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EXTENDED ABSTRACT

Pre-Exercise Hyperhydration Interventions in Adult Endurance Athletes: A Systematic Review of Performance, Physiological, and Tolerability Outcomes

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I. Introduction

Hyperhydration may enhance endurance performance, yet evidence remains inconsistent due to methodological heterogeneity and limited physiological tracking [1]. This systematic review critically evaluates randomized studies comparing pre-exercise hyperhydration with control or placebo. We examine effects on performance, physiological responses, and tolerability, highlighting gaps in sex representation, outcome validity, and mechanistic clarity to inform hydration strategies in endurance athletes [2].

II. Methods

This review was prospectively registered with PROSPERO and conducted according to the PRISMA 2020 guidelines. A comprehensive literature search was performed in Web of Science, PubMed, Scopus, and OVID MEDLINE from database inception to January 10th, 2025. Studies were included if they examined healthy endurance-trained adults aged 18–50 years, using one-off oral hyperhydration interventions administered ≤2 hours before exercise. Eligible study designs included randomized crossover or parallel trials and non-randomized within-participant comparisons.

Primary outcomes included exercise performance indicators such as time-trial results or time to exhaustion. Secondary outcomes included physiological measures (e.g., plasma volume, core/skin temperature, heart rate), urine output, and gastrointestinal symptom scores. Two reviewers independently screened titles, abstracts, and full texts, achieving high inter-rater agreement, with discrepancies resolved by a third reviewer. Data were extracted using customized REDCap forms, capturing intervention characteristics, outcome measures, ambient conditions, and participant demographics.

Risk of bias was assessed using Cochrane RoB 2 for RCTs, ROBINS-I for quasi-experimental trials, and the Newcastle-Ottawa Scale for observational studies. Subgroup analyses examined agent type, exercise duration, environmental conditions, and female representation. Narrative synthesis was used when data pooling was inappropriate due to heterogeneity or insufficient data.

III. Results and Discussion

A. *Identify and Appraise Studies*

Thirty studies met the inclusion criteria, mostly randomized crossover trials with predominantly male participants. Risk of bias varied but was generally low. Studies differed widely in protocols, agents used, and outcomes measured, limiting direct comparisons. Methodological inconsistency and limited female inclusion challenge the generalizability of findings and reinforce the need for more uniform, inclusive designs [3].

B. *Effects on Exercise Performance*

Hyperhydration improved exercise capacity (time to exhaustion) in most constant-load trials, with gains up to 26% [4]. Effects on time-trial performance were mixed, with benefits more evident under heat stress and longer durations. Sodium and glycerol both showed potential, but performance outcomes depended on protocol specifics, such as fluid availability and exercise intensity.

C. *Physiological Responses*

Plasma volume increased 3.5–12.6% with hyperhydration, particularly when sodium and glycerol were combined. Heart rate decreased by 3–11 bpm during exercise, and core temperature reductions of up to 0.8 °C were reported [5]. However, these effects were inconsistent, with some studies reporting no change, likely due to variations in dose, agent, and exercise context.

D. *Tolerability and GI Symptoms*

Gastrointestinal symptoms occurred in many studies, with nausea and vomiting reported, especially with glycerol boluses [6]. Slower ingestion, dilution, and co-ingestion strategies reduced severity. No single protocol consistently outperformed others in tolerability. Lack of validated symptom assessment tools remains a limitation, but practical recommendations suggest moderate dosing and gradual ingestion for better tolerability.

Fig. 1 shows an example of an image with country distribution. Check the country distribution to reveal the important detail in the figure.

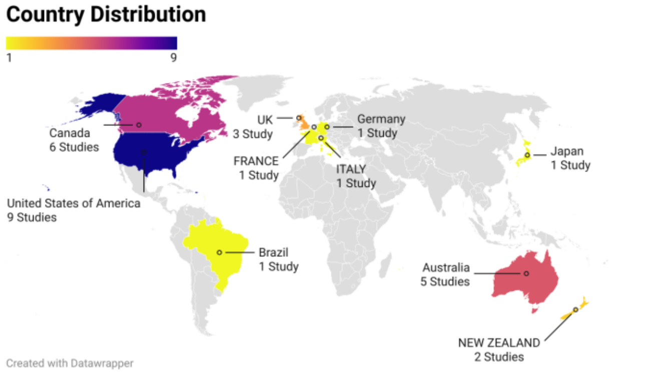

Fig. 1 Map showing the geographic origin of the 30 studies included in this systematic review. Colour intensity reflects the number of studies per country (scale 1–9).

TABLE I
SUBJECT CHARACTERISTICS

Characteristic	Mean	Median	Min	Max
Age (*yrs*)	28.4	26.7	18.5	59.7
BMI (*kg/m2*)	24.1	23.8	21.5	29.3

Fig. 2 shows the study design distribution for included studies.

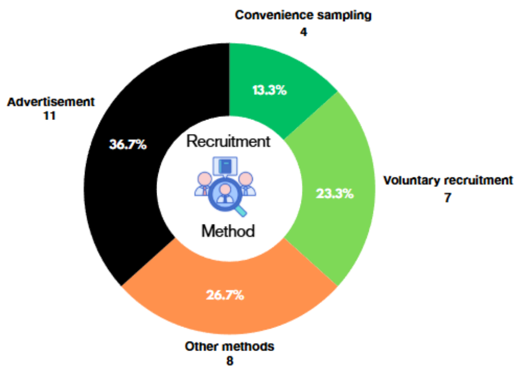

Fig. 2 shows the distribution of participant-recruitment methods in a four-segment doughnut chart. Advertisements, other methods, voluntary recruitment, and convenience sampling.

IV. CONCLUSIONS

Pre-exercise hyperhydration can enhance endurance capacity and influence physiological responses, though benefits for time-trial performance remain inconsistent. Effects vary by agent, dose, and context. Gastrointestinal symptoms are common but manageable with protocol adjustments. Standardized outcome reporting and inclusive study designs are needed to guide safer, more effective hydration strategies.

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