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The Effect of Personalized Advice on Hydration Status in Track and Field Athletes: A Randomized Controlled Study

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Abstract

Introduction: Optimum hydration is vital for athletes, positively impacting performance and overall health. However, many athletes train in a state of hypohydration or become dehydrated during training sessions. Hence, the present study evaluated the impact of a personalized hydration plan on improving hydration status among track and field athletes.

Methods: The present study was a randomized controlled clinical trial, conducted at the Faculty of Medicine, University of Colombo, Sri Lanka. Thirty athletes were randomized into an intervention group (IG: n=15) and a control group (CG: n=15). The IG received an individualized hydration plan developed and delivered through one-on-one consultations at three time points (0, 4, and 8 weeks) and ongoing online support throughout the 16 weeks. The CG received no advice during the intervention. The hydration status was assessed using morning urine specific gravity (USG), urine color, and thirst perception before and after three typical training sessions.

Results: Twenty-eight athletes completed the study (IG: n=14; CG: n=14). The IG showed significant improvement in hydration, with USG reducing from 1.016±0.00 to 1.010±0.00 (p=0.018), whereas the CG exhibited a non-significant increase from 1.014±0.00 to 1.017±0.00 (p=0.275). All IG athletes achieved adequate hydration by the end of the study (p=0.034), while four CG athletes remained hypohydrated. Minimal changes in pre-training urine color were observed in the IG (2.37±0.73 to 2.38±0.68) compared to an increase in the CG (2.83±0.80 to 3.04±0.60; p=0.967). Pre-training thirst perception decreased in the IG (3.36±0.56 to 2.97±0.99) but slightly increased in the CG (3.28±0.85 to 3.38±0.86; p=0.06).

Conclusion: A 16-week personalized hydration intervention effectively improved hydration status among track and field athletes in Sri Lanka.

Keywords: Athletes, hydration, sports nutrition, Sri Lanka, track and field

1. Introduction

Optimum hydration is important for athletes, as it positively impacts performance, recovery, and overall health. Intensive training sessions for track and field athletes generate substantial heat, leading to increased sweating as a physiological response to regulate core body

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temperature[1]. The risk of dehydration remains considerable because voluntary fluid intake often fails to compensate for actual fluid losses, such as sweat. Research indicates that even a 2% dehydration level can negatively affect sports performance and overall health[2]. Dehydration significantly impairs sport-specific cognitive-motor tasks in athletes[3] and also heightens the risk of heat-related injuries, such as heat exhaustion and heat stroke[4]. Conversely, adequate hydration has been shown to enhance performance and health as it helps maintain heart rate, VO_2 max, and physical performance[5]. Despite the widespread evidence on the importance of hydration, some athletes begin exercise in a hypohydrated state[6].

Sri Lankan athletes face heightened dehydration risks due to the tropical climate[7]. Hot and humid conditions impair heat dissipation, causing thermal strain[8,9], leading to heat injuries such as heat stroke[10,11]. In a qualitative study among Sri Lankan national athletes, participants emphasized the importance of hydration for injury prevention, recovery, and sporting performance, sharing personal experiences of dehydration symptoms[12]. A study on university or club-level athletes in Sri Lanka found that 31.9% began training in a dehydrated state, and 43.6% were dehydrated after training or competition[13]. The high prevalence of dehydration underscores the need for hydration monitoring and education to prevent performance issues and health risks.

Athletes from different countries adopt varied hydration strategies. In Sri Lanka, where sports nutrition is still a developing field, a mix of fluids such as water, oral rehydration solution (ORS) (*Jeewani*), king coconut water, and isotonic drinks are used for hydration[12]. Individualized hydration plans, which consider sport dynamics, exercise intensity, exercise duration, sweat rate, and environmental factors, are recommended for optimizing athletic performance[14]. Despite the high prevalence of dehydration in Sri Lankan athletes, no interventions have been conducted to improve hydration status. Therefore, this study aimed to evaluate the impact of culturally tailored, evidence-based, personalized hydration strategies on the hydration status of track and field athletes.

2. Methods

CONSORT 2010 statement guidelines regarding randomized trials (www.consort-statement.org) were followed for this randomized controlled trial (RCT)[15]. The protocol of this study has been published elsewhere[16].

2.1. Trial design

This study was designed as a parallel-group, randomized controlled clinical trial, conducted at the Department of Physiology, Faculty of Medicine, University of Colombo, Sri Lanka, over a duration of 16 weeks. Strict compliance with the Helsinki Declaration was upheld throughout the participant recruitment process, with documented informed consent procured from each individual involved. Ethical clearance was granted by the Institutional Ethical Review Committee of the Faculty of Medicine at the University of Peradeniya, Sri Lanka (2023/EC/71). The trial (Universal Trial Number of U1111-1304-8890) was registered with the Sri Lanka Clinical Trials Registry (024/013). The progression of this RCT is illustrated in the flow diagram (Figure 1).

2.2. Participants

Track and field athletes of both genders were qualified to participate in the study. They were enrolled on a voluntary basis after conducting an appropriate screening a few weeks before the intervention. Potential participants were identified through networks established with coaches, athletes, and public communications within social media forums dedicated to athletes on a voluntary basis. Two weeks prior to the intervention, individuals were required to undergo a screening assessment and provide both written and verbal informed consent. The criteria for inclusion encompassed male and female elite and highly trained athletes who were at least 18 years of age, possessed a personal WhatsApp number, and were full-time athletes, motivated to engage in the 16-week hydration intervention. Athletes adhering to a prescribed hydration plan, and those experiencing sports-related injuries were excluded from participation.

2.3. Outcome measures

Demographic details, anthropometric measurements, and several hydration-related parameters were also collected from all participants at different time points in the study. The details are given in Table 1.

Table 1: Hydration assessment instruments and time points in the study

Parameters	Instruments	Time points (weeks)
USG (morning urine sample)	Hand-held clinical refractometer	0, 16
Urine color	Urine color chart	0, 4, 16
Thirst	Thirst assessment scale	0, 4, 16

For the assessment of urine specific gravity (USG), early morning first void urine samples before any intake were collected by the athletes based on prior instructions. The samples were received at the data collection center within two hours of collection and were immediately analyzed using a hand-held clinical refractometer (model 300 CL; Atago Company Ltd., Tokyo, Japan) for USG. Hydration status was defined based on USG values. Values $\leq$1.020 were considered euhydrated, and values >1.020 were hypohydrated[17].

The athletes' self-assessment of hydration status was carried out during the intervention period in relation to their training sessions. Self-assessments included pre- and post-training urine color and thirst on three consecutive days of typical training sessions at 0 week, 4 weeks, and 16 weeks. The mean values from these three days were used for analysis. To enhance self-reporting accuracy during baseline measurements, athletes' ability to correctly perceive urine color using a color chart was evaluated[18]. Six urine-like samples of varying color intensities were prepared using specific chemicals in glass tubes. Three independent investigators with no known vision impairments assessed the samples against the chart, with the majority opinion determining the final color. The chart ranged between 1-8 and was used to train athletes whose initial perception deviated by more than ±1 from the finalized color. These athletes received additional training until accurate identification was achieved, ensuring reliable self-assessment for pre- and post-training hydration status. The mean values and changes in urine color were calculated across this period. Similar glass test tubes were provided for field use. Thirst perception was measured using a 7-point categorical scale, with one representing extreme thirst, four being neutral, and seven indicating no desire to drink, even when prompted[19]. Thirst was recorded immediately before and after training sessions for three consecutive days, and the mean values and changes in thirst were calculated across this period.

2.4. Intervention

The intervention spanned 16 weeks and involved consultations at 0 week, 4 weeks and 8 weeks. The consultations followed two distinct formats, designed to ensure the progressive adaptation of hydration strategies based on individual needs.

Method 1: One-to-one consultations at the Faculty of Medicine, University of Colombo

Before each consultation, the athletes conducted a self-assessment of their hydration status by evaluating thirst levels and urine color, following prior instructions. These assessments, alongside baseline hydration data, were used to develop individualized hydration plans tailored to each athlete. Knowledge gaps regarding hydration were addressed to enhance the athletes' understanding and enable informed hydration decisions. Hydration plans were adjusted in subsequent consultations, informed by changes in hydration status observed over time.

Method 2: Online mode of communication

Athletes received periodic hydration tips via WhatsApp to reinforce their knowledge, and opportunities were provided to ask questions and seek clarification from the research team.

- If early morning USG exceeding 1.020 was detected before morning training, athletes were advised to consume 500 ml of water before bed. Flavor enhancements like lime, salt, and honey were allowed.
- Depending on the morning urine color, athletes were instructed to drink adequate fluids in the morning.
- Personalized fluid recommendations were provided based on hydration status, availability, and cost, including water, king coconut water, ORS, fruit juices, or commercially available isotonic solutions.

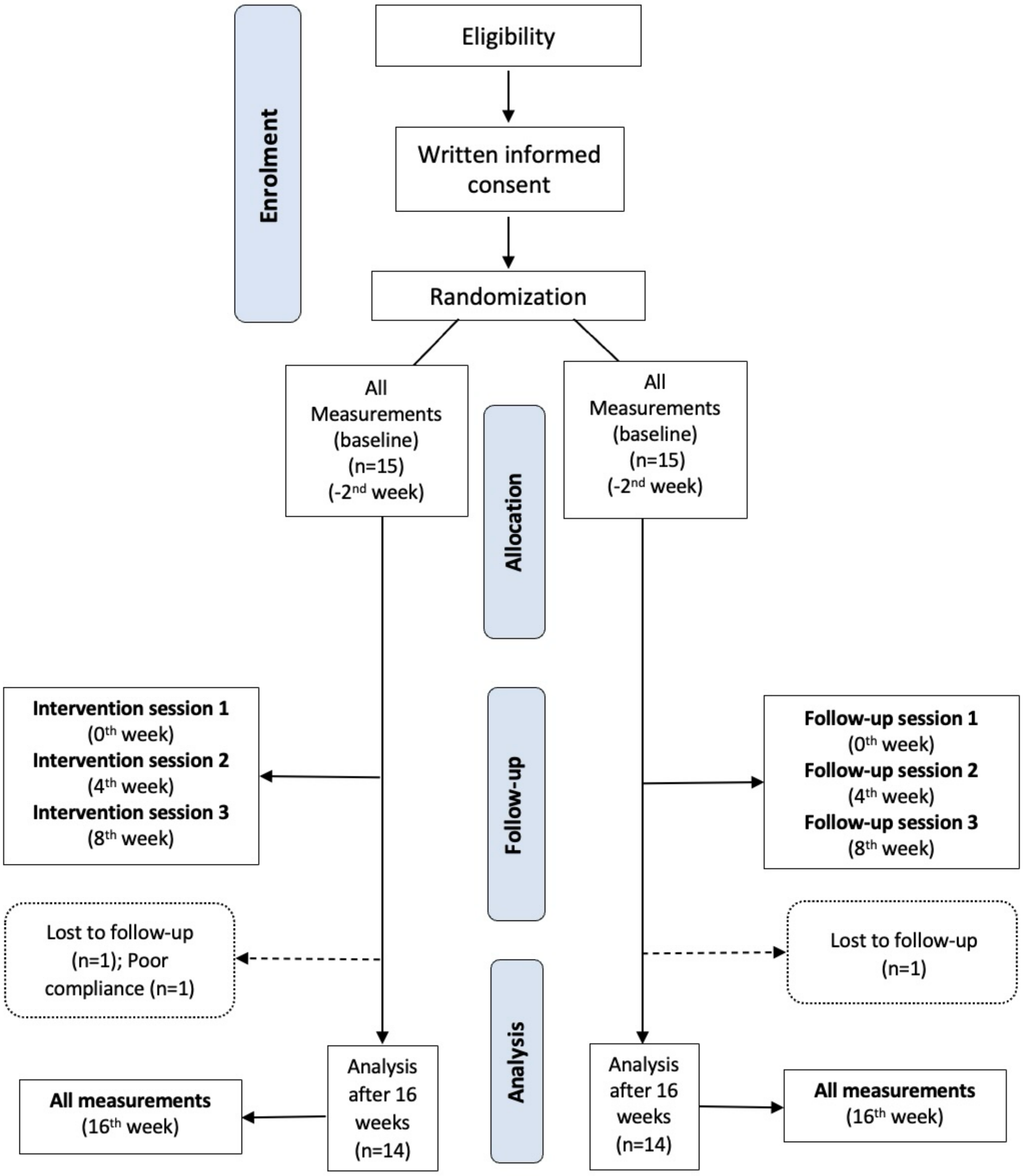

Figure 1: CONSORT flow diagram

- Athletes were generally advised to alternate between water and ORS during training sessions. For more intensive training, isotonic solutions were also recommended to enhance hydration and replenish electrolytes, complementing the intake of other fluids.
- Athletes were instructed to weigh themselves before and after each training session to assess fluid loss and understand their hydration status. If weight loss was detected, they were advised to consume fluid equal to 1.5 times the weight lost within the next 2-3 hours.
- Athletes were encouraged to consume fruit juices such as watermelon and lime, enhanced with added salt, glucose, or sucrose to improve hydration and electrolyte balance.

- Athletes who experienced digestive discomfort from consuming large volumes of fluids were advised to take small, frequent sips. Chilled fluids, including water, fruit juices, and ORS, were recommended to ease consumption and support hydration.
- Following their morning training and breakfast, athletes were instructed to hydrate with a glass of liquid, preferably fresh fruit juice, just before taking a nap. They were also trained to monitor their urine color throughout the day as a basic indicator of hydration levels. Darker urine signaled dehydration, prompting them to increase fluid intake accordingly. This approach aimed to foster consistent hydration practices by linking fluid consumption to observable physiological markers.

These recommendations were based on the sports nutrition guidelines developed and validated by nutritionists in Sri Lanka, specifically addressing the Sri Lankan context.

3. Results

Out of 30 participants recruited, 28 completed the intervention, with 14 in each IG and CG (Figure 1). Data from these 28 participants were analyzed using a per-protocol approach. The mean age of the IG was 23.14±2.98 years, comprising eight males and six females. In the CG, the mean age was 21.93±4.00 years, with nine males and five females. The IG and CG had the same composition: five elite and nine highly trained athletes. In terms of event specialization, the IG consisted of 11 runners, two jumpers, and one thrower. Conversely, the CG had nine runners and five jumpers.

At baseline, the IG had a mean USG of 1.016±0.00, significantly reducing to 1.010±0.00 by the study end (p=0.018). In contrast, the CG began with a mean USG of 1.014±0.00 and showed a non-significant increase to 1.017±0.00 (p=0.275). Initially, four out of 14 athletes in both the IG and CG were classified as hypohydrated. Following the intervention, all athletes in the IG were fully hydrated, while four out of 14 athletes in the CG remained hypohydrated (p=0.034).

Pre-training thirst levels decreased in the IG, from 3.40±0.58 to 2.96±1.00, while the CG experienced a slight increase from 3.31±0.81 to 3.35±0.64. The results approached statistical significance (p=0.06). Post-training thirst levels decreased in both groups: from 5.00±1.10 to 4.12±1.49 in the IG (p=0.005) and from 5.05±0.90 to 4.58±1.00 (p=0.045) in the CG with thirst level decreasing more in the IG. Similar trends were observed for changes in thirst following training sessions, with reductions noted in both the IG (1.60±0.97 to 1.14±1.26; p=0.083) and the CG (1.74±1.15 to 1.23±1.01; p=0.059) from baseline to the end of the study.

Changes in hydration status based on urine color were also observed. When comparing pre-training urine color from baseline to the end of the study, the IG showed minimal change (2.37±0.73 to 2.38±0.68), while the CG exhibited a slight darkening of urine color from 2.83±0.80 to 3.04±0.60 (p=0.967). Post-training urine color followed a similar pattern, with the IG improving from 2.74±0.98 to 2.48±1.00, while the CG exhibited a slight reduction from 3.62±0.93 to 3.53±1.17 (p=0.682) (Figure 2). Regarding urine color changes between training sessions, the IG showed a decrease from 0.37±1.16 to 0.10±0.86, while the CG experienced a decrease from 0.79±1.00 to 0.50±1.08 (p=0.563).

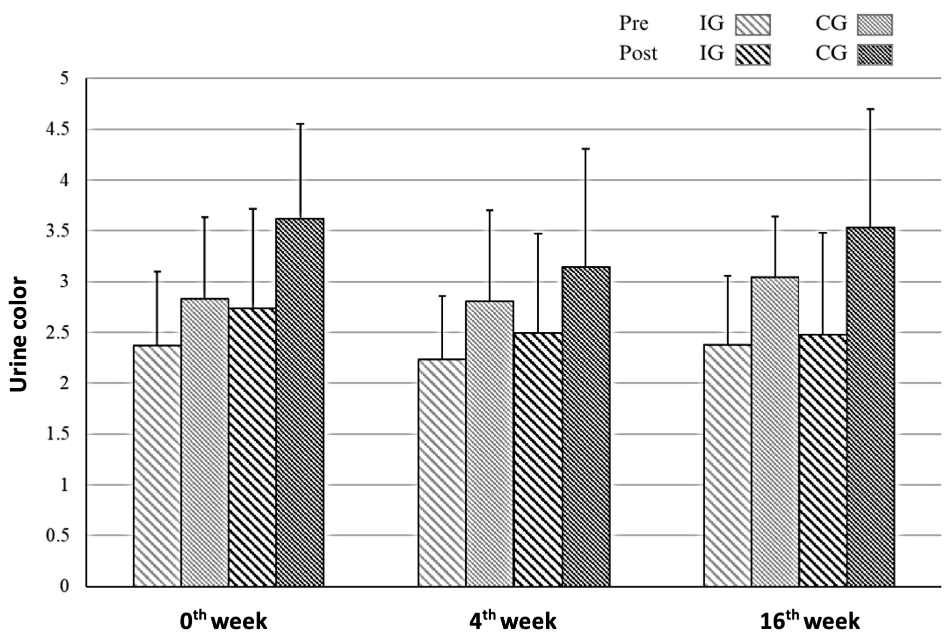

Figure 2: Comparison of the mean pre- and post-training urine color between IG and CG

4. Discussion

This study evaluated the effectiveness of a 16-week individualized hydration intervention aimed at improving the hydration status of track and field athletes. The key finding was that athletes who followed the personalized hydration intervention showed improved hydration outcomes compared with those in the CG. To our knowledge, this is the only study conducted among track and field athletes that attempts to improve hydration status through personalized advice using dual assessment methods.

Developing individualized hydration plans requires evaluating athletes' hydration status before, during, and after training. Hydration assessment techniques range from non-invasive to invasive methods, as well as other complicated techniques. Non-invasive techniques include body weight changes, urine color, USG, thirst sensation, bio-impedance analysis, and tear osmolality. Moderately invasive techniques include serum osmolality and sodium concentrations, while more complex approaches include stable isotope dilution and neutron activation analysis[20]. In the present study, only field-based assessment techniques, such as USG, urine color, and thirst sensation, were used. These are feasible in resource-constrained settings. A similar approach was reported in Sri Lankan cricketers, where body weight change, urine color, USG, and sweat rate were used to examine dehydration effects on skill performance[21]. Although body weight change is a reliable hydration marker, logistical limitations such as lack of calibrated weighing scales across training facilities prevented its consistent use in this study. Other studies have incorporated sweat rate and sodium loss in individualized hydration strategies, demonstrating their value in optimizing fluid intake[22,23].

The findings of this study demonstrated an improvement in hydration markers, particularly a reduction in USG in the IG over the four-month period. These results align with previous studies reporting significant reductions in USG following hydration interventions. For example, one study showed USG values decreasing from 1.025±0.005 to 1.022±0.006 in the IG, while the CG increased from 1.023±0.005 to 1.024±0.005 after a one-week intervention involving an additional 750 ml of daily fluid intake[24]. Similarly, another study reported a decrease in USG from 1.022 to 1.016 in the hydrated group after a three-day hydration intervention, while the dehydrated group increased from 1.020 to 1.023[25]. These patterns resemble the present findings, where hydration improved in the IG but worsened in the CG. The study also observed slight changes in thirst perception. The IG increased from 2.38 pre-training to 2.48 post-training, while the CG increased from 3.04 to 3.53, although the difference was not statistically significant. Similar trends were observed in an RCT involving healthy males exercising in hot conditions, where thirst increased less in the intervention group compared with the control group[26].

Another distinctive feature of this intervention was its cultural tailoring. Athletes were encouraged to consume locally available fluids such as king coconut water, ORS, and fruit juices alongside structured hydration plans and behavioral education. Comparable research has shown that prescribed fluid intake based on sweat rate improves physiological responses compared with *ad libitum* drinking or no fluid intake[27].

This study has several strengths. Hydration parameters were assessed at multiple time points – baseline, 4-weeks, and 16-weeks, allowing dynamic monitoring of hydration status. The hydration strategies were based on validated nutrition guidelines for Sri Lankan athletes, ensuring cultural relevance. Hydration status was evaluated using multiple indicators, such as USG, urine color, and thirst perception, which allow for a more comprehensive assessment. Additionally, the individualized recommendations aligned with current sports nutrition practices that emphasize personalized hydration strategies[28].

However, several limitations should be considered. The relatively small sample size (n=28) limits generalizability and statistical power. Some measures, such as urine color and thirst perception, relied on self-reporting and may be subject to bias. Improvements in hydration markers were observed but were not statistically significant, possibly because participants in the CG also monitored their hydration, unintentionally improving their fluid intake. Logistical constraints prevented consistent measurement of body weight changes. Furthermore, the study did not account for individual sweat rate or electrolyte loss, and more precise biomarkers such as plasma osmolality were not measured. Future studies should include larger samples, objective biomarkers such as plasma osmolality and sweat electrolyte analysis, and potentially wearable hydration monitoring technologies to enhance personalization and adherence.

5. Conclusion

The findings of this study demonstrated that a 16-week individualized hydration intervention positively improved hydration status markers, including USG, urine color, and thirst perception, among Sri Lankan track and field athletes. These improvements indicate that culturally tailored hydration strategies are effective in enhancing hydration, which may contribute to better performance and improve overall health. Therefore, the implementation of individualized hydration plans utilizing locally available resources is recommended for optimizing hydration in athletic populations, particularly in tropical environments.

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Conflict of Interest

The authors declare no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Authors’ Contributions

RJ conceived and designed the study, while RJ and AT were responsible for data collection, analysis, and obtaining study results. RJ and AT also contributed to drafting the manuscript. Supervisory team members APH, NSK, TM, and IN provided critical revisions to the paper. All authors contributed valuable feedback and thoroughly reviewed and approved the final manuscript version.

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