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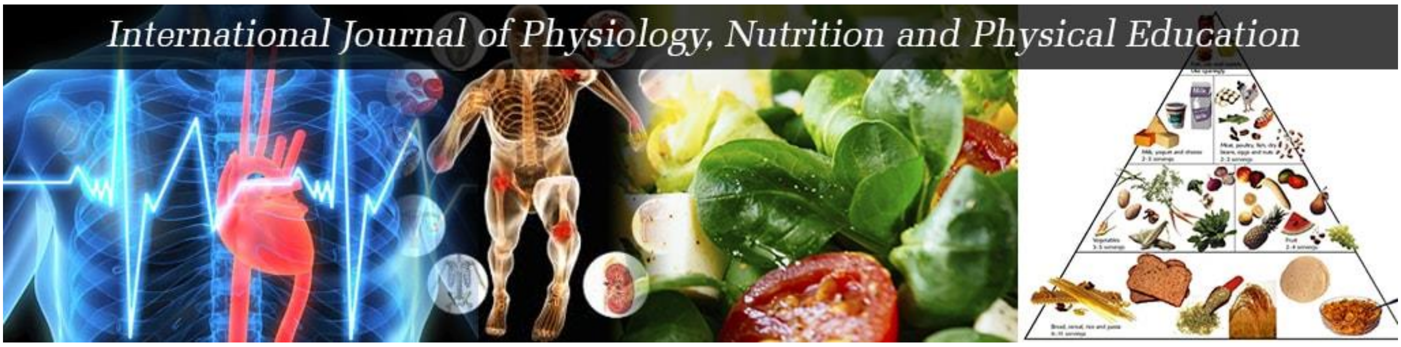

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Vani Bhushanam Golla
Research Scholar, Guru Gobind Singh Indraprastha University, New Delhi, India

Raj Kapoor
Professor of Excellence, Department of Physiology, VMMC & Safdarjung Hospital, New Delhi, India

Corresponding Author:
Vani Bhushanam Golla
Research Scholar, Guru Gobind Singh Indraprastha University, New Delhi, India

Fluid consumption habit, fluid balance and perceived fatigue during exercise among adolescent national level cyclists

Vani Bhushanam Golla and Raj Kapoor

Abstract
Background: Poor hydration compromises performance and heightens the risk of heat stress which adolescents are particularly susceptible. This study aims to evaluate the fluid consumption pattern and perceived fatigue among adolescent National level cyclists at Sports Authority of India.
Methodology: 45 cyclists were assessed for fluid consumption pattern using Food Frequency Questionnaire (FFQ), 24 hour Hydration Recall, Rate of Perceived Exertion (RPE) using Borg's Scale and pre-post workout weights in the morning session of each training day for 3 consecutive training days. Type and amount of fluid consumed in pre, during and post training sessions and total fluid consumption was recorded.
Results: The mean fluid consumption was 6.09 +1.79 L/day. The most widely and frequently consumed fluid by cyclists was plain water (100%) followed by milk (92.68%), lemonade (80.49%), tea (75.61%) and fruit juice (63.41%). Commercial sports drink has never been consumed by 85.37% while over three-third (78.05%) have never consumed energy drink. Daily intake of commercial sports drink (7%) and energy drink (9.8%) during training and post training respectively was observed. Significant difference in fatigue levels was observed between pre and during training ($p<0.05$), pre and post training ($p<0.05$) and during and post training. Fluid balance was highly significant (r = 0.903; $p<0.01$) during training sessions.
Conclusion: Cyclists maintained fluid balance during training sessions. Nevertheless, consumption of fluid during training alone cannot address fatigue. Inadequate sleep, electrolyte imbalance, inappropriate replenishment of muscle glycogen stores, poor nutrient timing are some of the many factors which contribute to fatigue and thereby affect recovery.

Keywords: fatigue, fluid balance, adolescent cyclists, hydration

Introduction
Water is the largest component of the human body contributing to 45-70% of body weight [1]. In physically active individuals, it is a challenge to maintain fluid balance, mainly due to a large amount of fluid loss via increased sweating combined with uncompensated fluid intake [2]. Although the sweating response is widely variable between individuals and depends on several factors, including physical fitness, heat acclimation, and exercise intensity [3-5], it is common to observe sweat rates exceeding 1.5 liter per hour [6]. It is pertinent that athletes maintain optimum hydration status to prevent dehydration and support cardiovascular and thermoregulatory functions needed for optimum athletic performance [7]. Dehydration resulting in a loss of body mass >2% has been associated with a decline in performance [4, 8]. Prevention of dehydration is of greater significance in adolescents as they are at a greater risk of suffering from heat illness. They produce a higher amount of metabolic heat compared to adults, mainly due to their larger surface area to body weight ratio and inability to produce sweat as efficiently as adults [9, 10]. Further, it is well established that the body does not adapt to repeated bouts of dehydration. Training repeatedly in the dehydrated state will impair the quality of training and will confer no advantage. Hence, it is significant to assess potential hydration strategies that preserve and promote fluid homeostasis. Water alone is often not sufficient for promoting rehydration, as fluids and beverages are necessary to restore lost fluid.
Determining the daily fluid requirement of athletes living and training in the heat will be based primarily on sweat losses during training, in addition to substantial losses during the rest of the

day if time is spent outdoors or if air conditioning is not available [11]. The available evidence suggests that most athletes do not ingest sufficient fluid to replace losses [12]. Fluid intake and hydration status monitoring are essential factors in the growth processes, performance development, and preventing fatigue accumulation in young athletes [13-15]. The maintenance of hydration status during training and competition has been identified as a rate-limiting factor for athletic performance [3]. However, this aspect is often ignored [9, 16, 17]. Thus, the aims of the present study are to (i) evaluate fluid intake behavior for adolescent cyclists and (ii) compare fatigue perception at time intervals of training sessions using RPE scale, and (iii) correlate fluid intake and sweat loss during exercise.

Methodology

Subjects: The study was conducted on 45 cyclists (24 male and 21 female) aged 14 to 19 years with minimum of 2 years of training, practicing a minimum of 15 hours per week. Cyclists having participated in national or international level competition were included in the study.

Ethical Clearance: Ethical clearance was obtained from the Ethics Committee of Sports Authority of India. Written voluntary assent and informed consent to participate was obtained from each cyclist and the parent/guardian prior to participation in the study. The participants were free to withdraw from the study at any time without any reason.

Data Collection: The fluid intake was recorded in time intervals throughout the day by 24 hour recall method. Pre, during and post training fluid intake was measured in standardized bottles, glasses and cups used for the purpose. All fluid intakes were recorded in ml and fluid consumed counted for a day's total intake. The level of fatigue by the athlete was subjectively measured using Borg's RPE scale ranging from 6-20 with a value of six considered, no exertion at all, and a value of 20 considered, maximal exertion before, during and post training. Fluid intake, RPE and body weights data were on the same days. Food Frequency Questionnaire was used to elicit information on the fluid consumption pattern. Pre and post training body weights were recorded immediately prior to and on completion of the training session in their cycling training outfit, barefoot using a digital SECA weighing scale on a flat surface. Sweat loss was assessed from the change in body mass after correction for the volume of fluid consumption and urine excretion.

Statistical Analysis: Mean, SD and percentages were used for calculating participant characteristics and amount of fluid consumed. Pearson's correlation co-efficient test was used to detect the relationship between parameters of fluid intake, RPE, body mass at individual time points in the morning training session using the Statistical Package for the Social Sciences (SPSS) version 28.

Results

The total number of participants within the study was 45 cyclists. Of the total respondents 58.53% were male. All the cyclists were between 14 to 19 years. The body weight ranged between 39.7kg to 79.8kg and height ranged between 150 cm to 186.5 cm. The cyclists average hours of sleep a day ranged between seven to eleven hours including rest between two training sessions.

Table 1: General profile of Cyclists

S. No.	Variables	Male (N= 24)	Female (N=21)	Mean ± SD
1	Age (years)	16.8 ± 1.0	16.3 ± 1.4	16.6 ± 1.2
2	Weight (kg)	71.3 ± 7.6	58.7 ± 4.6	65.7 ± 8.9
3	Height (cm)	175.9 ± 8	161.8 ± 5.2	169.6 ± 4.1
4	BMI	23.2 ± 2.3	22.5 ± 1.9	22.9 ± 2.2
5	Training Years	3.68 ± 1.9	3.1 ± 1.93	2.68 ± 1.93

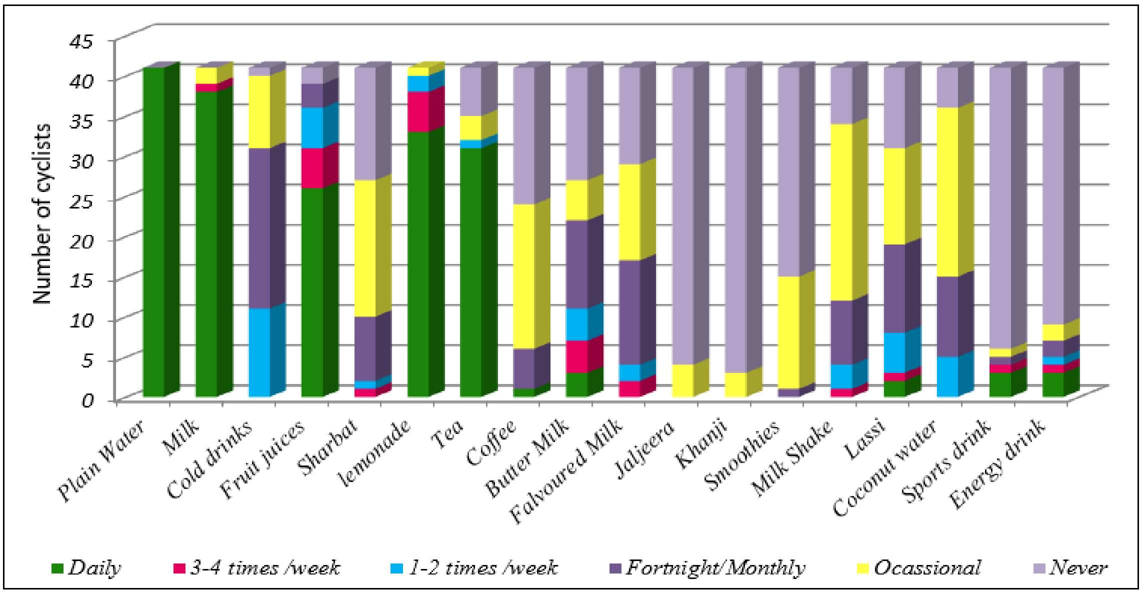

Fig 1: Frequency of fluid consumption of Cyclists.

The daily fluids consumed by cyclists include plain water (100%) followed by milk (92.7%), lemonade (80.5%), tea (75.6%) and fruit juice (63.4%). Nearly half (48.8%) of the cyclists consumed cold drinks every fortnight. Occasionally consumed beverages include milk shake (53.6%) followed by coconut water (51.3), coffee (43.9%) and sharbat (41.5%). Khanji (rice porridge) has never been consumed by 92.5% followed by jaljeera (90.2%). Commercial sports drink has never been consumed by 85.4% while over three-third of the cyclists (78.1%) have never consumed energy drink. Daily intake of commercial sports drink by 7% and energy drink by 9.8% during training and post training respectively was observed.

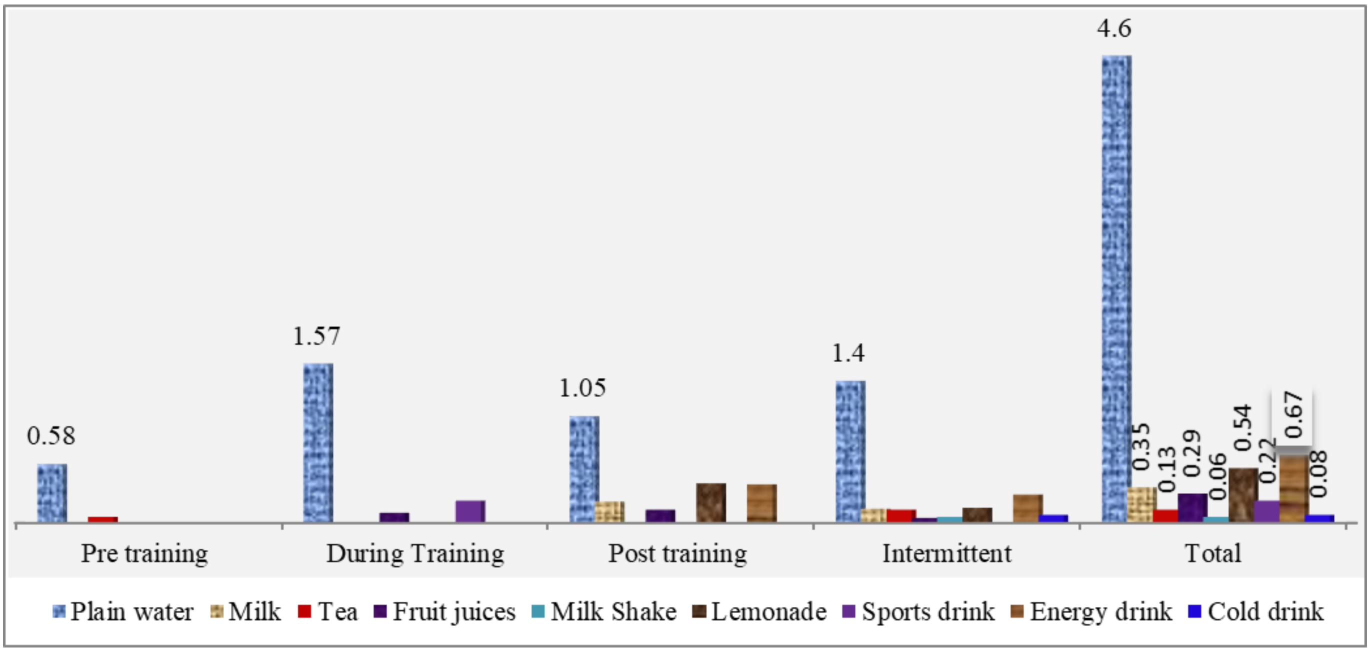

Fig 2: Mean intake of fluids (L/day) in pre, during, post training and intermittent time intervals of cyclists

The pre-training fluid consumption comprised of plain water or tea 15 minutes prior to training with a minimum and maximum fluid intake between 0.35 L and 0.75 L. Plain water was widely consumed during training (1.57 ± 0.16 L). In addition to plain water, lemonade (0.39 ± 0.22 L), energy drink (0.38 ± 0.14 L), milk (0.2 ± 0.16 L) and fruit juice (0.13 ± 0.05) were consumed post training.

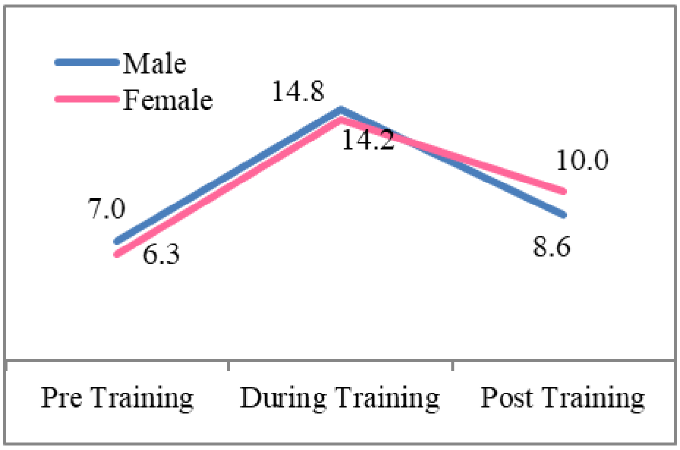

Fig 3: Comparison of means for Perceived Fatigue (RPE) in different time intervals of training session between genders

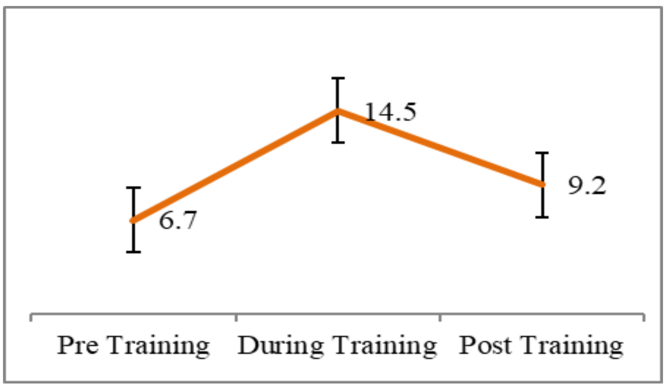

Fig 4: Comparison and Standard Error of means for Perceived Fatigue (RPE) in different time intervals of training session

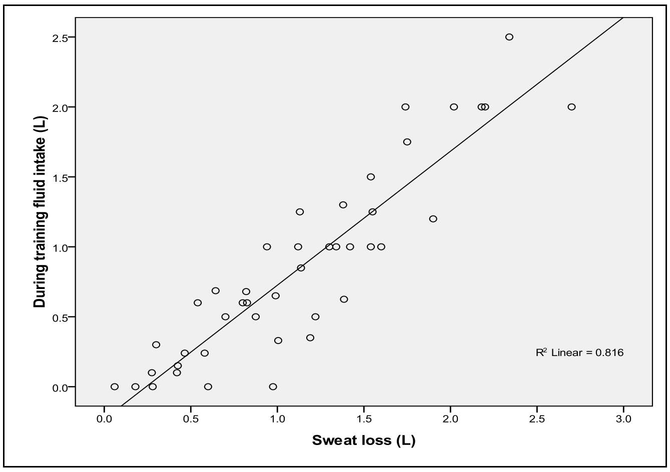

Fig 5: Pearson's Correlation between during training fluid intake and sweat loss

Significant difference was observed between pre and during ($p<0.001$), pre and post ($p<0.001$) and during and post training ($p<0.001$) fatigue levels. No significant difference was observed between male and female cyclists. During training sweat loss replenished by fluid intake during training sessions was highly significant (r = 0.903; $p<0.01$) indicating adequate fluid intake to maintain sweat loss.

Discussion

Fluids are a vital requirement for humans and can be consumed from a range of fluid sources other than water. Many factors impact total fluid volume including diet (water and sodium intake), environmental temperature, evaporation, activity level, and certain disease states. Humans have a remarkable capacity to maintain constant osmolality of extracellular fluid (ECF) through both behavioral responses and physiological mechanisms [18]. The selection of appropriate fluids, timing of the intake, and supplement choices are pertinent for optimal health, especially in young people [19]. Nevertheless, athletes seldom replace fluids completely due to sweat loss. Proper hydration during training or competition will enhance performance, avoid ensuing thermal stress, maintain plasma volume, delay fatigue, and prevent injuries associated with dehydration and sweat loss. In contrast, hyper-hydration before, during, and after endurance events may cause Na(+) depletion and may lead to hyponatremia [20]. The nutritional challenge is to prevent major dehydration and thus contribute to the prevention of fatigue [21]. In this study, cyclists maintained fluid balance with consumption of fluids at regular intervals and thereby alleviating fatigue. One method of calculating fluid replenishment is by weighing athletes both before and after a workout [22-24]. Replenishment, as it pertains to recovery, can first be looked at in the realm of hydration. The main concern with hydration recovery is dehydration or hypo-hydration, when less fluid is taken in than what is lost from the body particularly, in sweat [25]. Impairments due to hypo-hydration include postural balance, cognitive performance, mental readiness, and aerobic performance, which can see a decrease by 40-60% when the individual loses two percent or more of their body weight through a fluid [25, 26].

The use of changes in body weight due to sweat loss should be limited to determining acute hydration changes during practice. Nevertheless, it should not be used as an indicator of actual hydration status in athletes [27]. The cyclists in this study consumed sufficient fluids to prevent excessive hypohydration during exercise, complying with the consensus recommendation on good hydration practices that include: (1) beginning exercise in a state of optimum hydration, (2) preventing, and (3) replacing remaining losses following exercise before the next exercise bout[28]. However, it is acknowledged that fluid needs are individualistic and rely on factors like personal sweat rate, exercise mode, exercise intensity, environmental conditions, and exercise duration [22, 29, 30].

The components of a given beverage, namely fluid volume, energy content, and osmolality, can impact gastric emptying and absorption in the small intestine. In addition, the mineral constituents of these beverages are also metabolized on different time scales [31]. Thus, beverages with different compositions are likely to have varying effects on promoting hydration. This has led to increased interest in recent years regarding beverages, especially those that occur naturally, that may promote rehydration to a similar or greater extent than common sports drinks. Dairy-based beverages have a high electrolyte concentration [32, 33] and the cyclists in this study consumed tea, coffee, butter milk and lassi which are dairy-based beverages.

Fatigue is an exercise-induced impairment of performance and hydration is one of the fatigue measures [34] which can be determined through the “Rating of Perceived Exertion” (RPE) at the time during exercise [35]. Researchers have continued to understand and evaluate multiple types of fatigue that can be assessed at different time intervals to determine the impact of fatigue on performance [36, 37]. One contributing factor to the recovery of an athlete is the initial fatigue from which the athlete attempts to recover. In a broader sense, fatigue can be looked at in two realms; chronic and acute fatigue. While one can cause changes in the other, acute fatigue can be looked at specifically on game-day for areas of concern to mitigate perceived fatigue at specific times for improved performance. While chronic fatigue continues for a greater length of time after just moments of performance and continually impacts recovery, training capacity, and mental health if not corrected [38-41]. In this study, significant differences were observed in the perception of fatigue levels before, during and post training with decline in post training fatigue levels immediately after exercise. However, no gender differences were observed in the fatigue levels of cyclists.

Factors such as inadequate sleep, electrolyte imbalance, inappropriate replenishment of muscle glycogen stores, poor nutrient timing contribute to fatigue and thereby affect recovery. Assessment of these factors in addition to biomarkers and other hydration indices need exploration to establish a relationship between fatigue, fluid habits, and the hydration status of athletes which is a limitation to the study.

Conclusion

Cyclists consumed a wide variety of fluids to stay hydrated and comply with the consensus recommendation of during training hydration strategy by maintaining fluid balance between fluid loss and intake. Fatigue perception post training is significantly less than during training indicating faster recovery. Consumption of plain water during training alone cannot ensure optimal hydration and hence other hydration indices must be studied assess the hydration status.

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