration to youth athletes' health and sustainable sport participation and performance, a contemporary approach utilizing multi-domain, complex systems and state-of-the-art tools and methods is warranted. Moreover, the research needs to go beyond simply identifying risk factors to achieving insights that would enable real-world implementation of advanced pattern recognition and flexible predictive classification modelling, thus providing more informed decision support (Bittencourt et al., 2016, Lopez-Valenciano et al., 2018).

More wide-ranging insights and corroborated perspectives resulting from this forward-thinking modern holistic approach will reduce the gap between research discovery in the laboratory and general acceptance and uptake of recommendations and guidelines (Finch, 2017). The emerging rigorously validated models will then be aptly translated to an assortment of new corresponding practical and evidence-informed applications for coaches, health care professionals and parents. With simple and seamless utility, individuals will be widely and independently enabled to clarify and thus mitigate their hydration-related challenges and consequent health risks (Dolci et al., 2022). Universal recognition and integration of this contemporary paradigm will be essential in making hydration and hydration health justifiably and routinely more prominent for youth athletes and those responsibly overseeing them.

PRACTICAL RECOMMENDATIONS

- Youth athletes and those adults overseeing them should appreciate the fundamental role of hydration beyond only during sport participation and always maintain an emphasis on sound hydration habits and behaviors throughout each day.
- Hydration needs progressively increase across adolescence, as youth athletes grow, mature and develop as athletes and in their sport(s). Accordingly, preparation, during sport activities, and recovery hydration strategies should be in parallel more deliberate and robust and increasingly responsibly managed by the athlete.
- Despite the advent and rapid evolution of modern technologies for conveniently monitoring hydration status, these novel and intriguing devices should not supplant self-monitoring of body weight changes incurred during training and competition and first-morning urine to generally gauge one's sport-related hydration needs and daily rehydration effectiveness.

SUMMARY

Hydration plays a key role for all youth athletes, where sound daily hydration management is central to sport performance and safety, along with generally facilitating learning and setting the stage for long-term health and well-being as an adult. A broad multi-domain network systems approach, using state-of-the-art technology, will enable a more optimal development and reinforce the valid utility of tools and applications designed to seamlessly track hydration status, as well as provide clarity to the underlying role of hydration in supporting acute and chronic health and mitigating disease risk.

The views expressed are those of the author and do not necessarily reflect the position or policy of PepsiCo, Inc.

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