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Do Current Pre-Exercise Fluid Recommendations for Athletes Need to be Updated? A Short Review

Short Review

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Abstract

Introduction: Maintaining adequate hydration throughout the day is extremely important, especially for the athletic population. While several recommendations have been developed to aid in timing (i.e., before, during and after exercise) and quantity of fluid intake, research has shown that approximately 70% of collegiate athletes arrive to practice in a dehydrated state. This review aims to identify the studies that have developed fluid protocols or utilized fluid recommendations for athletes prior to exercise.
Methods: Two databases and 13 search terms were used to find relevant articles.
Results: To date, several position papers, observational, and experimental (25 investigations total) studies that included a pre-exercise fluid recommendation and protocols to achieve euhydration were identified.
Conclusions: Many of the fluid recommendations and protocols identified are different and some are not supported with evidence. In addition, very few have utilized fluid recommendations based on body weight. Future research could further investigate the use of fluid protocols catered to body weight or based on other practical assessment methods, in an effort to make individualized hydration plans.

Key Words: euhydration, sport, fluid protocol

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Introduction

Hydration research has been ever evolving for several decades; however, the constant goal has been to assist in maintaining euhydration, which is the act of sustaining the body's normal fluid homeostasis.[1] This fluid balance fluctuates on a day-to-day basis through various normal biological functions, but typically the body is comprised of between 55-70% water.[2,3] Researchers continue to discover the consequences of hypohydration (i.e. body water deficit), including increased cardiovascular strain, impaired cognitive functioning, and impaired thermoregulation, to name a few.[4–7] Athletes are one population that have been found to experience these negative effects, which could lead to a decline in their athletic performance.[7–9]

Practioners who assess hydration status within the athletic populations tend to utilize more practical and inexpensive options, such as urine color, urine specific gravity (USG), and changes in body weight (BW). Urine color has been established as a valid hydration assessment method within several populations, against urine osmolality and USG.[10–12] Researchers determined that euhydration, based on urine color is considered $\leq$ 4 on the urine color chart.[13–15] Researchers using USG, through the use of a handheld refractometer, determined that euhydration for athletes could range from 1.018-1.020 when looking at 24hr USG samples and 1.024-1.026 for a first morning USG sample.[16–18] Some research has discovered variability in the USG threshold (i.e. euhydration <1.020, hypohydration >1.020);[9,18] however, the general consensus among recent studies has continued to utilize this threshold when assessing hydration status.[19–22] Although, when assessing urine indices, spot urine samples have been found to be less valid when compared to first morning voids.[7] However, recent research has determined that 24hr urine and late afternoon spot urine are equivalent when assessing hydration in children, using urine osmolality.[23] Changes in BW have long been used to assess fluid loss from exercise, and thus hydration status. To accurately utilize this measure for determining hydration status, a valid baseline BW (i.e. 3 consecutive days) must first be established.[15,24] Euhydration is considered ≤ 1% of BW change from baseline.[7,25] Therefore, with the ease of evaluating hydration status through various means, athletes can self-assess their status to determine if a fluid intervention is needed before exercise.

In a laboratory setting, researchers have investigated various outcomes during exercise for years, specifically requiring participants to arrive in a euhydrated state. For their participants to achieve euhydration before exercise, a specific fluid recommendation or ad libitum consumption was utilized.[26–33] Findings have shown that those who exercise in a euhydrated state exhibit lower core body temperatures, USG, urine color, heart rate, rate of perceived exertion, and the ability to exercise longer than their dehydrated counterparts.[29,32–34] However, these fluid recommendations for reaching a euhydrated state appear every changing and may not be translatable to a field setting. In fact, field researchers have discovered that the prevalence of dehydration among athletes, primarily before exercise, is approximately 70%.[10,16,35] Moreover, the recommendations that have been extensively studied and adapted are for post-exercise (i.e., rehydration) rather than pre-exercise. Therefore, this review aims to examine the evidence of pre-exercise fluid recommendations and protocols that were developed and are currently utilized by athletes and sports practitioners.

Methods

Study Criteria and Search Strategies

Eligibility criteria was developed based on the population, intervention, and study design. The populations included were only athletes and general, active individuals. Studies conducted in children, adolescents, pregnant women, the general elderly population, and animals were excluded. The interventions included were studies that conducted an exercise test and provided or mentioned a pre-exercise fluid recommendation to achieve euhydration at the start of exercise. The interventions excluded those studies with post-exercise (i.e., rehydration) fluid recommendations, those that provided fluids during exercise, fluid recommendations that included fluid additives (ex: glycerol), and exercise interventions that did not include a fluid recommendation.

Search terms were connected with Boolean search operators and some search terms included "hydration," "euhydration," "athlete OR athletes," "fluid intervention OR fluid protocol OR fluid recommendation," "pre-exercise OR pre-practice." Thirteen total search terms that were used. The main databases used for this review were PubMed and EBSCOhost. This review included randomized control trials (RCTs), experimental, observational, cohort, cross-sectional, review, and systematic review studies that were conducted between 1950-present.

Pre-Exercise Fluid Recommendations

Position Statements

Position statements/stands are developed through the use of evidence-based methodologies and critical analysis for certain issues or topics. These statements are written by numerous experts in the field who rate the evidence to determine major recommendations on a topic. It is well known that a hydration regimen should begin several hours before exercise to ensure euhydration at the start of exercise (see Table 1).[7,9,12,25,36,37] In fact, sports practitioners tend to utilize position stands developed from professional organizations, such as National Athletic Training Association (NATA) and the American College of Sports Medicine (ACSM), when educating athletes on pre-exercise hydration.[7,12,25,36] These position statements are updated every few years, as new research is conducted and changes in outcome measures are being discovered. However, some of the identified position statements do not provide a source for the pre-exercise fluid recommendation mentioned,[25,36,37] while others provide the source to their predecessor

position stand.[7,9,12] In addition, two of the position statements[7,12] refer to only one or two clinical trials[24,27,38] as the source for the development of those fluid recommendations. Moreover, each position statement appears to suggest a slightly different amount of fluid to be consumed leading up to the start of exercise. This could indicate that the fluid recommendations provided in previous position statements are no longer relevant, as newer position statements have since replaced them. Therefore, more clinical trials are needed within upcoming position statements to determine which fluid recommendations are more practical and appropriate for an athletic population.

There appears to be inconsistency within the current quantity recommended as some fluid recommendations provide an absolute (i.e., 400-600 mL of fluid) amount, while others provide a relative amount (i.e., 5-10 milliliters of fluid per kilogram of BW) that should be consumed within 2-4 hours before exercise. However, the most updated position statement from the NATA does not specify a certain amount of fluid, but rather suggests that athletes utilize a variety of outcomes measures (i.e. urine color, thirst, changes in BW) to develop individualized hydration plans.[7] Therefore, to develop a more individualized hydration plan, more research needs to be done to identify the appropriate amount of fluid relative to body mass to ensure euhydration before exercise. One review article[39] was found to be the source for the position statement developed by the Academy of Nutrition and Dietetics (AND) to ensure euhydration, based on Armstrong's urine color chart.[9,26] With urine color being a validated hydration assessment method, future research could investigate a variety of fluid recommendation amounts in coordination with the 8-color urine color chart.[13]

Pre-Exercise Fluid Protocols

Several of the studies identified in Table 2 have either developed or utilized a specific fluid protocol for their athletes to achieve euhydration prior to exercise. These protocols are conducted or mentioned within several different types of studies, including observational studies and randomized control trials.

Epidemiologic/Observational Studies

Several of the early epidemiologic studies (i.e. conducted within 1990's) either prescribed a specific amount of fluid or ad libitum consumption to ensure exercise began within a euhydrated state (see Table 2).[1,26,33,40] While some of these studies might have been used as sources for the previously mentioned position statements, they do not appear to contain a source or justification for their fluid protocol. For instance, a study conducted in 2000 by Casa and colleagues prescribed ad libitum consumption based on a study conducted by Riebe and colleagues, who does not provide a source for its protocol.[30,33] Moreover, the fluid protocols prescribed varied in both quantity and when the fluids should be consumed (i.e., night before or hours before exercise). In addition, the epidemiologic studies identified were all conducted using small sample sizes and only male athletes.[1,26,29,30,33,40–42] Therefore, the fluid protocols used in these studies may not be appropriate for the female population.

Randomized Control Trials (RCTs)

Ten RCTs were identified for using a pre-exercise hydration protocol to ensure euhydration at the start of exercise (see Table 2). Several of the early studies (i.e., 1990s-early 2000s) did not provide a source for the fluid protocol that was utilized.[27,28,31,32,38] In addition, three studies that were conducted in the 2010s[16,43,44] referenced some of the older position papers.[12,25,36] Some of these protocols appear to vary in terms of whether body mass was taken into consideration or not (i.e., 500mL vs 5ml/kg). However, within the last 10 years, only three studies have used a fluid protocol that did not take body mass into consideration.[16,44,45] While each study might have been investigating a different desired outcome, the consensus appears to be that those who start practice in a euhydrated state will experience less physiological impairments during exercise and ultimately perform better. However, there appears to be inconsistencies in terms of which hydration protocol should be used for active individuals and athletes.

Table 1. Studies including fluid recommendations for athletes and their source of origin

Author(s)	Publication Year	Population	Fluid Recommendation Provided/Used	Recommendation Source
Position Stands/Statements				
Convertino VA, et al.[36]	1996	Athletic Population (all ages, sports, competition levels)	400-600 ml about 2 hr prior to exercise	None
Casa DJ, et al.[12]	2000	Athletic Population (all ages, sports, competition levels)	500-600 ml about 2-3 hr before and 200-300 ml about 10-20 minutes before	Position Statement – 1996 Two RCTs – 1971 & 1965
Sawka MN, et al.[25]	2007	Athletic Population (all ages, sports, competition levels)	5-7 ml/kg BW about 4 hr prior to exercise	None
Racinais S, et al.[37]	2015	Athletic Population (all ages, sports, competition levels)	6 ml/kg BW about 2-3 hr prior to exercise	None
Thomas DT, et al.[9]	2016	Athletic Population (all ages, sports, competition levels)	5-10 ml/kg BW in about 2-4 hr prior to exercise	Position Statement – 2007 Review Article - 2012
McDermott BP, et al.[7]	2017	Athletic Population (all ages, sports, competition levels)	Create individualized hydration plans based on thirst, BW, UC, and void frequency; hyperhydrate before exercise (<2% BW) before exercise	Position Statement – 2000 Clinical Trial - 2009
Review Articles				
Goulet ED.[39]	2012	Athletic Population (all ages, sports, competition levels)	5-10 mg/kg BW about 2 hr prior to exercise	Clinical Trial - 1998

Abbreviations: BW= body weight; USG= urine specific gravity; RCT= randomized control trial; UC:=urine color; NCAA= National Collegiate Athletic Association; D1= Division 1

Table 2. Studies including fluid protocols for achieving euhydration for athletes and their source of origin

Author(s)	Publication Year	Population	Fluid Protocol Provided/Used	Protocol Source
Epidemiologic/Observational Studies				
Montain SJ, et al.[40]	1992	8 Active Males	Same diet and fluid intake 24 hr before each exercise trial and 5ml/kg of BW 2 hours before exercise	None
Sawka MN, et al.[1]	1996	8 Active Males	Ad Libitum before the euhydration stress test	None
Riebe D, et al.[33]	1997	8 Active Males	Ad Libitum fluid intake before dehydration and rehydration protocol	None
Armstrong LE, et al.[26]	1998	9 Highly trained Males	30 ml/kg BW within 24 hr prior to exercise	None
Casa DJ, et al.[30]	2000	8 Male Endurance Cyclists	Ad Libitum fluid intake before dehydration and rehydration protocol	Clinical Trial - 1997
Maresh CM, et al.[29]	2001	8 Male Endurance Cyclists	24 oz water night before and 24 oz water morning before dehydration protocol (no exercise that day)	Clinical Trial - 2000
Stover EA, et al.[41]	2006	46 High School Football Players	591 mL night before and 591 mL about 1.5 hours before practicing next day of water or sports drink	None
Hamouti N, et al.[42]	2013	18 Aerobic Male Athletes	Three days of data collection: Day 1: 500 mL night before Day 2: 500 mL within 2 hours of exercise	None
Experimental/Randomized Control Trials (RCT)				
Moroff SV, & Bass DE[38]	1965	30 Active Males	2000 ml water within 50 minutes of exercise	None
Greenleaf JE & Castle BL[27]	1971	8 Active Males	Ad libitum group (100-200 ml water); hyperhydrated group (40 ml/kg)	None

Robinson TA, et al.[31]	1995	8 Male Endurance Cyclists	5 ml/kg BW of water 2 hr before arriving to the lab and 350 mL water	None
Goulet ED, et al.[32]	2008	6 Endurance Athletes	Hyperhydration protocol: 26ml/kg of fluid + 1.2 g/kg of glycerol Euhydration protocol: 10ml/kg of water ~120 min before arriving to the lab	None
Lee JK, et al.[28]	2008	8 Active Males	500 mL of water 90 minutes before arrival to lab & 900 mL within 30 minutes prior to exercise	None
Casa DJ, et al.[34]	2010	17 Distance Runners (9 males, 8 females)	Ad Libitum before each 12-km run in the heat	None
Merry TL, et al.[43]	2010	12 Active Males	500 mL of fluid	Position Statement – 1996
Logan-Sprenger HM, et al.[44]	2013	10 Recreational Athletes	A total of 600 mL of water (300 ml consumed at 0 min and 15 minutes of trial)	Position Statement – 2000 Position Statement – 2007
Magal M, et al.[16]	2015	56 NCAA D1 Male Athletes	Normal hydration habits + additional 750 ml per day	Position Statement – 2000 Position Statement – 2007
Benjamin CL, et al.[45]	2021	12 Field Sport Athletes	500 mL of water if USG >1.020	None

Abbreviations: BW= body weight; USG= urine specific gravity; RCT= randomized control trial; UC:=urine color; NCAA= National Collegiate Athletic Association; D1= Division 1

Discussion

Pre-exercise fluid recommendations and protocols have been utilized for achieving euhydration within the athletic and active, general populations. However, the justification for these fluid amounts is difficult to discern and the prevalence of dehydration among collegiate athletes before practice still ranges from 65-75%.[10,16,35] Therefore, the purpose of this review was to identify current pre-exercise fluid recommendations and protocols and their sources.

Of the 25 studies identified, several of the studies reference one another as their justification for the pre-exercise fluid recommendation or protocol. While the fluid recommendations work for achieving euhydration, it is confusing to determine which is most appropriate for the field setting. Within the past five years, there have been two articles (1 position paper; 1 RCT)[7,45] that used or recommended different fluid protocols. The most recent NATA position paper[7] justified its recommendation of creating an individualized plan from the previous position paper from 2007 and research that was conducted by Baker and colleagues.[24] Baker et al, specifically prescribed that their participants either consumed fluid or did not consume fluids based on the desired change in body mass before exercise.[24] However, no specific amount of fluid was recommended from this research. In addition, a majority of the experimental studies identified consisted of small sample sizes, using primarily male athlete.[27,28,31,32,38,43] Therefore, more research is needed in larger samples of both male and female athletes. The NATA position paper also did not prescribe a specific amount of fluid to reach euhydration, but rather suggested that athletes develop individualized hydration plans based on BW, sweat rate, exercise duration and intensity, and environmental conditions.[7] While the fluid recommendations mentioned in position statements are beneficial for aiding sport practitioners in educating athletes on hydration, it's possible that they might not be practical for the field setting, especially for pre-exercise.

Currently, most fluid protocols that have utilized BW and sweat rate have been specific to after exercise, with the goal to match fluid losses.[9,11,25] To adapt this idea to pre-exercise, the question that must be answered is, what is the right amount of fluid per kilogram of BW for an athlete to achieve euhydration? One research group utilized a fluid protocol relative to BW, while investigating the additive glycerol. Participants were instructed to consume 1.2 g/kg of BW of glycerol in 26 ml/kg of fluid before exercise. The goal of this protocol has been shown to achieve "hyperhydration" when consumed over 60 minutes and within 30 minutes of exercise.[46] While this review acknowledged the use of a pre-exercise fluid protocol, specifically based on fluid amount per kilogram of BW, it was not included in Table 2, as it was focusing on a different overall goal. Moreover, the source of this protocol was unknown. However, if 26ml/kg of fluid aided participants in achieving hyperhydration before exercise, what is the appropriate amount that will aid them in achieving euhydration? Therefore, more experimental studies with fluid protocols are needed, not only to determine which protocol is most effective, but is it reasonable to follow so that an athlete can effectively pre-hydrate before exercise. For example, fluid protocols could be established based on the use of practical hydration assessment methods, like UC and USG. While there might be limitations to using these methods, this could also help teach athletes how to effectively self-assess and self-correct their hypohydrated state in real-time. Through this research, the upcoming position statements could include both an appropriate fluid amount per kilogram of BW, as well as a standardized fluid recommendation based on these validated and practical methods.

Conclusion

To the authors' knowledge, this is the first review to investigate the topic of pre-exercise fluid recommendations among athletes. Several studies have stressed the cruciality for athletes to begin exercise in a euhydrated state;[4,12,47–51] however, there is no definitive consensus on which fluid recommendation or protocol is most accurate for the athletic population. While creating an individualized hydration plan can be challenging, it is understood that it should be based on several factors, including BW. Therefore, more research is needed to determine the appropriate amount of fluid to consume per kilogram of BW prior to exercise or if it could be possible to correct one's hypohydration based on practical assessment methods

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