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Impact of wet and dry cupping therapy on endurance, perceived wellness, and exertion in recreational male runners

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A R T I C L E I N F O

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A B S T R A C T

Background: Cupping therapy (CT), an ancient practice revived in modern sports medicine, offers potential benefits for athlete recovery and performance. Distinctions between wet CT (WCT) and dry CT (DCT) in sports science focus on their effects on recovery metrics, particularly how they influence sleep quality, perceived wellness, and athletic performance. Despite anecdotal evidence of its efficacy, rigorous comparative studies are scarce.

Objective: This study aimed to evaluates and compare the effects of WCT and DCT on endurance, perceived wellness, exertion levels, and sleep quality among young, active males, addressing the gap in the literature regarding CT's efficacy in sports performance and recovery.

Methods: Thirty-two amateur runners were randomly divided into two groups: one followed WCT sessions and the other followed DCT sessions. The study assessed the interventions' impacts on endurance performance (Yo-Yo intermittent recovery test), sleep quality (Pittsburgh Sleep Quality Index), and perceived exertion (Borg CR10 Scale). Heart rate was measured using a Polar H10 sensor to gauge physiological responses during physical tests.

Results: Significant improvements were observed in the WCT group for sleep latency (% change = −82.31%; interaction group × time $p = 0.006$; Cohen's $d = 0.74$) and sleep disturbance (% change = −68.70%; interaction group × time $p < 0.001$; Cohen's $d = 1.09$), suggesting enhanced sleep quality (global score; % change = −52.81; interaction group × time $p = 0.004$; Cohen's $d = 0.77$). However, no significant differences were found in direct performance metrics (distance, maximal heart rate, maximal oxygen uptake) between WCT and DCT groups. These findings highlight WCT's potential as a recovery aid, particularly through improved sleep, without directly influencing endurance performance outcomes.

Conclusion: WCT may serve as an effective ergogenic aid for athletes by potentially improving sleep quality and reducing perceived exertion, thus contributing indirectly to performance through enhanced recovery.

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Abbreviations

CR10	Borg CR10 Scale
CT	Cupping Therapy
DCT	Dry Cupping Therapy
HR	Heart Rate
MHR	Maximal Heart Rate
PSQI	Pittsburgh Sleep Quality Index
RPE	Rating of Perceived Exertion
$\dot{V}$ **O$_2$max**	Maximal Oxygen Uptake
WCT	Wet Cupping Therapy
Yo-Yo IRT	Yo-Yo intermittent recovery test

1. Introduction

Cupping therapy (CT) has traditionally had a cultural, religious and spiritual significance in various societies.[1] In some Muslim communities, it was believed that observing certain ceremonial practices, such as timing the therapy to align with specific days of the lunar calendar, would improve treatment outcomes.[1] In Eastern and Middle Eastern cultures, CT has gathered attention in alternative and complementary medicine for its claimed benefits across a wide range of health conditions.[2] The resurgence of CT in sports, particularly highlighted by its visible use by athletes during the 2016 Rio de Janeiro Olympic Games, has generated significant interest in the potential benefits of this ancient practice for modern athletic performance and recovery.[3] Many athletes, including basketball players and swimmers, have started using this method, known to leave noticeable circular marks on the skin to relieve stiffness in their muscles, speed up recuperation, and enhance performance.[4,5] This technique, which involves creating suction on the skin, is primarily categorized into two forms: dry CT (DCT) and wet CT (WCT).[2] DCT employs suction without skin incisions, whereas WCT enhances this process by making slight incisions on the skin to draw blood and serum into the cup.[6,7] The application of both DCT and WCT in sports medicine suggests an increasing recognition of their perceived benefits, including reduced muscle fatigue, enhanced blood flow, and alleviated pain.[3,8] However, despite anecdotal endorsements by high-profile athletes and the historical use of CT for various health conditions, the scientific community remains divided on its efficacy, particularly regarding its direct impact on sports performance metrics, recovery parameters, and overall athlete wellness.[2] This highlights the need for thorough scientific analyses to determine the real benefits of CT in sports, making a distinction between outcomes based on evidence and conventional appeal.[3,9]

This renewed interest emphasizes the need to critically evaluate and understand the mechanisms, efficacy, and potential benefits of both WCT and DCT, setting the stage for a deeper exploration of their roles within contemporary therapeutic practices and sports performance optimization.[2] The comparative effectiveness of WCT and DCT in enhancing sports performance and recovery remains largely unexplored.[10] While unreliable evidence and preliminary studies suggest potential benefits, such as improved central nervous system activation and increased endogenous substance release like nitric oxide, which may facilitate vasodilation and muscle recovery, scientific evidence supporting these claims is scarce.[11]

The literature lacks rigorous, controlled trials that explicitly evaluate the effects of WCT and DCT on quantifiable sports performance outcomes, such as sprint times, endurance levels, and recovery rates, as well as on subjective measures like perceived exertion and wellness.[12,13] Furthermore, the effect of various cupping techniques on sleep quality has not been thoroughly studied.[14,15] Despite suggestions that improved sleep could contribute to better performance outcomes, including enhanced sprint capability and reduced muscle damage, the role of CT in promoting restorative sleep and its subsequent effect on physical performance remains under-researched.[16,17]

This lack of definitive evidence highlights a significant research gap, emphasizing the need for studies that investigate the physiological and psychological effects of CT on athletes and discern the specific contributions of WCT versus DCT to athlete wellness and performance enhancement. Therefore, the primary objective of this study was to investigate and compare the effects of WCT and DCT on key outcomes related to athletic performance, including repeated sprint performance, perceived wellness, exertion levels, and, importantly, sleep quality in young active males. We propose the following hypotheses: (i) WCT and/or DCT significantly improves the quality of sleep, recovery in particular by inducing improvement in physical performance (ii) the WCT and DCT do not differ significantly in terms of performance measures and (iii) both types of cupping therapy WCT and DCT have no impact on sleep quality, recovery and improvement in physical performance.

2. Methods

2.1. Ethical approval

This study adheres to the ethical guidelines outlined in the Helsinki Declaration for human research and received ethical approval from the Ethical Committee of Farhat HACHED Hospital in Sousse, Tunisia (Approval Number: FH/20200411), for both segments of the research under the same Institutional Review Board reference. The initial part of our investigation was published in the journal Sports Medicine and Health Science in September 2023.[3] This subsequent segment extends our inquiry, focusing on a comparative evaluation of WCT and DCT regarding their effects on endurance, perceived wellness, and exertion in recreational runners. The study also complied with the highest ethical and procedural requirements of the conduct of sports medicine and exercise science research as outlined by Guelmemi et al., 2024.[18]

Comprehensive information regarding the study's aims, procedures, potential risks, and relevant details was provided to each participant. Following this detailed briefing; informed consent was secured from all participants, affirming their informed and voluntary engagement in the study, with the assurance that both protocols were sanctioned under the same Institutional Review Board approval, ensuring consistency and ethical oversight across the study's entirety.

2.2. Study design

This study employed a randomized, parallel-group design to investigate the effects of WCT and DCT on endurance, submaximal exercises, perceived wellness, and exertion among recreational runners. Initially, 34 participants were randomly allocated into two distinct groups: one group receiving WCT ($n = 17$) and the other receiving DCT ($n = 17$). Each group underwent the following protocol: ***i)*** A familiarization session, ***ii)*** A control session, and ***iii)*** An intervention session (either WCT or DCT, depending on group allocation). The order of the control and intervention sessions was randomized within each group. This design allowed for comparison between the effects of WCT and DCT, as well as comparison of each intervention to the control condition.

The research was meticulously conducted between May 9 and September 13, 2022. This 4-months interval was strategically chosen to facilitate the comprehensive establishment of the experimental setup, the execution of the involved procedures, and the subsequent phase of data analysis. The study adhered to COVID-19 safety protocols to protect participants from infection. All participants were vaccinated with at least two doses of a COVID-19 vaccine. Health screenings, including temperature checks and symptom questionnaires, were conducted before each session. Hygiene measures were strictly enforced, with hand sanitizers and disinfectants provided, and all equipment sanitized before and after use. Social distancing was maintained during non-physical activities, and masks were required for both participants and staff when not engaged in physical tasks. These precautions aligned with local health guidelines to ensure participant safety.[19,20] Fig. 1 represents the flowchart of the whole study protocol.

2.3. Sample size estimation

The sample size was estimated using the predictive formula:[21]

$$N = [(r+1)\,(Z_{\alpha/2} + Z_{1-\beta})^2\,\delta^2]/(r\,d^2),$$

where.

- "N" is the sample size equal to $n_1 + n_2$ (*ie;* sample sizes for the WCT and DCT groups);
- "$Z_{\alpha/2}$" is the normal deviate at a 1% level of significance (= 2.58);
- "$Z_{1-\beta}$" is the normal deviate at 85% statistical power with 10% type II error (= 1.03);
- "r" (equal to n_1/n_2) is the ratio of the sample size required for the two groups (here, $r = 1$ gives a sample size distribution of 1:1 for the WCT and DCT groups);
- "δ" and "d" are the pooled standard deviation (*SD*) and the difference of the main outcome (*ie*; change in the global Pittsburgh sleep quality index [PSQI] post-intervention).

Given the pioneering nature of this study at the time of its realization, values of "δ" and "d" were obtained from a previous randomized placebo-controlled trial evaluating the efficacy of CT to improve sleep quality (and other variables) in patients diagnosed with the fibromyalgia syndrome (47 in the DCT group and 48 in the sham cupping group). Eighteen days after the interventions, the estimated group difference (means ± standard deviation [*SD*]) between the DCT group and the sham group concerning the global PSQI was 0.9 ± 0.7.[22] The insertion of the afore mentioned data into the formula resulted in a total sample of 32 participants (16 in each group). Assuming a 5% absence during the post-intervention evaluation session, the revised sample size was calculated to be 34 participants [34 = 32/(1–0.05)]. The sample size calculation was double-checked using ChatGPT-4, following Methenni et al.'s guidelines, and the same result was obtained.[23]

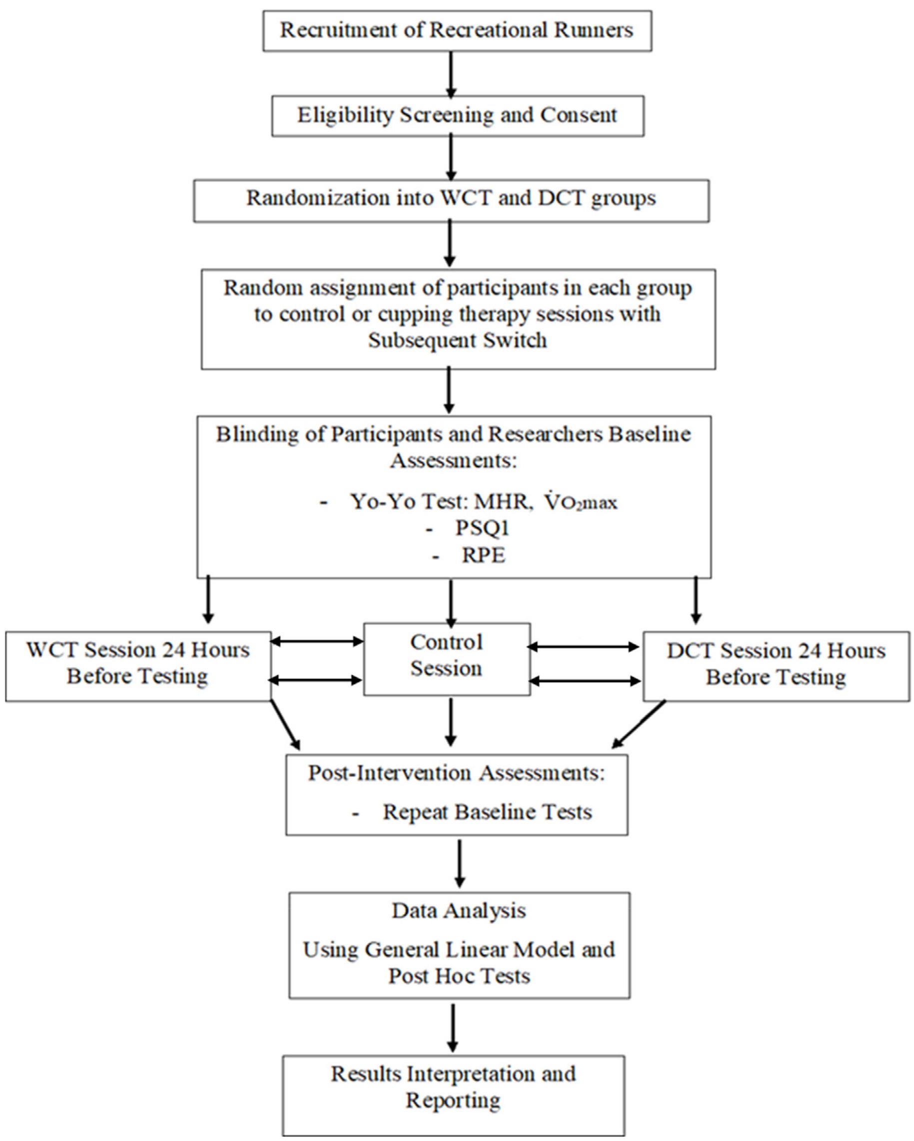

Fig. 1. Flowchart summarizing the whole study protocol. **DCT:** Dry cupping therapy. **MHR:** Maximal heart rate. **PSQI**: Pittsburgh sleep quality index. **RPE:** Rating of perceived exertion. **V̇O2max:** Maximal oxygen uptake. **WCT:** Wet cupping therapy.

2.4. Participants

Thirty-four runners aged 18–45 years, with a minimum of one year of running experience, were recruited for the study. Participants were eligible for the study if they met the following criteria: no musculoskeletal injuries in the last six months, no participation in other endurance training or rehabilitation programs during the study period and no previous experience with CT. In addition, participants were excluded if they had wounds or skin conditions in the areas where CT was to be applied, were sensitive or fragile, had infections, had recent surgery, had blood disorders, were taking anticoagulant medication, had an unstable heart condition or suffered from hypo- or hyper-tension.

2.5. Randomization and blinding

Of the 34 participants initially recruited, two (one from each group) missed the second session, and were consequently excluded from the study, resulting in a final sample size of 32 participants (16 in each group). The remaining participants were randomly assigned to either the WCT or the DCT groups, using a computer-generated randomization sequence. Participants were then randomly assigned to either a control session or a cupping therapy session and then switched to the alternative session. In an effort to maintain blinding, participants were not informed of the specific type of CT they were receiving until the study was completed. The researchers who performed the assessments were also blinded to group assignment. Although there were inherent differences between WCT and DCT, participants were told that all techniques were equivalent and were not informed of the specific benefits or characteristics of each method. They were also instructed not to discuss their treatments with others.

2.6. Interventions

Both WCT and DCT sessions were performed by a certified cupping therapist with over five years of experience. The therapies were applied to five specific points along both sides of the neck and thoracic spine, selected based on previous studies[24,25] that have used similar protocols for their relevance to overall body posture and muscle tension that can affect running performance (Fig. 1). Each session lasted approximately 30 min and was conducted 24 h before the testing sessions to ensure any acute effects of the therapy were observable during performance assessments.

All cupping procedures were performed using single-use plastic cups from the HANSOL brand. These sterile, disposable cups were used to ensure hygiene and consistency across all wet and dry cupping sessions. Vacuum pressure was measured using a hand-held suction pump equipped with a digital pressure gauge (Model DPG-2000, Omega Engineering, 2019) to measure and monitor the pressure continuously.

The vacuum pressure for both WCT and DCT was set to a range of 250–300 mmHg, based on previous research and expert recommendations.[26,27] A trained technician monitored these readings and made adjustments as necessary to maintain the pressure within the specified range, allowing for a tolerance of $\pm$ 10 mmHg. Throughout the cupping treatment, a trained technician continuously monitored cup placement and pressure. Participants were instructed to report any sensation of loosening cups. In cases where slight pressure adjustments were needed, these were promptly made using the suction pump to maintain proper cup adherence. A 3-minutes (min) treatment time was chosen for both WCT and DCT to maintain consistency between interventions, allowing for direct comparison. While longer durations have been reported in literature, especially for DCT,[28] this standardized approach was adopted based on pilot testing and practical considerations for our recreational runner population.[23,29]

2.7. Wet cupping therapy

The WCT session was performed by a certified and experienced healthcare professional according to the established protocols. During the treatment, participants were placed in the prone position (were on their abdomen). Five points on the sides of the neck and thoracic spine were first cleaned with an antiseptic solution to reduce the risk of infection. Single-use cups were placed on the designated points, and the cupping pressure was carefully adjusted for 3 min (Fig. 2). They were then removed and incisions approximately 2 mm deep were made at the cupping sites using a sterile scalpel. Cups were reapplied for an additional 3–5 min to optimize blood and serum extraction. Povidone-iodine was applied to the incision sites to prevent infection and support the healing process. After completion of the WCT, the sites were covered with sterile dressings treated with an anti-infective solution as an additional precaution. An emergency medical team, consisting of a doctor and a nurse with emergency equipment, was stationed in the treatment room. This was to ensure that quick action could be taken in the event of unexpected incidents, even if their assistance was not required throughout the treatment.[3]

2.8. Dry cupping therapy

The protocol for DCT was meticulously executed by a healthcare professional who held both certification and extensive experience in cupping techniques, ensuring adherence to established best practices. Participants underwent the therapy in a prone position to facilitate access to the targeted areas. Similar to the WCT protocol, the skin over the bilateral paraspinal regions of the neck and thoracic spine was thoroughly cleaned with an antiseptic solution before the commencement of the therapy, reducing the risk of infection.

In the DCT procedure, disposable cups were placed on predetermined points as outlined in the protocol (Fig. 2). The therapy utilized a carefully controlled vacuum pressure, set between 250 and 300 mmHg, mirroring the parameters used in WCT to maintain consistency in the application of CT across both modalities. This specific pressure range as well as the locations of the cups were chosen based on evidence from prior research, aiming to achieve a balance between the therapy's effectiveness and the safety of the participants.[26,27] The cups remained in place for a duration

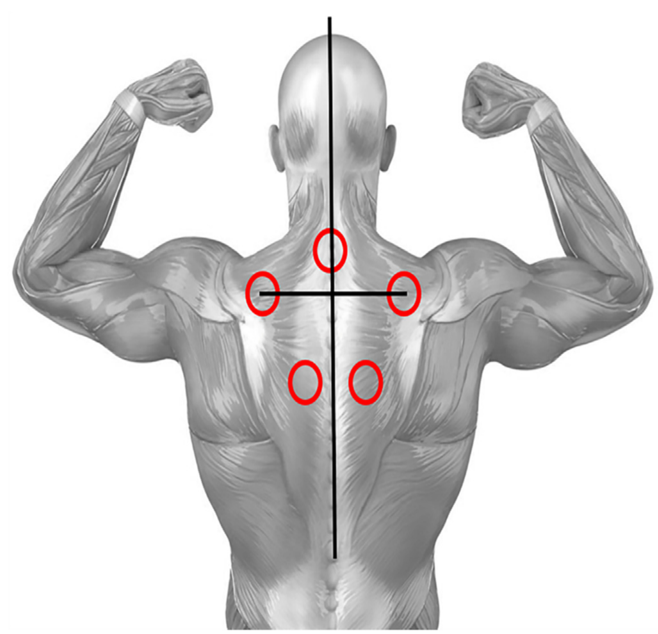

Fig. 2. Posterior torso showing points on the skin in which wet cupping therapy and dry cupping therapy were applied.

of 3 min, after which they were removed without the subsequent scarification step that characterizes WCT, distinguishing the dry method from its wet counterpart.

The absence of incisions in DCT meant that there was no need for the application of sterile pads post-therapy. As with WCT, the same medical team was on standby during DCT, but no intervention was needed, as the protocol adhered to the highest safety standards.[30]

2.9. Yo-Yo intermittent recovery test (Yo-YoIRT)

The Yo-YoIRT is widely used to gauge an athlete's endurance and recovery ability from intermittent, high-intensity activity.[31] It involves running between markers set 20 m apart to the pace of audio beeps, which gradually increase in speed. The test progresses through levels, ending when the participant can no longer keep up with the pace. This tool is considered as a gold standard for determining athletes' fitness levels, particularly in sports requiring bursts of high-intensity effort followed by recovery. All Yo-YoIRT testing sessions were performed indoors and at the same time of the day (***i.e.***, between 7:00 a.m. and 9:00 a.m.) to minimize the effects of diurnal variations in the measured.[32,33]

2.10. Estimated maximum oxygen uptake ($\dot{V}O_2max$)

$\dot{V}O_2max$ was calculated using the following equation[31]:

$$\dot{V}O_2\max\left(\mathrm{ml{\cdot}min{\cdot}^{-1}kg^{-1}}\right) = \text{distance covered in Yo} - \text{YoIRT (m)} \times 0.008\,8 + 45.73$$

2.11. The Pittsburgh sleep quality index

The PSQI is a standardized self-reported questionnaire that assesses sleep quality and disturbances over a one-month interval.[34] It is composed of seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The PSQI generates an overall score derived from these components, where higher scores indicate poorer sleep quality. Each item is scored from 0 to 3, and the total score of the seven components is called the total PSQI score, which ranges from 0 to 21. A total PSQI score of more than 5 indicates poor sleep.[34]

2.12. Rating of perceived exertion (RPE)

The Borg CR10 Scale, an extension of the original RPE scale, is a more refined tool that allows individuals to rate their perception of effort and exertion during physical activity on a scale from 0 (no exertion at all) to 10 (maximal exertion).[35] This scale is particularly useful in high-intensity workouts and rehabilitation since it offers a more nuanced assessment of physical exertion and subjective effort.[35] The CR10 scale's adaptability makes it suitable for diverse populations, from elite athletes to patients in clinical settings, facilitating tailored exercise programming and intensity adjustments based on individual perceptions of exertion.[36] In this study, each participant from both WCT and DCT groups completed the 0 to 10 scale 5 min after Yo-Yo IRT.

2.13. Heart rate (HR) assessment

For the accurate assessment of HR during the study, a Polar H10 HR (Polar Electro Oy, Kempele, Finland) was utilized. The Polar H10 model was selected based on its enhanced connectivity options and improved electrode design, which ensures stable heart rate readings even under the most intense workout conditions.[37] The strap's compatibility with a wide range of fitness apps, as well as its own Polar Beat app, allows for detailed analysis and tracking of HR data, catering to the needs of our experimental protocol.[37] In this study, participants were equipped with the Polar H10 HR sensor strap immediately before the commencement of each physical test, including the Yo-YoIRT. The device was positioned according to the manufacturer's instructions to ensure optimal signal reception and accuracy of HR measurements. HR data were recorded from the onset of physical activity until the completion of the test, providing reached maximum HR (MHR) measurements of participants.

2.14. Outcome measures

The primary outcome measures included endurance performance assessed by Yo-YoIRT, submaximal exercise capacity evaluated through distance covered, MHR, $\dot{V}O_2max$, perceived wellness measured using the PSQI, and exertion rated by the Borg Rating of RPE scale.

2.15. Statistical analysis

The distribution of variables was assessed using the Shapiro-Wilk test statistic and indicated normality. We implemented a general linear model designed to examine the effects of two categorical factors (***i.e.***, group = DCT and WCT, and time = pre (control session) and post (CT session) on outcome variables (***i.e.***, Yo-YoIRT, PSQI). To indicate the magnitude of the effect associated with the aforementioned model, we calculated partial eta squared values, where values of 0.01–0.059, 0.06–0.13, and $\geq$ 0.14 were considered to demarcate small, intermediate and large effects, respectively.[38]

The percentage change for all parameters was calculated as follows:

% change = [((Upper value - Lower value))/ (Lower value)] × 100

Following the general linear model, we conducted post hoc tests to further explore the differences between specific groups. To account for multiplicity and maintain a family-wise error rate, we employed Tukey's correction method. This permitted comparison of all possible pairs of means while controlling for Type I errors. In order to express the standardized mean difference (*SMD*) between pairs in the post hoc tests, we computed Cohen's *d*, where *d* is expressed as the mean difference between groups divided by the pooled *SD*.[38] Accordingly, the magnitude of the *SMD* (***i.e.***, Cohen's *d*) was interpreted as trivial (< 0.2), small (0.2–0.6), moderate (0.6–1.2), large (1.2–2.0), and very large ($\geq$ 2.0).[38] All statistical analyses were conducted using R (R Core Team 2018. R: A Language and environment for statistical computing. Computer software; retrieved from https://cran.r-project.org/). Statistical significance was accepted, a priori, at $p < 0.05$.

3. Results

Among the initial sample of 34 participants (17 in each group), two (one from each group) missed the one of the intervention sessions.

Table 1 exposes the anthropometric data of the DCT and WCT groups. The DCT group was significantly older than the WCT group by 3.25 years (large effect size). For height, there was no significant difference between the groups (negligible effect size). Weight differences approached significance ($p = 0.056$), with the DCT group weighing less than the WCT group (moderate effect size). Body mass index differences were not statistically significant (small to moderate effect size).

Table 1
Anthropometric data.

Variable (unit)	Group	Mean	*SD*	Statistic	*p*	Mean difference	*SE*	Lower	Upper	Cohen's *d*	Lower	Upper
Age (year)	DCT	29.31	5.13	3.36	0.001	3.25	0.97	1.32	5.18	0.84	0.33	1.35
	WCT	26.06	1.92									
Height (m)	DCT	1.76	0.09	−0.48	0.631	−0.01	0.02	−0.05	0.03	−0.12	−0.61	0.37
	WCT	1.77	0.08									
Weight (kg)	DCT	75.76	6.29	−1.95	0.056	−3.10	1.59	−6.28	0.08	−0.49	−0.98	0.01
	WCT	78.86	6.43									
Body mass index ($kg·m^{-2}$)	DCT	24.54	1.96	−1.52	0.133	−0.68	0.44	−1.56	0.21	−0.38	−0.87	0.12
	WCT	25.22	1.56									

DCT: Dry cupping therapy. ***SD***: Standard deviation. ***SE***: standard error. **WCT**: Wet cupping therapy.

Table 2
Group by time mean and percentage change values and general linear model output.

Variables (unit)	Group	Time		% Change	*p* (Cohen's *d*)		
					Main effect		Interaction
		Pre-	Post-		Group	Time	Group × time
Distance (m)	DCT	1 738.75	1 756.25	1.01	0.921 (0.026)	0.061 (0.494)	0.201 (0.334)
	WCT	1 705.00	1 795.63	5.32			
MHR (bpm)	DCT	193.63	192.13	−0.77	0.381 (0.228)	0.356 (0.24)	0.831 (0.056)
	WCT	192.19	191.25	−0.48			
$\dot{V}O_2max$ ($ml·kg^{-1}·min^{-1}$)	DCT	51.00	51.15	0.29	0.921 (0.026)	0.061 (0.494)	0.201 (0.334)
	WCT	50.72	51.48	1.50			
RPE (scores)	DCT	9.38	8.95	−4.50	0.471 (0.188)	0.061 (0.494)	0.201 (0.334)
	WCT	9.34	9.16	−2.01			
Subjective sleep quality	DCT	1.06	0.94	−11.76	0.204 (0.332)	0.104 (0.426)	0.362 (0.238)
	WCT	1.44	1.00	−30.46			
Sleep latency	DCT	0.56	0.50	−11.19	0.511 (0.17)	0.002 (0.854)	0.006 (0.74)
	WCT	1.06	0.19	−82.31			
Sleep duration	DCT	0.44	0.38	−14.38	0.225 (0.316)	0.464 (0.19)	0.807 (0.064)
	WCT	0.31	0.19	−39.93			
Sleep efficiency	DCT	0.88	0.81	−7.09	0.004 (0.768)	0.511 (0.17)	0.742 (0.086)
	WCT	0.38	0.19	−49.87			
Sleep disturbance	DCT	1.13	1.19	5.60	> 0.001 (1.448)	> 0.001 (0.906)	> 0.001 (1.086)
	WCT	1.00	0.31	−68.70			
daytime dysfunction	DCT	1.06	0.88	−17.69	0.567 (0.148)	0.015 (0.644)	0.184 (0.346)
	WCT	1.38	0.75	−45.45			
Sleep medication	DCT	0.00	0.00	0.00	–	–	–
	WCT	0.00	0.00	0.00			
Global score	DCT	5.13	4.69	−8.53	0.056 (0.504)	> 0.001 (1.046)	0.004 (0.774)
	WCT	5.56	2.63	−52.81			

Note: Recruited participants are healthy so sleep meditation was equal to zero.
DCT: Dry cupping therapy. **MHR:** Maximal heart rate. **RPE:** Rating of perceived exertion. **$\dot{V}O_2max$:** Maximal oxygen uptake. **WCT:** Wet cupping therapy.

Mean values for each variable, pre- and post-, for each therapy group (WCT and DCT), alongside percentage change, are detailed in Table 2. In addition, model outputs, in the form of '*p*' and *SMD* values, are presented.

The DCT and WCT groups showed differences across variables such as distance, MHR, $\dot{V}O_2max$, and RPE pre- and post-intervention. The WCT group exhibited a more notable increase in distance and a slightly higher increase in $\dot{V}O_2max$ than the DCT group. Both groups saw an MHR and RPE, with the DCT group having a larger reduction in RPE versus the WCT group. Despite these changes, no variable showed a significant main effect for group or time, nor was there a significant interaction between group and time (all $p > 0.05$).

The effects on sleep-related outcomes between DCT and WCT groups reveal significant differences. The WCT group experienced a more pronounced improvement in subjective sleep quality, sleep latency, sleep duration, and sleep efficiency than the DCT group. Interestingly, sleep disturbance increased in the DCT group but decreased in the WCT group. Both groups reported feeling better during the day, with the WCT group reporting a greater improvement. The global score, which likely aggregates all sleep-related metrics, declined significantly for both groups, with a more substantial decrease in the WCT group, suggesting an overall positive intervention effect, particularly on the WCT group's sleep quality. Statistically, sleep disturbance and the global score changes were significant over time ($p > 0.001$), with a notable interaction between group and time ($p = 0.004$ for the global score), highlighting that the intervention had a differential impact on the groups' sleep quality.

3.1. Post-hoc investigations

Only sleep latency, sleep disturbance, and global score indicated a significant interaction between the two categorical variables (group and time). Sleep latency was only significantly decreased, pre-vs. post-, for the WCT group (mean difference: −0.875, $p < 0.001$, Cohen's $d = -1.54$ [large]). Sleep disturbance significantly decreased, pre-vs. post-, for the WCT group (mean difference: −0.688, $p < 0.001$, Cohen's $d = -1.93$ [large]). Finally, the global score was only significantly improved, post-vs. pre-, for the WCT group (mean difference: −2.938, $p < 0.001$, Cohen's $d = -1.76$ [large]). The mean change scores for the afore mentioned three variables are visualized in Fig. 3.

4. Discussion

Preliminary findings indicate that while WCT significantly improved sleep quality and reduced perceived exertion; neither cupping modality distinctly enhanced the Yo-YoIRT performance, suggesting that the primary benefits of CT, especially WCT, might be more aligned with recovery and subjective wellness enhancements rather than direct

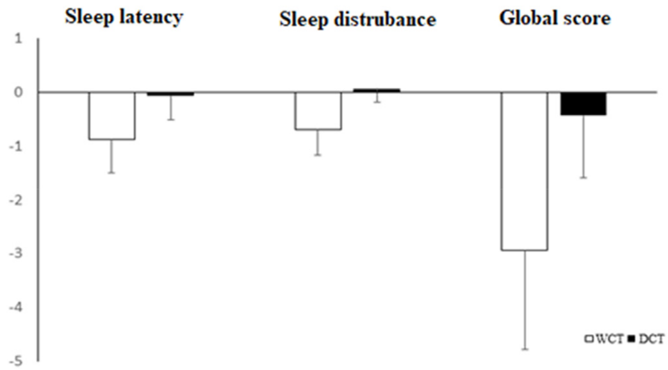

Fig. 3. Comparison of Sleep Latency, Sleep Disturbance, and Global Sleep Scores Between WCT and DCT Groups. DCT: Dry cupping therapy. **WCT:** Wet cupping therapy Data were expressed as means and standard deviations. According to the Pittsburgh Sleep Quality Index interpretation, more negative values indicate better sleep quality, with lower scores reflecting improvements in sleep-related parameters.

improvements in athletic performance metrics.

4.1. Impact of cupping therapy on sleep quality

Our study revealed significant improvements in sleep latency and sleep disturbance exclusively within the WCT group. These findings suggest that WCT has the potential to enhance certain aspects of sleep quality among athletes. The mechanisms behind these improvements could be multifaceted, including both physiological changes, such as enhanced blood circulation[39] and reduced muscle tension,[9] and psychological benefits, including reduced stress and anxiety levels.[40,41] Such physiological and psychological changes are critical for initiating and maintaining sleep, potentially explaining the observed enhancements in sleep latency and sleep disturbance.[42] Comparatively, the existing literature on sleep interventions in athletes has predominantly focused on strategies like mindfulness, relaxation techniques, and sleep hygiene practices, which have been shown to improve various aspects of sleep quality.[43] For instance, studies have indicated that interventions aimed at reducing pre-sleep anxiety can significantly shorten sleep latency and mitigate sleep disturbances.[44] The improvements observed in our WCT group align with these findings, suggesting that CT might offer similar benefits through mechanisms that warrant further investigation.[7] The implications of our findings are particularly relevant for athletes seeking to optimize recovery and performance through improved sleep quality.[3,45] Considering the importance of sleep in physical recovery and mental well-being, applying WCT as a complementary intervention could represent a valuable addition to athletes' recovery regimens. However, it is crucial to note that while our results highlight the potential of WCT in improving specific sleep parameters, further research is needed to fully understand the underlying mechanisms and to confirm these preliminary findings across broader populations and settings.

4.2. Physical performance and perceived exertion

In examining the effects of WCT and DCT on physical performance metrics such as distance, MHR, and $\dot{V}O_2max$, as well as RPE, our study found no significant differences post-intervention. This lack of significant findings may be attributed to several factors, including the timing of measurement post-intervention, the intensity of the exercise tests used, and the potential ceiling effects within a population of recreational athletes.[46–48] The timing of performance assessments following CT interventions might not have been optimal to capture the acute or delayed effects on physical performance measures.[48] Comparative literature on interventions aimed at enhancing athletic performance and reducing perceived exertion suggests varied results. For instance, other recovery modalities, such as cryotherapy and compression garments, have shown some efficacy in improving subsequent performance and reducing RPE in certain contexts.[49,50] The discrepancy between these modalities and CT could be due to differences in the mechanisms of action, with CT potentially offering more subtle or long-term benefits not captured in immediate post-intervention assessments. The findings from our study contribute to the ongoing discourse on the efficacy of traditional and alternative recovery strategies in sports science. While WCT and DCT may not significantly impact specific physical performance metrics or immediate perceptions of exertion among recreational athletes, this does not preclude their potential benefits for recovery, wellness, and possibly long-term performance enhancement.[45,51] Future research should consider exploring the longitudinal effects of CT, employing a diverse array of performance and exertion measures, and targeting athlete populations with varying baseline fitness levels to elucidate the nuanced effects of these interventions.

4.3. Limitations

The main limitation of our study lies in its relatively small and homogenous participant pool, consisting solely of young, active males. This demographic specificity restricts the generalizability of our findings to broader populations, including female athletes, older individuals, and those with varying levels of athletic engagement. These varying levels of fitness may affect individual responses to intervention and test performance. The results should then be interpreted with caution, keeping in mind this limitation. Furthermore, our study design did not account for potential differences in optimal treatment duration between wet and dry cupping. The standardized 3-min treatment time, while allowing for direct comparison, may not capture the full range of benefits for each method, particularly for dry cupping where longer durations are sometimes used in practice. Additionally, the short-term nature of the intervention and follow-up period may not adequately capture the long-term effects and potential benefits of WCT and DCT on athletic performance and recovery. The reliance on self-reported measures for assessing sleep quality and perceived exertion also introduces a subjective bias, potentially affecting the accuracy of these outcomes. The selection of cup placement points, while based on previous studies, lacks definitive scientific validation for enhancing running performance. This highlights a gap in the current literature regarding optimal cup placements for specific performance outcomes in athletes. Moreover, a significant limitation of this study was the difficulty in fully blinding participants to their treatment condition. The presence or absence of scarification and post-therapy sterile pads in wet and dry cupping, respectively, could have allowed participants to infer their treatment type. While participants were not informed about the expected effects of each therapy, and the current literature shows divergent results regarding wet versus dry cupping, this potential for inference could have influenced both objective and subjective outcomes. Additionally, our study did not explore the potential dose-response relationship of CT. The fixed treatment time and pressure across both interventions may not account for possible differences in optimal application parameters between wet and dry cupping. Although our study was not registered as a randomized controlled trial, which is not mandatory, we acknowledge this as a limitation. Registering trials is strongly recommended to enhance transparency and accountability. Future studies should consider ways to address this challenge, such as using sham procedures by using a device that mimics the sensation of cupping without actually performing the therapy or more elaborate blinding protocols. Additionally, future research would benefit from having more demographically diverse participants, including different age groups, sexes, and fitness levels, to enhance generalizability. Longer intervention periods and follow-up assessments would be valuable to evaluate both immediate and long-term effects of CT. The use of a wider array of objective measurement tools, such as biomechanical analysis and muscle oxygenation sensors, could quantify physiological changes more precisely. Investigating different cup placements, including comparisons between traditional acupuncture points and sport-specific muscle groups, would provide insights into optimal application strategies. Conducting dose-response studies to determine ideal treatment durations, frequencies, and pressures for both wet and dry cupping in athletic populations would be crucial. Finally, exploring the potential synergistic effects of combining CT with other recovery modalities could offer a more comprehensive understanding of its role in athletic performance and recovery.

5. Conclusion

Our results showed that WCT significantly improved sleep quality. However, neither CT modality significantly enhanced physical performance or reduced perceived exertion, highlighting the need for a cautious interpretation of these findings. The relationship between improved recovery indicators and actual performance enhancement requires further exploration. Future research should expand the scope of participants, extend the duration of interventions, and include objective measures of performance. Such efforts will provide a clearer understanding of CT's efficacy as a recovery tool and its indirect role in enhancing athletic performance.

CRediT authorship contribution statement

Ismail Dergaa: Conceptualization. **Hatem Ghouili:** Conceptualization. **Cain C.T. Clark:** Writing – review & editing. **Morteza Taheri:** Writing – review & editing. **Mohamed Saifeddin Fessi:** Conceptualization. **Nizar Souissi:** Writing – review & editing. **Noomen Guelmami:** Writing – review & editing. **Mohamed Ben Aissa:** Writing – review & editing. **Helmi Ben Saad:** Writing – review & editing. **Katja Weiss:** Writing – review & editing. **Beat Knechtle:** Writing – review & editing. **Lamia Ben Ezzeddine:** Writing – review & editing.

Ethical approval statement

The study was designed according to the guidelines of the Helsinki Declaration for conducting human experimentation and was approved by the ethical committee of the Farhat HACHED Hospital, Sousse, Tunisia (Approval N°: FH/20200411). Each participant was informed of the purpose, procedure, risks, and study details and consequently signed an informed consent form.

Availability of data and materials

The data related to this manuscript is available from the first author upon reasonable request.

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Declaration of competing interest

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

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In preparing this paper, the authors used ChatGPT model 4 on January 13, 2024, to revise some passages of the manuscript, to double-check for any grammar mistakes or improve academic English only.[52,53] After using this tool, the authors have reviewed and edited the content as necessary and take full responsibility for the content of the publication.

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