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Tea for Sport and Fitness: A Scoping Review

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Abstract

An extended evidence-base has evaluated the role of nutrition in sports and fitness. The roles of hydration are also well covered but within this the specific roles of tea are not yet discussed widely. Subsequently, the present scoping review aims to evaluate the potential roles of tea in relation to aspects of sports and fitness performance. Searches for human observational studies and clinical trials were undertaken in PubMed.gov, Science Direct and Google Scholar databases. Sixteen relevant publications were identified with five focusing on outcomes related to body weight, composition, adiposity, or fat oxidation. Other reported outcomes included strength, muscle strength, or mass, oxidative/antioxidant and hydration status, salivary antibacterial capacity, and balance performance. Evidence appeared strongest for green and matcha tea with the typical ingestion of 2 to 3 cups daily being associated with improved body composition, antioxidant profile, sleep quality (low caffeine green tea), salivary defence mechanisms against microbial pathogens and reduced adiposity. From a general stance tea drinking could be an alternative beverage choice for those keeping active, providing a source of fluids and polyphenols. Older populations, those undertaking activities in colder climates, or for prolonged durations e.g., long-distance walking may benefit from personalised hydration programmes that could involve tea drinking. Larger and longer randomised controlled trials using tea in beverage form rather than as extracts or supplements are now warranted to further advance science in this field.

Keywords: Tea; Sports; Fitness; Performance; Hydration; Polyphenols; Health; Wellness

Introduction

It is well appreciated that nutrition is important for sports performance with Hippocrates stating in the fifth century BC that *"eating alone will not keep a man well, he must also take exercise. Food and exercise work together to produce health"* [1]. In contrast hydration advice for sport and fitness is less commonly spoken about in practical terms and not yet firmly embedded within public health guidance. Much confusion remains apparent when it comes to fluid/hydration knowledge and understanding. This is demonstrated by results from a knowledge questionnaire administered to 101 youth academy athletes which showed that less than half (46%) answered fluid/hydration questions correctly and 72% could not identify fluid requirements for training sessions [2].

Increasingly, the body's total fluid balance has been linked to the cognitive, technical, and physical aspects of sports performance [3]. It is known, for example, that total body water as a percentage of body weight declines from around 80 percent at birth to approximately 50-60 percent in adulthood [4,5]. 'Body water balance' has been defined as the net difference between water loss and gain and is referred to as "hydration" whilst "hypohydration" and "hyperhydration" refer to water deficits or excess, respectively [6]. At times, the term "euhydration" may be used which relates to the maintenance of normal water balance -a state of equilibrium which preserves body water levels within homeostatic ranges [6,7]. Exercise, however, can swiftly disrupt fluid balance, challenging goals of 'optimal performance', especially in warm environments [7]. In general, a 2 percent body mass loss (as water) has been defined as the threshold beyond which exercise dehydration can impact on aerobic exercise performance in temperate conditions and this is likely to be further accentuated in warm and hot environments [8]. In sports such as football significant hypohydration (defined as mean body mass loss <2 percent) has been commonly reported [3]. In endurance cycling hypohydration equivalent to 2-3 percent body mass has also been associated with reduced performance in the heat when inadequate fluids are consumed [9].

In various sports, such as combat sports practices such as total body fluid reduction have been used as a strategy for "weight-cutting" to compete against a smaller opponent, which could have extended health implications [10]. Such cultural effects of sports are particularly prominent in weight division sports (combat sports, lightweight rowing), appearance-based (body building) and acrobatic sports (gymnastics, climbing, jumping) [7]. At the other end of the spectrum over-drinking fluids should be discouraged to avoid exercise-associated hyponatraemia (hypo-osmolar water intoxication with cerebral oedema) [11].

An established body of evidence has already looked at the effects of drinking certain beverages in relation to their effects on sports performance and fitness which includes water and 'fluids' [12,13], caffeine-containing energy drinks [14] and chocolate milk [15]. It is already recognised that black tea when ingested by healthy males (up to six cups/mugs each being 240 ml) can offer similar hydrating properties to water [16]. Tea consumption could also contribute to energy, nutrient and polyphenol intakes [17,18] which could be of value from a sports and fitness stance. Given this, combined with a growing number of studies in the field, the objective of present scoping review was to provide an overview of how tea ingestion could impact on aspects of sport and fitness. This does not appear to have been undertaken by any other reviews at present.

Eligibility criteria

Participants, concept and context: Athletes, sports competitors, and adults engaged in habitual sport or fitness, specific sports, and activities were included. Studies focusing on infants or children were excluded. Studies that did not recruit active, sports or fitness populations were also omitted unless they focused on hydration status or sleep quality or patterns. Human trials and observational studies were included if the total number of participants was ≥ 10. Review, discussion papers and animal studies were excluded from the scoping review.

Types of sources

The scoping review considered evidence from human trials, including clinical studies, clinical trials, Phase I, Phase II, Phase III, Phase IV, controlled clinical trials, multicentre studies, observational studies, and randomised controlled trials. Publications were included if they were published between the 1st of January 2000 and the 30th of March 2021.

Methods

Scoping reviews are increasingly being used to map the breadth and depth of emerging topics [19] which in this instance was tea drinking in relation to aspects of sports and fitness. The Joanna Briggs Institute scoping review guide (2020) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Scoping Review extension (PRISMA-ScR) guidelines and 22-item scale were applied [20,21]. The main review questions were 'What is known about tea consumption in sport and fitness? and 'Can tea consumption have a role to play in sport and fitness performance?'

Eligibility criteria were linked to the research objective (s) and question (s). Three levels of scientific searches were undertaken which included:

1) An initial search to identify key words and phrases

2) A second search using allocated key terms to conduct a formal search within specified databases and

3) A reference list search from papers identified.

For studies to be included the tea form needed to be ingested or consumed. Studies focusing on white, oolong, rooibos, black, green and matcha tea were included. Those using tea extracts, supplements, mixed or multiple infusions were also excluded as these forms could not be translated into practical public health messages. Studies using tea powders were included if these were diluted and consumed in beverage form.

Search strategy

Searches for relevant publications were undertaken using PubMed.gov, Science Direct and Google Scholar databases (Figure 1). The search strategy included the keywords: Tea combined with cogn* (must be in exercise/fitness settings), concentration (must be in exercise/fitness settings), weight (must be in exercise/fitness settings), hydration, sleep, muscle, cycling, running, walking, training, endurance, exercise, performance, athlete*, fitness and sport with in the title of publications (full search terms displayed in Table 1). These were adapted for each included database.

Studies published in any language were included. Following the search, all identified citations were uploaded and collated into End Note (Version 19) and any duplicates removed. Titles and abstracts were screened by authors and compared against the inclusion criteria for the review. A tree map was developed using NVivo (X64.exe, QSR international) qualitative data analysis software (Figure 2). This used autocodes to identify 'themes' using the references from the selected studies thus collating the most commonly reported themes by visual means.

Results

Figure 1 shows the algorithm for selecting papers. Eighty-six publications were identified (84 from PubMed.gov and 2 from Google Scholar). Of these 32 were excluded due to then using mixed or multiple infusions, extracts or supplements, 21 were not related to sports or fitness, seven were replicas, five were irrelevant, four used different tea forms that did not meet the inclusion criteria and one was a review paper.

After screening 16 relevant studies were identified from the specified databases (Table 2). These investigated a range of outcomes related to sports, fitness and wellbeing, including hydration status [16,22,23], body weight, composition, adiposity or fat oxidation [24-28], sleep and mood [23,29,30], strength, muscle strength or mass [31,32], oxidative

Table 1: PubMed search terms.

tea[Title] AND cogn*[Title]	7
tea[Title] AND concentration[Title]	2
tea[Title] AND weight[Title]	18
tea[Title] AND hydration[Title]	3
tea[Title] AND sleep[title]	5
tea[Title] AND muscle[Title]	5
tea[Title] AND cycling[Title]	1
tea[Title] AND running[Title]	0
tea[Title] AND walking[Title]	5
tea[Title] AND training[Title]	4
tea[Title] AND endurance[Title]	4
tea[Title] AND exercise[Title]	22
tea[Title] AND performance[Title]	6
tea[Title] AND athlete*[Title]	1
tea[Title] AND fitness[Title]	1
tea[Title] AND sport[Title]	0

Filters: Clinical Study, Clinical Trial, Clinical Trial, Phase I, Clinical Trial, Phase II, Clinical Trial, Phase III, Clinical Trial, Phase IV, Controlled Clinical Trial, Multicentre Study, Observational Study, Randomized Controlled Trial, Humans, from 2000/1/1 -2020/3/30.

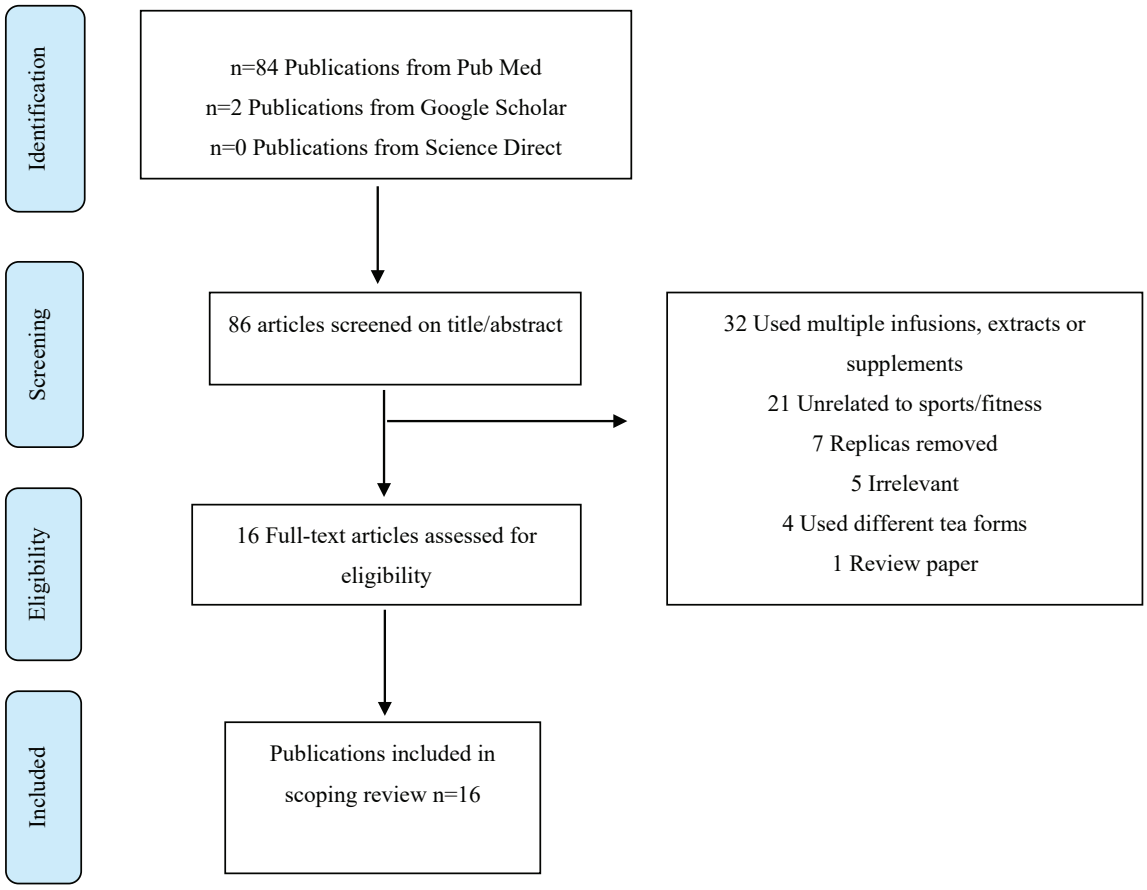

Figure 1: PRISMA algorithm used to identify publications.

stress or antioxidant status [27,31], cognitive impairment [33], salivary antibacterial capacity [34] and balance performance [35]. As shown in the Tree Map (Figure 2) of the 16 studies identified most focused on green, mate tea or its associated catechins. Outcomes studied included muscle mass, muscle strength, body composition, obesity, antioxidant and hydration status and resistance training.

Regarding tea forms, seven studies monitored sports and fitness outcomes in relation to green tea consumption [25-29,32,34], one studied the effects of drinking matcha tea [24], one mate tea [31], one study focused on oolong tea [35], another rooibos tea [22] and the remaining five studies focused on traditional black tea [16,23,30,33,36]. Methods were variable with some studies being observational in nature [33,36] whilst the majority were clinical trials (14 studies) which ranged from day trials to 12-week interventions.

Body weight, composition, adiposity, or fat oxidation

Five studies investigated the effects of tea drinking on body weight, composition, adiposity, or fat oxidation [24-28]. Willems MET, et al. (2018) recruited 13 females and asked them to drink three Matcha tea beverages (1 g of Matcha mixed with water X3) at mealtimes on the day before testing and again after an overnight fast on the day of testing. Matcha consumption (4 cups in 24 hours) significantly lowered respiratory exchange ratio ($p<0.01$) and enhanced levels of fat oxidation ($p<0.01$) during the 30-minute brisk walk [24]. Other work conducted with females (mean age 28.2 years) who were sedentary at baseline showed that drinking green tea alone over 8-weeks (3 cups daily each 150 ml) reduced central adiposity whilst the dual effects of green tea consumption and aerobic exercise improved both lipid profile and central adiposity [25].

Cardoso GA, et al. (2013) recruited women who were overweight or obese and after 4-weeks on an adaptive diet found that drinking green tea (two drinks daily; 10 g diluted with 200 ml ice water) resulted in favorable changes to body composition, weight and body fat loss and reduced waist circumference [26]. When green tea drinking was further combined with resistance training its potential was further increased, with reductions in body fat, waist circumference, and triacylglyceride levels being observed along with increased lean body mass and muscle strength [26]. Similarly, Maki KC, et al. (2009) recruited overweight or obese adults who were allocated to drink 500 ml/day of green tea providing 625 mg catechins or a control drink matched for caffeine content and asked to undertake ≥ 180 minutes of moderate intensity activity each week [28]. After 12-weeks there was a trend toward greater body weight loss amongst the green tea catechin group and significant reductions in total abdominal fat and subcutaneous abdominal fat area, indicating that green tea catechin ingestion appeared to enhance physiological benefits induced by exercise [28].

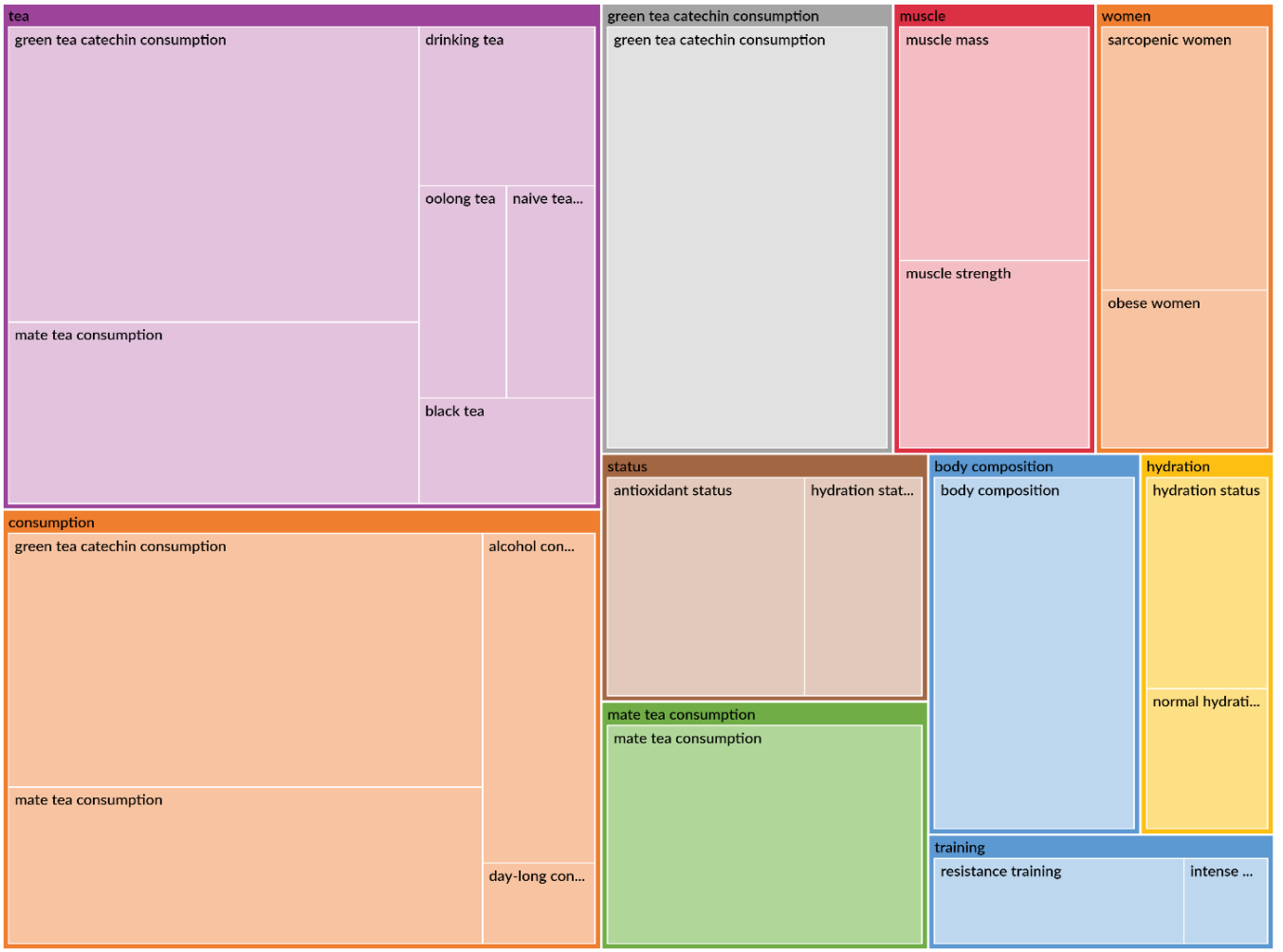

Figure 2: Tree map of themes extrapolated from key studies.

Amongst older adults (mean age 71.1 years) drinking 3 cups of green tea daily and vitamin E supplementation (400IU) over 12-weeks also resulted in significant reductions in waist circumference [27].

Sleep and mood

Three studies have investigated the effects of tea drinking in relation to sleep quality, patterns, or mood [23,29,30]. Unno K, et al. (2017) after a one-week washout allocated middle-aged adults to drink either ≥ 300 ml/day of standard of low-caffeine green tea, finding that the low-caffeine green tea resulted in reduced stress and better sleep quality [29]. Other research allocating healthy volunteers to receive 1 to 2 cups of tea (providing 37.5 or 75 mg caffeine), coffee (providing 75 or 150 mg caffeine) or water showed that day-long tea ingestion improved alertness but was less likely to disrupt sleep [30]. Another trial showed that tea drinking enhanced mood when undertaking endurance activities [23]. Similarly, Scott D, et al. (2004) found that mood was improved, and fatigue reduced amongst altitude climbers who ingested hot brewed tea during their expedition [23].

Strength, muscle strength or mass

Two studies focused on strength, muscle strength per se or mass as outcomes [31,32]. Panza VP, et al (2016) allocated 12 healthy males to drink 200 ml of mate tea or water three times daily over 8 days [31]. Plasma levels of phenolic compounds were significantly higher in the mate tea group [31]. Muscle strength was unaffected but strength recovery in the 24-hours post exercise was improved [31]. In a community trial setting with Japanese women with sarcopenia drinking 350 ml tea daily, fortified with catechins, over 3-months improved walking speed which appeared to be facilitated by improved muscle mass strength [32].

Hydration status

Three studies focused on hydration status [16,22,23]. Ruxton CH, et al (2011) conducted a randomised controlled trial allocating four 240 ml cups of black (i.e. regular) tea, six 240 ml cups of black tea, providing 168 or 252 mg of caffeine, or similar amounts of boiled water to healthy males [16]. Standardised tea made from tea bags and including 20 ml semi-skimmed milk was found to exhibit hydrating properties similar to water [16].

Earlier research by Scott D, et al. (2004) found that both tea and control conditions had similar effects on hydration status when ingested by altitude climbers amounts ingested, and urine volume were similar under both conditions [23]. Research using Rooibos tea provided to wrestlers after a 3 percent reduction in body mass showed that rooibos was equally hydrating as water [22].

Table 2: Studies investigating tea drinking in relation to sports and fitness outcomes.

Author (Year)	Population	Overall Sample size	Context/Concept	Methodology	Tea intervention	Outcomes	Key Findings
Torquati L, et al. (2018) [36]	Australian women	n=7580	To determine whether habitual consumption of coffee and tea is associated with participation in physical activity.	Analysis from the Australian Longitudinal Study on Women's Health study.	Participants who consumed 1-2 cups of coffee/day were 17% more likely to meet the recommended 500 metabolic equivalent min/week than women who had <1 cup/day (OR1.17, 95% CI1.04-1.32).	Levels of physical activity.	Middle-aged women who drank 1-2 cups of coffee or >1 cup of tea/ day were more likely to meet the moderate-to-vigorous physical activity guidelines than those who drank <1 cup/day.
Willems MET et al. (2018) [24]	Females walking briskly	n=13	Studied the effects of matcha green tea on metabolic, physiological, and perceived intensity responses.	Randomized, crossover X3 day visits.	Matcha powder mixed with water at mealtimes on the day before testing and on the day of testing.	Fat oxidation.	Matcha green tea significantly enhanced fat oxidation during a 30-minute brisk walk ($p<0.001$).
Unno K, et al. (2017) [29]	Middle-aged adults	n=20	To examine the effects of green tea with lowered caffeine content on quality of sleep.	7-day double-blind crossover trial.	One tea bag of standard green tea or low caffeine green tea (3 g of tea in each bag) was steeped in 500 ml of room temperature water in a water bottle. Tea bags were left in water until all tea had been fully consumed.	Sleep quality	Sleep quality was higher in participants that consumed a larger quantity of low caffeine green tea.
Hoseini S, et al. (2016) [25]	Sedentary women	n=40	Studied the effect of green tea consumption and aerobic exercise on obesity measures.	8-week randomised control trial with a quasi-experimental design.	The green tea consumption group consumed 3 cups (each 150 ml) per day (morning, afternoon, evening).	Central adiposity. Serum lipids.	The combination of green tea consumption and aerobic exercise appeared to improve lipid profile and reduce central adiposity.
Panza VP, et al. (2016) [31]	Males undertaking elbow flexion exercises	n=12	Studied whether mate tea improved muscle strength and oxidative stress after exercise.	8-day randomised, controlled, cross-over trial.	Matcha tea (1 g) in 200 ml or the control 3X daily (morning, afternoon, night)	Muscle strength. Oxidative stress.	Matcha tea did not affect muscle strength but hastened strength recovery over 24-hours post exercise and improved blood antioxidant concentrations.
Lin SP, et al. (2014) [34]	Taekwondo athletes	n=22	Studied the short-term effects of green tea consumption on salivary defence proteins, antibacterial capacity, and anti-oxidation.	Day trial.	Dried non-fermented green tea leaves. Extraction was carried out by soaking 20 g of green tea leaves in 600 ml of distilled water at 25ºC for 24 h. Infusions were filtered through a tea strainer.	Activity of α-amylase. Salivary antibacterial capacity.	Green tea consumption significantly enhanced salivary defence against microbial pathogens.

Cardoso GA, et al. (2013) [26]	Overweight or obese women	n=36	Studied the effects of green tea on weight loss due to its thermogenic effects.	8-week double-blind placebo-controlled trial (after 4-weeks on an adaptive diet).	Two 200 ml drinks daily made with ice water.20 g of either green tea or placebo per day (10 g at10:00 a.m. and 10gat 4:00 p.m., diluted in 200 ml of ice water).	Resting metabolic rate. Body composition.	Green tea combined with resistance training has potential to decrease body fat, waist circumference, and triacylglyceride levels by increasing lean body mass and muscle strength.
Kim H, et al. (2013) [32]	Japanese sarcopenic women.	n=128	Studied the effects of exercise and/ or tea catechins on muscle mass, strength, and walking ability in elders with sarcopenia.	3-month randomised controlled trial.	The tea catechin group ingested 350 ml of a tea beverage fortified with catechin daily for 3 months.	Muscle mass. Strength. Walking ability.	The exercise + tea catechin group had significant effects on physical function - leg muscle mass and walking speed compared with the control health education group.
Narotzki B, et al. (2013) [27]	Elderly men and women	n=22	Studied the effects of green tea, vit E and exercise on body composition, antioxidant, and metabolic profiles.	6-day intervention.	Green tea plus vitamin E (3 cups and 400 IU)	Glucose regulation. Antioxidant status. Body composition.	Green tea combined with vitamin E improved the benefits linked to exercise including body composition, glucose balance and oxidative burden.
Ruxton CH, et al. (2011) [16]	Healthy males	n=21	Studied the effects of black tea ingestion on hydration.	4-day randomised controlled trial.	Test beverages, provided at regular intervals, were 4 × 240 ml black (i.e. regular) tea and 6 × 240 ml black tea, providing 168 or 252 mg of caffeine. The controls were identical amounts of boiled water.	Hydration status.	Black tea, in the amounts studied, offered similar hydrating properties to water.
Utter AC, et al. (2010) [22]	Athletes	n=23	Studied the effects of rooibos tea on rehydration.	3-day randomised crossover study.	After a 3% reduction in body mass Rooibos tea was ingested.	Hydration status.	Rooibos tea was no more effective in promoting rehydration than plain water,
Maki KC, et al. (2009) [28]	Overweight and obese adults	n=107	Studied the influence of a green tea catechin beverage on body composition and fat distribution.	12-week randomised controlled trial.	Eligible participants were randomly assigned to receive either 500 ml/d of a beverage providing; 625 mg catechins or a control beverage.	Body weight. Abdominal fat loss.	There was a trend toward greater loss of body weight in the catechin group compared with the control group (p=0.079). Percentage changes in total abdominal fat area [-7.7 p=0.013], subcutaneous abdominal fat area [-6.2 p=0.019], and fasting serum triglycerides [-11.2 p=0.023 were greater in the catechin group

Huang CQ, et al. (2009) [33]	Chinese nonagenarians and centenarians	n=681	Studies associations between cognitive impairment and exercise and tea drinking patterns in those aged 90 to 108 years.	Cohort study.	Amongst males those with cognitive impairment had a significantly lower prevalence of habits of tea consumption (p=0.041 and 0.044, for former/current, respectively) and current exercise (p=0.020)	Cognitive impairment.	Amongst male Chinese nonagenarians/ centenarians those with cognitive impairment had significantly lower habits of tea consumption and current exercise levels.
Zhou B, et al. (2007) [35]	Balance performance	n=13	Studied the effect of oolong tea drinking on balance control.	Randomized, double-blind design.	Oolong tea was freshly prepared by adding 100 ml of boiling distilled water to 25 g of dry tea leaves. The tea infused for more than 10 minutes and filtered to 75 ml of distilled tea drink before it was used by the subjects.	Balance performance.	Oolong tea improved balance control. Significant improvements were observed for adaptation (p<0.01) and vestibular (p<0.05).
Scott D, et al. (2004) [23]	Mountain climbers	n=13	Studied effects of hot tea drinking on mood and hydration status.	Two 24-hr interventions.	In the "tea" condition, hot brewed tea formed a major part of fluid intake, whereas in the "no-tea" condition tea was excluded from the diet.	Hydration status.	Even at high altitude where fluid balanced is stressed tea did not act as a diuretic but did help to enhance mood.
Hindmarch I et al. (2000) [30]	Healthy volunteers	n=30	Studied the effects of day-long consumption of tea, coffee and water on cognitive and psychomotor performance, and sleep quality at night.	Day trials -5-way randomised crossover design.	Received equal volume drinks equivalent to either 1 or 2 cups of tea (containing 37.5 mg or 75 mg caffeine), or coffee (75 mg or 150 mg caffeine), or water.	Sleep onset Sleep quality.	Day-long tea consumption produced similar alerting effects to coffee, despite lower caffeine levels, but was less likely to disrupt sleep than coffee.

Other variables

Some studies focused on levels of oxidative stress or antioxidant status [27,31]. In particular, Panza VP, et al. (2016) showed that mate tea consumption favorably improved blood anti oxidant levels [31] whilst Narotzki B, et al (2013) found that a combination of green tea (3 cups daily) and vitamin E supplementation reduced levels of exercise-induced oxidative stress [27].

One study measured salivary antibacterial capacity amongst taekwondo athletes after intense training observing that this was enhanced after drinking green tea (20 g green tea leaves in 600 ml distilled water) ingestion [34]. Another small trial showed that oolong tea (25 g dry tea leaves and 100 ml boiling water) improved balance control in young adults (mean age 27.3 years) [35].

Two studies were observational in nature [33,36]. An Australian longitudinal study showed that middle-aged women who drank >1 cup of tea daily were more likely to meet guidelines for moderate to vigorous physical activity benchmarks than those drinking <1 cup daily though it was not clear whether this was a cause or effect relationship [36]. Cross-sectional research amongst male Chinese nonagenarians/ centenarians showed that those with cognitive impairment had significantly lower habits of tea consumption and current exercise levels [33].

Hydration guidance

There is a generic need to provide a clear consensus on hydration guidance, as this can vary somewhat between organisations. The United Kingdom Eatwell Guide advises that the public should aim to drink 6 to 8 glasses of fluid daily with water, lower fat milk and sugar-free drinks which include tea and coffee all counting towards this [37]. Within this guidance, formal advice for sport and fitness is not yet been provided. The British Dietetic Association informs that adults should drink 1.5 to 2 liters of fluid daily, equating to 8 to 10 drinks per day with a typical mug or glass being 200 ml and specifies that athletes may need regular fluid top ups as they lose more fluid through sweat [38].

Water intake guidelines have also been developed by the European Food Safety Authority. For adults the Adequate Intake (AI;

recommended intake based on approximations of intake) has been established at 2.0 litres/day for females and 2.5 litres/day for males [11]. These benchmarks include water from both beverages and foods providing moisture with the assumption that 70 to 80% of total dietary water intakes will be provides by beverages and 20 to 30% from foods [11]. The American College of Sports Medicine recommends that "athletes should be well hydrated before exercise and drink enough fluid during and after exercise to balance fluid losses" [39]. Considering these varying benchmarks updated clear and consistent guidance are needed. These should clearly distinguish whether fluids should be derived from beverages alone or combinations of foods and drinks and specify which beverage forms are included within guidance.

Discussion

Active lifestyles are an important part of modern living. Reflecting on the present pandemic it has been purported that physical inactivity due to sustained quarantine and social distancing could down regulate the organs' systems ability to resist to viral infections and elevate the risk of immune, brain, cardiovascular, respiratory and musculoskeletal system damage [40]. In the United Kingdom it is advised that adults and older adults should undertake at least 150 minutes of 'moderate intensity' activity each week e.g., brisk walking or cycling, or at least 75 minutes of 'vigorous activity' weekly that makes breathing faster and talking difficult e.g., running [41]. Alongside this older adults are advised to partake in activities that could improve their balance on 2 days a week e.g. through dance, tai chi or bowling [41]. Data collated between November 2018 and November 2019 showed that 63.3 percent of people in England were physically active thus aligning with guidance [42]. Unfortunately, this implies that a large proportion of the population did not meet such guidance with older adults, females and the long-term unemployed being most associated with physical inactivity [42].

An extended body of literature shows that a range of factors can impact on hydration status. For example, female collegiate athletes were found to drink more and compensate for sweat rates during indoor practice, indicating that drinking may need to be encouraged when practicing outdoors [43]. In other work adults with excessive body weight have been found to store more 'total body water' for height and age than those of normal weight, indicating that hypohydration risk is greater amongst these individuals [44]. Recent work assessing hydration status across three European countries showed that men were more likely to have inadequate hydration status on several days of the week which could impact more broadly on health and daily life [45]. It is also known that elderly adults in general are at higher risk of becoming dehydrated than adults due to a combination of diminution of liquid intake and increase in liquid losses [46].

Recently, it has been proposed that sub-optimal hydration proceeding severe acute respiratory syndrome corona virus 2 infections could result in a series of risk factors including: 1) heightened abundance of angiotensin converting enzyme 2 lung receptors, increasing infection risk, 2) epithelial lung cells which are 'pre-set' for an amplified immune response, 3) increased capacity for capillary leakage of fluid into airway spaces, and/or 4) decreased capacity for active and passive transport of fluid out of airways [47]. Thus, attention to optimal hydration could potentially help to reduce coronavirus mortality and related disparities [47].

The present review has shown that there is an emerging evidence-base studying tea drinking in relation to aspects of sports fitness and performance. Evidence currently appears to be strongest for green and matcha tea with the typical ingestion of 2 to 3 cups daily being associated with improved body composition and adiposity levels [24-28], antioxidant profile [27,31], sleep quality (low caffeine green tea) [29] and salivary defence mechanisms against microbial pathogens [34]. From an overarching stance, tea drinking in general could provide an alternative beverage choice for those keeping active providing fluids, polyphenols, l-theanine and caffeine, with the latter being an established ergogenic aid associated with improved sports performance in moderate doses [18,48,49].

The importance of 'personalised nutrition' has been gaining attention in relation to physical performance [50]. However, in stark contrast the roles of personalised hydration plans are less heard of. Potentially, these could play valuable role in optimising performance and safety during sports activities [7]. When it comes to beverage choices in sports and fitness balance is important. Clearly, whilst dehydration can impact on performance 'over drinking' or drinking before thirst should not be promoted. The concept that "once you're thirsty you're already dehydrated" is now being dismissed, with instinctive thirst mechanisms and parameters such as urine color, body temperature and race pace being more appropriate makers of hydration needs [51].

Table 3: Questions that could help with the development of hydration plans.

Directing Question	Steps to Correct	Examples of Implementation
Is the athlete/active individual in a state of optimal hydration?	Evaluation hydration status	Record fluid needs *via* sweat rate. Weigh individuals before and after sport/activity to evaluate fluid deficits.
Is the exercise prolonged or intense?	Improve the availability of suitable fluids	Have more breaks during longer periods of more intense exercise.
Is the exercise undertaken in extreme climates?	Improve the availability of suitable fluids	Have more breaks during longer periods of activity in extreme climates.
Is there access to fluids during the duration of exercise	Ensure that suitable fluids are available if required. In instances where fluids are restricted e.g., running races, football matches provide opportunities for rehydration	Provide access to suitable fluids during activities. Encourage adults to make to most of breaks to rehydrate if opportunities are restricted.
Are there factors linked to the sport that need to be considered? e.g. weight restrictions	Advise individuals on health and performance risks of utilizing dehydration for weight loss	Evaluate hydration status alongside weight measurements to promote healthy weight management.

Source, Adapted from Belval LN, et al. (2019) [7].

The present scoping review suggests that older populations, those undertaking activities in colder climates, or for prolonged durations e.g., long-distance walking may benefit from personalised hydration programmes that could involve tea drinking. The establishment of hydration plans could also help to inform suitable practices that are tailored in an individualised manner (Table 3). For example, active individuals may need to utilise breaks to rehydrate when opportunities may be limited [7].

Conclusions

It is well appreciated that suitable hydration practices have an important role to play in sports and fitness. A growing body of evidence indicates that tea drinking could form part of this. Presently, evidence appears to be strongest for green and matcha tea (drinking around 2 to 3 cups daily) in relation to markers of body composition and adiposity. It seems plausible that tea drinking in general could contribute to hydration status, provide polyphenols that attenuate oxidative stress and work alongside innate metabolic and physiological pathways that benefit from exercise. Tea drinking could also help to narrow hydration gaps where shortfalls exist. This could particularly be the case amongst longer endurance activities, those undertaken in extreme climates or amongst older individuals keeping active. Ongoing trials are now needed including further human clinical trials.

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Conflicts of Interest

The authors declare no conflicts of interest. The views expressed are those of the authors alone and personnel from the United Kingdom Tea & Infusions Association (UKTIA) had no role in writing this review.

References

1. Jones WHS (1868) Digital Hippocrates. Cambridge Harvard University Press.
2. Bird SP, Rushton BD (2020) Nutritional knowledge of youth academy athletes. BMC Nutr 6: 35.
3. Nuccio RP, Barnes KA, Carter JM, Baker LB (2017) Fluid Balance in Team Sport Athletes and the Effect of Hypohydration on Cognitive, Technical, and Physical Performance. Sports Med 47: 1951-1982.
4. Friis-Hansen BJ, Holiday M, Stapleton T, Wallace WM (1951) Total body water in children. Pediatrics 7: 321-327.
5. Virgili F, Amicis AD, Ferro-Luzzi A (1992) Body composition and body hydration in old age estimated by means of skinfold thickness and deuterium dilution. Ann Hum Biol 19: 57-66.
6. Liska D, Mah E, Brisbois T, Barrios PL, Baker LB, et al. (2019) Narrative Review of Hydration and Selected Health Outcomes in the General Population. Nutrients 11: 70.
7. Belval LN, Hosokawa Y, Casa DJ, Adams WM, Armstrong LE, et al. (2019) Practical Hydration Solutions for Sports. Nutrients 11: 1550.
8. Kenefick RW, Cheuvront SN (2012) Hydration for recreational sport and physical activity. Nutr Rev 70: 137-142.
9. James LJ, Funnell MP, James RM, Mears SA (2019) Does Hypohydration Really Impair Endurance Performance? Methodological Considerations for Interpreting Hydration Research. Sports Med 49: 103-114.
10. Barley OR, Chapman DW, Abbiss CR (2019) The Current State of Weight-Cutting in Combat Sports-Weight-Cutting in Combat Sports. Sports (Basel) 7: 123.
11. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA) (2010) Scientific Opinion on Dietary Reference Values for water. EFSA J 8: 1459.
12. McCartney D, Desbrow B, Irwin C (2018) Post-exercise Ingestion of Carbohydrate, Protein and Water: A Systematic Review and Meta-analysis for Effects on Subsequent Athletic Performance. Sports Med 48: 379-408.
13. Holland JJ, Skinner TL, Irwin CG, Leveritt MD, Goulet EDB (2017) The Influence of Drinking Fluid on Endurance Cycling Performance: A Meta-Analysis. Sports Med 47: 2269-2284.
14. Souza DB, Coso JD, Casonatto J, Polito MD (2017) Acute effects of caffeine-containing energy drinks on physical performance: a systematic review and meta-analysis. Eur J Nutr 56: 13-27.
15. Amiri M, Ghiasvand R, Kaviani M, Forbes SC, Salehi-Abargouei A (2019) Chocolate milk for recovery from exercise: a systematic review and meta-analysis of controlled clinical trials. Eur J Clin Nutr 73: 835-849.
16. Ruxton CH, Hart VA (2011) Black tea is not significantly different from water in the maintenance of normal hydration in human subjects: results from a randomised controlled trial. Br J Nutr 106: 588-595.
17. Landais E, Moskal A, Mullee A, Nicolas G, Gunter MJ, et al. (2018) Coffee and Tea Consumption and the Contribution of Their Added Ingredients to Total Energy and Nutrient Intakes in 10 European Countries: Benchmark Data from the Late 1990s. Nutrients 10: 725.
18. Khan N, Mukhtar H (2018) Tea Polyphenols in Promotion of Human Health. Nutrients 11: 39.
19. Maggio LA, Larsen K, Thomas A, Costello JA, Artino AR Jr (2021) Scoping reviews in medical education: A scoping review. Med Educ 55: 689-700.
20. Peters MDJ, Godfrey C, McInerney P, Munn Z, Tricco AC, et al. (2020) Scoping Reviews In: Aromataris E, Munn Z (Editors). JBI Manual for Evidence Synthesis, JBL.
21. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, et al. (2018) PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med 169: 467-473.
22. Utter AC, Quindry JC, Emerenziani GP, Valiente JS (2010) Effects of rooibos tea, bottled water, and a carbohydrate beverage on blood and urinary measures of hydration after acute dehydration. Res Sports Med 18: 85-96.
23. Scott D, Rycroft JA, Aspen J, Chapman C, Brown B (2004) The effect of drinking tea at high altitude on hydration status and mood. Eur J Appl Physiol 91: 493-498.
24. Willems MET, Şahin MA, Cook MD (2018) Matcha Green Tea Drinks Enhance Fat Oxidation During Brisk Walking in Females. Int J Sport Nutr Exerc Metab 28: 536-541.
25. Hoseini S, Nazarali P, Hanachi P, Khosravi N, Maria K (2016) Combining Green Tea with Aerobic Exercise Reduces Central Adiposity and Serum Lipid in Sedentary Women. Athens J Sports 3: 253-265.

26. Cardoso GA, Salgado JM, Cesar MDC, Donado-Pestana CM (2013) The effects of green tea consumption and resistance training on body composition and resting metabolic rate in overweight or obese women. J Med Food 16: 120-127.

27. Narotzki B, Reznick AZ, Navot-Mintzer D, Dagan B, Levy Y (2013) Green tea and vitamin E enhance exercise-induced benefits in body composition, glucose homeostasis, and antioxidant status in elderly men and women. J Am Coll Nutr 32: 31-40.

28. Maki KC, Reeves MS, Farmer M, Yasunaga K, Matsuo N, et al. (2009) Green tea catechin consumption enhances exercise-induced abdominal fat loss in overweight and obese adults. J Nutr 139: 264-270.

29. Unno K, Noda S, Kawasaki Y, Yamada H, Morita A, et al. (2017) Reduced Stress and Improved Sleep Quality Caused by Green Tea Are Associated with a Reduced Caffeine Content. Nutrients 9: 777.

30. Hindmarch I, Rigney U, Stanley N, Quinlan P, Rycroft J, et al. (2000) A naturalistic investigation of the effects of day-long consumption of tea, coffee and water on alertness, sleep onset and sleep quality. Psychopharmacology (Berl) 149: 203-216.

31. Panza VP, Diefenthaeler F, Tamborindeguy AC, Camargo CDQ, Moura BMD, et al. (2016) Effects of mate tea consumption on muscle strength and oxidative stress markers after eccentric exercise. Br J Nutr 115: 1370-1378.

32. Kim H, Suzuki T, Saito K, Yoshida H, Kojima N, et al. (2013) Effects of exercise and tea catechins on muscle mass, strength and walking ability in community-dwelling elderly Japanese sarcopenic women: a randomized controlled trial. Geriatr Gerontol Int 13: 458-465.

33. Huang CQ, Dong BR, Zhang YL, Wu HM, Liu QX, et al. (2009) Association of cognitive impairment with smoking, alcohol consumption, tea consumption, and exercise among Chinese nonagenarians/centenarians. Cogn Behav Neurol 22: 190-196.

34. Lin SP, Li CY, Suzuki K, Chang CK, Chou KM, et al. (2014) Green tea consumption after intense taekwondo training enhances salivary defense factors and antibacterial capacity. PLoS One 9: 87580.

35. Zhou B, Lovegren M (2007) Effect of oolong tea on balance performance in naive tea users - a pilot study. J Exercise Physiol 10: 43-50.

36. Torquati L, Peeters G, Brown WJ, Skinner TL (2018) A Daily Cup of Tea or Coffee May Keep You Moving: Association between Tea and Coffee Consumption and Physical Activity. Int J Environ Res Public Health 15: 1821.

37. PHE 2016 The Eat well Guide. Helping you to eat a healthy, balanced diet. Food Standards Scotland and the Food Standards Agency in Northern Ireland 1-12.

38. Highett J (2019) The importance of hydration. The association of UK Dietitians, UK.

39. American Dietetic Association, Dietitians of Canada, American College of Sports Medicine, Rodriguez NR, Marco NMD, et al. (2009) American College of Sports Medicine position stand. Nutrition and athletic performance. Med Sci Sports Exerc 41: 709-731.

40. Woodsab JA, Hutchinsona NT, Powersc SK, Robertsd WO, Gomez-Cabrera MC, et al. (2020) The COVID-19 pandemic and physical activity. Sports Med Health Sci 2: 55-64.

41. CMO (2019) Physical Activity Guidelines. UK Chief Medical Officers Physical Activity Guidelines.

42. PHE (2020) Physical activity: Main facts and figures.

43. Olzinski S, Beaumont J, Toledo M, Yudell A, Johnston CS, et al. (2019) Hydration Status and Fluid Needs of Division I Female Collegiate Athletes Exercising Indoors and Outdoors. Sports (Basel) 7: 155.

44. Mattoo TK, Lu H, Ayers E, Thomas R (2020) Total body water by BIA in children and young adults with normal and excessive weight. PLoS One 15: 0239212.

45. Braun H, Andrian-Werburg JV, Malisova O, Athanasatou A, Kapsokefalou M, et al. (2019) Differing Water Intake and Hydration Status in Three European Countries-A Day-to-Day Analysis. Nutrients 11: 773.

46. Casado A, Ramos P, Rodríguez J, Moreno N, Gil P (2015) Types and characteristics of drinking water for hydration in the elderly. Crit Rev Food Sci Nutr 55: 1633-1641.

47. Stookey JD, Allu PKR, Chabas D, Pearce D, Lang F (2020) Hypotheses about sub-optimal hydration in the weeks before coronavirus disease (COVID-19) as a risk factor for dying from COVID-19. Med Hypotheses 144: 110237.

48. Salinero JJ, Lara B, Coso JD (2019) Effects of acute ingestion of caffeine on team sports performance: a systematic review and meta-analysis. Res Sports Med 27: 238-256.

49. Guest NS, Dusseldorp TAV, Nelson MT, Grgic J, Schoenfeld BJ, et al. (2021) International society of sports nutrition position stand: caffeine and exercise performance. J Int Soc Sports Nutr 18: 1.

50. Guest NS, Horne J, Vanderhout SM, El-Sohemy A (2019) Sport Nutrigenomics: Personalized Nutrition for Athletic Performance. Front Nutr 6: 8.

51. Vitale K, Getzin A (2019) Nutrition and Supplement Update for the Endurance Athlete: Review and Recommendations. Nutrients 11: 1289.