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Review

The effects of fluid loss on physical performance: A critical review

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Abstract

Purpose: The purpose of this review was to critically analyse the current evidence investigating the effect of an athlete's hydration status on physical performance.
Methods: A literature search of multiple databases was used to identify studies that met the inclusion criteria for this review. The included studies were then critically appraised using the Downs and Black protocol.
Results: Nine articles were found to meet the inclusion criteria, with an average score of 79% for methodological quality representative of a "high" standard of research.
Conclusion: The evidence suggests that dehydration has a negative impact on physical performance for activities lasting more than 30 s in duration. However dehydration was found to have no significant impact on physical performance for activities lasting less than 15 s in duration.

Keywords: Athlete; Dehydration; Euhydration; Hydration; Performance

1. Introduction

The idea that bodily fluid loss, in the form of dehydration, impairs an athlete's physical performance is not new. In 1955, Buskirk et al.[1] discussed the negative impact dehydration had on VO_{2max}. Since this research, evidence supporting dehydration related impairments in aerobic performance,[2] anaerobic performance,[3,4] and cognitive performance,[5] have been published, as have incidents whereby athlete dehydration has led to the risk of fatality.[6]

A state of dehydration can be induced through physical activity (PA).[7] However, the level of dehydration induced can be dependent upon a number of variables including the type, intensity, and duration of the PA and the temperature and humidity of the environment.[8] Hence studies have been undertaken to investigate the impact that PA has on dehydration, and conversely the impact that different levels of dehydration have on physical performance. The intent of these studies was to better understand the need for an athlete to maintain a state of euhydration (absence of dehydration).[8] As an athlete's performance essentially requires a degree of PA and PA is known to potentially induce a state of dehydration and reduce an athlete's performance, an understanding of the relationship between PA and hydration status is important if a coach wishes to optimize their athlete's performance and prevent a potentially life threatening incidence. On this basis, the purpose of this review was to critically analyse the current literature investigating the effect of dehydration on physical performance.

2. Methods

A two-layered search strategy was utilized for the review. Firstly, a comprehensive search of online databases including PubMed, CINHAL, Web of Science, SPORTSDiscus, and EBSCO: Academic Search Complete was completed. The search terms, "fluid loss" or "exercise induced dehydration" and "performance" and "physical task" or "exercise" and filters used for the searches of these databases are detailed in Table 1. All articles noted from the original database search were checked for duplicates, and these were subsequently removed. Secondly, the reference lists of articles from the database search that were retrieved in full text were cross-checked against the list of initial database articles and all new articles were noted and sourced.

All articles were then subjected to key inclusion criteria, these being: (1) the article specifically investigated the effect of dehydration on physical task performance; (2) the article was

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Table 1
Details of literature search: databases used, search terms, and filters.

Database	Filters	Number after exclusion	Number after inclusion	Total number	Duplicates	New articles
PubMed	2003–2013, human, English, clinical trial, RCT	4	3	3	0	3
CINHAL	2003–2013, human, English, research article, peer reviewed, RCT	1	1	1	1	0
Web of Science	Article, English, 2003–2013	72	8	8	5	6
SPORTSDiscus	Journal article, peer reviewed, English, 2003–2013	24	2	2	2	0
EBSCO: Academic Search Complete	Scholarly (peer reviewed) journals, 2003–2013, article, English	23	2	2	2	0

Abbreviation: RCT = randomized control trial.

published within the last 10 years; (3) the research involved human participants; (4) the article was published in English; and (5) the article was an original research article. For the purpose of this review, dehydration was defined as an increase in osmolality or similarly a decrease in body mass from a single exercise session/heat exposure. Physical tasks were defined as tasks that require physical exertion or activities that challenge the participant in a physical capacity.

The methodological quality of selected articles was assessed using the Downs and Black protocol.[9] The Downs and Black protocol employs a 27-question checklist to assess five key areas of methodological quality: statistical power, internal validity (bias and confounding), external validity, and reporting quality. The checklist comprised closed answer questions, where a "yes" is awarded 1 point and a "no" or "unable to determine" is awarded 0 point. There are two questions that have more points assigned to them. Question 5, reporting of confounding factors associated with the participants, is scored out of two (0 = no list, 1 = a partial list, 2 = a complete list of principle confounders). Question 27, a statistical power question, has scores derived from the number of participants involved in the clinical trial and is scored out of five. Scores were converted to a percentage of the total score by dividing each article's score by 32 (total possible score) and multiplying by 100. All studies were independently rated by the authors with the level of agreement measured using a Cohen's Kappa (κ) analysis of all raw scores (27 scores per paper). For final scores, any disagreements in points awarded were settled by consensus.

3. Results

From the initial search, 124 possible articles were identified from the database searches (Fig. 1). Of these articles, 108 were removed following review of the titles and abstracts against the five inclusion criteria. An additional seven articles were removed due to duplication. Six articles were added from the search of reference lists which identified previously unidentified articles. The remaining 15 articles were then reviewed in detail and considered against the inclusion criteria with nine papers retained for critical review.

The participants, methods, main findings and critical appraisal of the articles are shown in Table 2. The κ statistic for inter-tester agreement of the methodological quality of the studies indicated a "substantial" agreement (κ = 0.744).[10] The critical appraisal measures of power, quality of reporting, internal validity and external validity of the selected research articles were found to have reasonably high methodological scores (mean = 79% ± 4%) ranging from 72% to 81% using the Downs and Black checklist.[9] These scores are considered to represent a high standard of research.[11] Both the inability to blind the participants and the researchers, and poorly represented populations were identified as the main limitations of the studies identified for review.

The populations of the studies were all males, who were classified as healthy and active. Some of the participants were involved in specific sports including cycling,[8,12] rugby,[2] golf,[13] soccer,[14] and triathlon[7] with the remaining participants from the general population.[3,4,15] The average population size for the studies was nine participants ranging from seven to 12 participants. Seven of the nine studies[2,7,8,12–15] utilized a randomized crossover trial to allow for the capture of results from all participants across conditions whilst removing confounding effects in both learning and fatigue. The remaining two studies[3,4] used a one-day trial where the participants started in an euhydration state with exercise or heat exposure prescribed to achieve the dehydration condition for post-testing. There were a number of

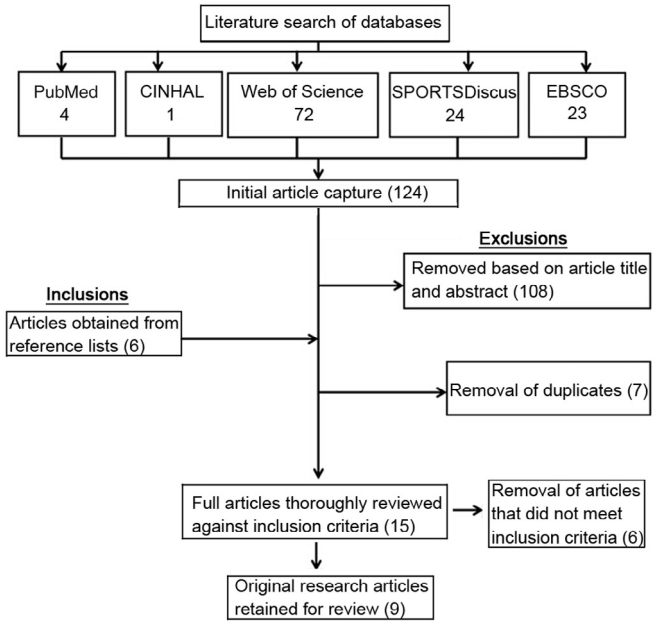

Fig. 1. A flow chart of the process used for the literature review.