***International Journal of Sports Physiology and Performance*, 2024, 19, 1218-1226**
https://doi.org/10.1123/ijspp.2024-0085

Human Kinetics
ORIGINAL INVESTIGATION

Chill Without Thrill: A Crossover Study on Whole-Body Cryotherapy and Postmatch Recovery in High-Level Youth Basketball Players

Marco Pernigoni,[1] Andrea Perazzetti,[2] Mattia Digno,[3] Antonio Tessitore,[2]
Sigitas Kamandulis,[4] and Daniele Conte[2]
[1]Department of Coaching Science, Lithuanian Sports University, Kaunas, Lithuania; [2]Department of Movement, Human and Health Sciences, University of Rome "Foro Italico," Rome, Italy; [3]Stella Azzurra Basketball Academy, Rome, Italy; [4]Institute of Sport Science and Innovations, Lithuanian Sports University, Kaunas, Lithuania

Purpose: To assess the effect of whole-body cryotherapy (WBC) on postmatch recovery in basketball. ***Methods:*** Using a crossover design, 17 youth male players (age 16.2 [1.2] y, stature 190.5 [9.4] cm, body mass 79.2 [9.6] kg, experience 9.9 [3.9] y) completed 2 simulated matches, followed by WBC (4 min, −75 to − 85 °C) or a placebo intervention (CON). Countermovement-jump height, change-of-direction performance, 10- and 20-m sprint times, heart-rate variability (log-transformed squared root of the mean sum of the squared differences between R-R intervals [Ln-rMSSD]), muscle soreness, and perceived recovery (Perceived Recovery Status Scale [PRS]) were recorded at prematch, postmatch, postrecovery, and 24 hours postmatch. Additionally, Ln-rMSSD was recorded upon awakening on match day and the following morning. ***Results:*** Compared with CON, higher PRS values were reported in WBC at prematch and postrecovery ($P \le .026$), while no significant between-interventions differences were found for any other measure ($P > .05$). Regarding the effect of time, our findings revealed that 20-m sprint times, Ln-rMSSD, and PRS deteriorated in both interventions from prematch to postmatch (ie, acute changes, $P \le .045$), while muscle soreness worsened in WBC only ($P \le .003$). Conversely, countermovement-jump height, change-of-direction, and 10-m sprint performance were unaffected by match play in the acute phase ($P > .05$), while none of the investigated measures showed impairments at 24 hours postmatch, compared with prematch ($P > .05$). ***Conclusions:*** Overall, these findings suggest that WBC was mostly ineffective for improving postexercise recovery in the investigated sample, with benefits observed for perceived recovery being potentially influenced by the participants' status at baseline (ie, higher prematch PRS scores in WBC compared with CON).

Keywords: athletic performance, fatigue, thermotherapy, adolescent, team sports

The intermittently intense nature of basketball match play has been shown to generate substantial fatigue, leading to significant impairments in measures of performance, physiological status, and perceived well-being, which may persist in the days following exercise.[1] Additionally, players are often exposed to congested schedules, which may lead to fatigue accumulation due to incomplete recovery between training sessions and/or matches.[2] Therefore, the use of recovery interventions is critical to preserve players' readiness and high-level performance throughout the competitive season.[3]

Among various recovery strategies, cold-based interventions have received significant attention in the scientific literature, standing out as the most extensively researched approach within basketball populations.[3] Specifically, the use of cold-water immersion has shown beneficial effects on measures of performance (ie, isokinetic strength, jumping, change of direction [COD], single and repeated sprinting), physiological (muscle damage and inflammation), and perceptual recovery (ie, muscle soreness and perceived fatigue) across various basketball samples (ie, adolescent, collegiate, and professional players) following both matches and training.[3]

In addition to water immersion, other cold-based techniques have gained popularity in recent years, such as whole-body cryotherapy (WBC), wherein minimally dressed subjects are exposed to very cold air (−60 to −195 °C) for 1 to 4 minutes.[4] The proposed mechanisms for WBC include reductions in muscle blood flow, inflammation, local metabolic activity, cellular leakage, muscle tension/pain, and edema development after exercise.[4,5] These phenomena are associated with exercise-induced muscle damage,[5] which typically occurs following basketball activity,[1,3] and offer an explanation of why WBC may represent an effective strategy for improving recovery in basketball. Accordingly, a recent survey among basketball practitioners indicated that ~25% of the interviewed participants used cryotherapeutic interventions on a regular basis to improve recovery.[6]

However, to the best of our knowledge, no study has directly assessed the effect of WBC on postexercise recovery in a basketball-specific context[3] (including in youth players), warranting the need for research in this area. Therefore, the aim of this study was to investigate the effect of a postexercise WBC intervention on measures of performance, physiological, and perceptual recovery following a simulated basketball match in high-level, youth male players.

Methods

Participants

Twenty-two male basketball players from 2 teams competing in the top-tier Under-15 (U15; n = 12) and Under-17 (U17; n = 10)

Perazzetti https://orcid.org/0000-0002-9835-2930
Tessitore https://orcid.org/0000-0002-3542-0991
Kamandulis https://orcid.org/0000-0001-6476-1069
Conte https://orcid.org/0000-0003-3551-1030
Pernigoni (marco.pernigoni@lsu.lt) is corresponding author, https://orcid.org/0000-0002-9989-845X

Italian leagues, respectively, were initially recruited for this study. Inclusion criteria comprised the following: (1) players had to be part of their basketball team (ie, no team transfers or dropout) and complete the team's training plan for the entire duration of the study and (2) players had to be injury-free across the experimental period and complete the intervention procedures. During the study, 4 U15 players were excluded due to illness (n = 2) or incomplete participation in the study procedures (n = 2), while 1 U17 player was excluded due to injury. Therefore, 17 players (age: 16.2 [1.2] y, stature: 190.5 [9.4] cm, body mass: 79.2 [9.6] kg, experience: 9.9 [3.9] y) were retained for analysis. A priori power analysis (G*Power, version 3.1.9.7, University of Düsseldorf) indicated that this sample size was adequate (minimum n = 14) using $\alpha = .05$, $\beta = 0.80$, and effect size $f = 0.23$, based on similarly designed research in soccer.[7] The study was conducted during the off-season phase (June 2023), immediately after participation in the final phase of the U15 and U17 national championships. Prior to the study period, the players' typical weekly schedule (Supplementary Table S1 in the Supplementary Material [available online]) included 10 training sessions (ie, five 90-min basketball-specific sessions and five 45-min strength/power sessions, total training volume: ~11 h/wk) and 1 competitive match. After providing an explanation of the experimental design, written consent was gathered from all players and their parents/guardians. The study was approved by the University of Rome "Foro Italico" Ethics Committee (CAR 168/2023) and designed according to the Declaration of Helsinki.

Design

Before the study—which was conducted over a 2-week period—participants were familiarized with all procedures and equally divided into 4 teams (ie, 2 U15 and 2 U17 teams). During the first week, the U15 teams faced off in 2 simulated basketball matches (each preceded by at least 48 h of rest), with U17 players replicating the same schedule in the following week. Given the smaller size of the U17 group (n = 10) compared with U15 (n = 12), 2 of the recruited U15 players also took part in the U17 matches, to ensure consistent playing time across all participants (note: only data from the first week were analyzed for these players). Furthermore, the 3 players who became ill/injured after the first match were replaced by players of similar competitive level (not included in the analysis) in the second one. Throughout the study period, participants consumed their meals (provided by the canteen located within the training facility) at the same time every day and were asked to maintain a consistent diet (ie, without excessive day-to-day variations in food intake). Additionally, players were asked to adhere to their regular sleep patterns, avoid all forms of physical exercise (except for the activities included in the study), and refrain from using any external recovery strategy (eg, nutritional supplements, massage, foam rolling, recovery-dedicated devices, etc).

Using a randomized, placebo-controlled crossover design, participants completed both WBC and a placebo intervention (CON) after each match (Figure 1). Specifically, before the commencement of the study, player allocation was randomized using a freely available online tool (https://www.randomlists.com/team-generator). To determine the effectiveness of WBC, measures of performance (ie, countermovement jump height [CMJ]; 505 COD time; 10- and 20-m sprint times), physiological (ie, heart rate variability [HRV]), and perceptual (ie, muscle soreness and perceived recovery) recovery were assessed at prematch, postmatch, postrecovery, and 24 hours postmatch, with physiological assessment also being conducted upon awakening on match day and the

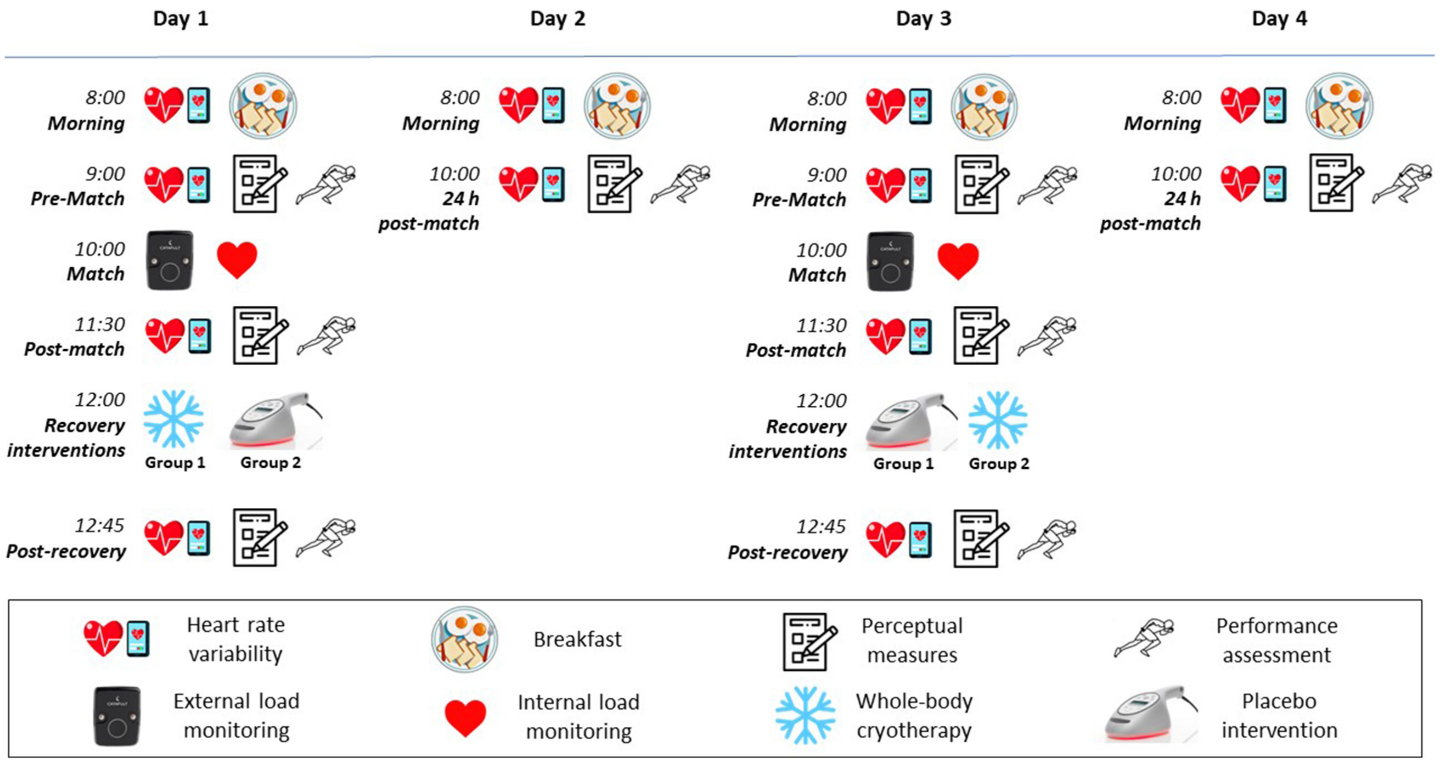

Figure 1 — Study timeline and procedures. Players were required to avoid any kind of physical exercise for a minimum of 48 hours before day 1 and throughout all 4 days where data collection was performed (except for the activities included in this study, ie, basketball matches, warm-up, and performance assessment).

following morning. Additionally, both external and internal loads were monitored during each match to ensure similar demands across experimental sessions.

Methodology

Basketball Match Structure

All simulated matches were officiated by a referee, took place on a 28 × 15-m wooden basketball court, and consisted of four 10-minute quarters (using a 24-s shot clock, 2-min interquarter breaks, and a 10-min halftime). To ensure equal playing time across all participants, substitutions were performed approximately every 3 minutes and 20 seconds, with each participant playing ~33 minutes in each match (see Supplementary Table S2 in the Supplementary Material [available online]).

Postmatch Recovery Interventions

Following the end of each match, players undergoing the WBC intervention transferred to a nearby fitness center (~5-min trip using the team's private bus), where the WBC device was located. Conversely, the CON group moved to a physiotherapy room within the team's training facility, where the placebo intervention was performed. Both interventions started simultaneously, approximately 30 minutes after the end of the match.

The WBC intervention involved a 4-minute session in an electrically powered cryotherapy chamber (Cryo:one, Mecotec GmbH), at temperatures ranging from −75 to −85 °C. Participants wore gloves, dry socks, and a hat covering the head and ears during exposure. This recovery protocol was selected for several reasons. Specifically, the current absence of clear, evidence-based guidelines for the characteristics of WBC interventions[4] makes it challenging to identify the optimal parameters (eg, temperature and duration) that would result in improved recovery. Therefore, the choice of the current protocol was mainly based on ecological validity, as the study participants routinely used it during the competitive season as recovery strategy. Additionally, a temperature of −75 to −85 °C was selected since it represented the lowest temperature range achievable by the WBC device used in this study.

Based on previous research in basketball,[8] the placebo intervention consisted of sham treatment, using inactive light-emitting diode devices (BCD 650, Biolight AB Sweden) to create a fictitious stimulation of glutei, hamstrings, quadriceps, adductors, and gastrocnemii. Specifically, the devices were placed in contact with each muscle group for 45 seconds, once for each lower limb (ie, right and left side).

Performance Assessment

The CMJ test without arm swing was used to assess jumping performance through the Optojump system (Microgate).[9] Players started in the erect standing position (with feet placed hip-width-to-shoulder-width apart and hands on their hips) and were instructed to jump "as high and as fast as possible" using a self-selected countermovement depth.[9]

The 505 test was used to assess players' COD ability. A set of timing gates (Racetime2 Light Radio Kit, Microgate) and a set of cones were placed at 10 and 15 m from the starting position, respectively.[10] Participants sprinted to the cones, performed a 180° turn, and sprinted through the timing gates at the 10-m mark.[10] The time from the 10-m gate to the 15-m cones and back to the 10-m gate was recorded as the 505 COD time.[10]

Furthermore, 10- and 20-m maximal sprint times were recorded through a 20-m sprint test with a 10-m split,[11] using the same timing gates described above (ie, 3 sets, positioned at 0, 10, and 20 m from the start, respectively). Players started 50 cm behind the first timing gate, to avoid involuntary triggering of timing in the start position.

At each time point, 3 CMJ trials (interspersed by 1 min of passive rest) and 2 COD and sprint trials (2-min passive rest) were performed by each player, with the best result used for analysis. The reliability of the CMJ,[12] COD,[10] and sprint[13] testing procedures described above has been previously established. Additionally, performance assessment at all time points (except for postmatch) was performed following a ~10-minute standardized warm-up (Supplementary Table S3 in the Supplementary Material [available online]), to ensure that potential changes between time points were due to fatigue-related factors, and not drops in muscle temperature.

Physiological Assessment

Bluetooth heart rate monitors (H10, Polar Electro Oy) were used to assess HRV in supine position. Players were required to measure HRV for 90 seconds through the Elite HRV smartphone application, a valid and reliable tool to assess HRV during ultrashort recordings.[14] The log-transformed squared root of the mean sum of the squared differences between R-R intervals (Ln-rMSSD) was calculated to investigate parasympathetic autonomic activity.[9] Of the 136 scheduled measurements, 8 were excluded due to poor signal quality or players being unable to perform the test.

Perceptual Assessment

According to previous research,[15] Borg CR10 scale of perceived muscle pain for lower limbs between 0 ("nothing at all") and 11 ("maximum pain") was used to assess muscle soreness in a static condition (ie, standing without moving). Additionally, muscle soreness was measured in the quadriceps muscles while performing a deep squat (ie, dynamic condition), through a previously used visual analog scale from 0 ("none") to 10 points ("intolerably intense").[16] Finally, the overall perception of recovery was obtained using the Perceived Recovery Status Scale (PRS), a valid and reliable method to detect postmatch changes in perceived recovery in youth team sports.[17] The scale ranges between 0 ("very poorly recovered/extremely tired") and 10 ("very well recovered/highly energetic").[17]

External- and Internal-Load Monitoring

External load was measured using accelerometry (ClearSky T6, Catapult Innovations) as previously described.[18] Briefly, match PlayerLoad (PL, in arbitrary units) was computed as the sum of the accelerations across all axes during movement (derived from the instantaneous rate of change of acceleration), while PL per minute (in arbitrary units per minute) was calculated by dividing PL by session duration (in minutes).[18] Summated-heart-rate-zones (SHRZ) internal load was calculated using the previously described heart rate monitors: SHRZ (in arbitrary units) = (duration in zone 1 × 1) + (duration in zone 2 × 2) + (duration in zone 3 × 3) + (duration in zone 4 × 4) + (duration in zone 5 × 5), where zone 1 = 50% to 59.9% maximum HR (HR_{max}), zone 2 = 60% to 69.9% HR_{max}, zone 3 = 70% to 79.9% HR_{max}, zone 4 = 80% to 89.9% HR_{max}, and zone 5 = 90% to 100% HR_{max}[19] and duration is calculated in minutes. For each player, the peak heart rate value achieved across the 2 matches was used as an estimate of HR_{max}.[20] Finally, players' rating of perceived exertion (RPE) scores were collected (using the paper and pencil method, without peer influence) approximately 10 to 20 minutes after the match through the modified CR10 scale[21] and then multiplied by session duration (in minutes) to determine session-RPE load (s-RPE, in arbitrary units).[21]

Statistical Analysis

Descriptive statistics (mean [SD] or median [interquartile range] for continuous and ordinal data, respectively) were calculated for each variable. Separate linear mixed models, which correctly deal with missing values and repeated measures, were used for each continuous dependent variable (CMJ height, 505 time, 10- and 20-m sprint times, and Ln-rMSSD) to calculate the effect of time, intervention, and time × intervention interaction. In these models, time and intervention represented the fixed effects, while player represented the random effect. In case of statistically significant differences, Bonferroni post hoc analyses were run. All variables showed normally distributed residuals (Shapiro–Wilk test $P > .05$), except for Ln-rMSSD. However, violations of this assumption within linear mixed models are rarely problematic, and the use of alternative methods (eg, nonparametric tests, generalized linear models) may affect the reliability of conclusions to a greater extent.[9] To assess the effect of time for ordinal data (muscle soreness and PRS), separate Friedman tests (ie, one for each intervention) were used. In case of statistically significant differences, post hoc analyses were run using the Wilcoxon test with Bonferroni correction. The Wilcoxon test was also used to compare ordinal data between interventions at corresponding time points. After assessing the normal distribution assumption via the Shapiro–Wilk test ($P > .05$), differences in PL, PL per minute, and SHRZ load data between WBC and CON were assessed using paired-samples t tests, while nonnormally distributed s-RPE data ($P < .05$) were compared via the Wilcoxon test. The magnitude of differences for pairwise comparisons was assessed using Cohen d effect size (ES) for parametric analyses and was interpreted as: trivial, <0.20; small, 0.20 to 0.59; moderate, 0.60 to 1.19; large, 1.20 to 1.99; and very large, ≥2.0.[22] For nonparametric analyses, ES was calculated using the r value (Wilcoxon z value/$\sqrt{N}$) and interpreted as: small, .10 to .29; moderate, .30 to .49; and large, ≥.50.[23] Statistical significance was set at $P < .05$ and all analyses were carried out using the Jamovi software package for Windows (version 2.3.28).

Results

The analysis of external and internal load data showed comparable match-related demands between interventions, as *trivial-to-small*, nonsignificant differences ($P > .05$) were observed for PL (WBC = 440.8 [75.5] AU; CON = 451.7 [82.5] AU), PL per minute (WBC = 8.2 [1.6] AU/min; CON = 8.4 [1.3] AU/min), SHRZ (WBC = 158.6 [27.8] AU; CON = 145.4 [22.4] AU), and s-RPE (WBC = 324.6 [134.7] AU; CON = 281.0 [104.8] AU).

Figures 2 and 3 show the time course of the investigated performance, physiological, and perceptual measures throughout the study.

For performance and physiological measures (linear mixed models outcomes: CMJ height [R^2 conditional = .87], 505 COD time [R^2 conditional = .70], 10- [R^2 conditional = .68] and 20-m sprint times [R^2 conditional = .72], Ln-rMSSD [R^2 conditional = .74]), no significant effects of time × intervention interaction or intervention ($P > .05$) were observed, while a significant effect of time ($P \leq .009$) was found for all of them, except 505 COD time ($P = .191$). Post hoc analysis for time showed better CMJ height at postrecovery compared with postmatch ($P = .013$; ES = 0.50, *small*). Worse sprint performance over 10 m was recorded at postmatch compared with postrecovery ($P = .021$, ES = 0.45, *small*) and 24 hours postmatch ($P = .025$, ES = 0.53, *small*), while 20-m performance ($P \leq .045$, *small-to-moderate* ES) and Ln-rMSSD ($P \leq .043$, *moderate-to-large* ES) worsened at postmatch compared with all other time points. Ln-rMSSD also decreased at 24 hours postmatch, compared with match-day morning ($P = .043$, ES = 0.77, *moderate*).

Regarding perceptual data, no significant, direct differences were found for static and dynamic muscle soreness between interventions at corresponding time points ($P > .05$). Conversely, a significant effect of time was found for static ($P < .001$) and dynamic ($P = .032$) muscle soreness in WBC, but not in CON ($P = .056$ and $P = .113$ for static and dynamic soreness, respectively). Post hoc analysis for time in WBC revealed significantly higher values at postmatch, compared with prematch, in both static ($P = .002$, $r = .56$, *large*) and dynamic ($P = .003$, $r = .53$, *large*) muscle soreness. In terms of perceived recovery (PRS), significant improvements were reported in WBC—compared with CON—at prematch ($P = .023$, $r = .41$, *moderate*) and postrecovery ($P = .026$, $r = .40$, *moderate*), with no differences at postmatch and 24 hours postmatch ($P > .05$). Additionally, a significant effect of time was observed in both WBC ($P < .001$) and CON ($P = .007$). Post hoc analysis for WBC showed lower values at postmatch compared with prematch ($P = .001$, $r = -.59$, *large*) and postrecovery ($P = .002$, $r = -.55$, *large*), while results from CON highlighted lower values at postmatch compared with prematch ($P = .004$, $r = -.51$, *large*) and 24 hours postmatch ($P = .004$, $r = -.52$, *large*).

Discussion

The main findings from this study indicate that WBC did not affect postmatch recovery in U15 and U17 basketball players, except for the presence of an apparently beneficial, *moderate* effect of WBC on perceived recovery shortly after the intervention.

Assessing prematch to postmatch changes in jumping, COD and sprint abilities offers insights into fatigue responses in basketball, as repetitive execution of these tasks during match play may impair players' muscle function, leading to reduced performance.[1] Findings from the present study indicate that WBC was not superior to placebo for improving any of the investigated performance measures, acutely and up to 24 hours postmatch. As reported in a recent review,[4] research into the use of WBC after fatiguing exercise has yielded mixed results in terms of performance recovery, possibly due to heterogeneity among study protocols (eg, type of fatiguing exercise, WBC temperature, duration, timing, and number of exposures).[2,4,5] Considering prior evidence from other team sports (given the lack of basketball-specific data for comparison), Russell et al[7] examined a soccer sample similar to ours (ie, high-level, youth male players). Their findings reported no benefits of a single WBC exposure on CMJ peak power output in the acute phase, as well as 2 and 24 hours following exercise (time × intervention $P = .522$, $\eta_p^2 = .055$), compared with control.[7] However, the type of fatiguing protocol (15 × 30-m sprints) and WBC intervention (30 s at −60 °C, followed by 2 min at −135 °C)[7] differed considerably from the present study. Two further investigations employed similar temperatures (−85 °C) and exposure duration (3–4 min) compared with our study, highlighting a negative[24] or mixed[25] effect of WBC on strength-related measures

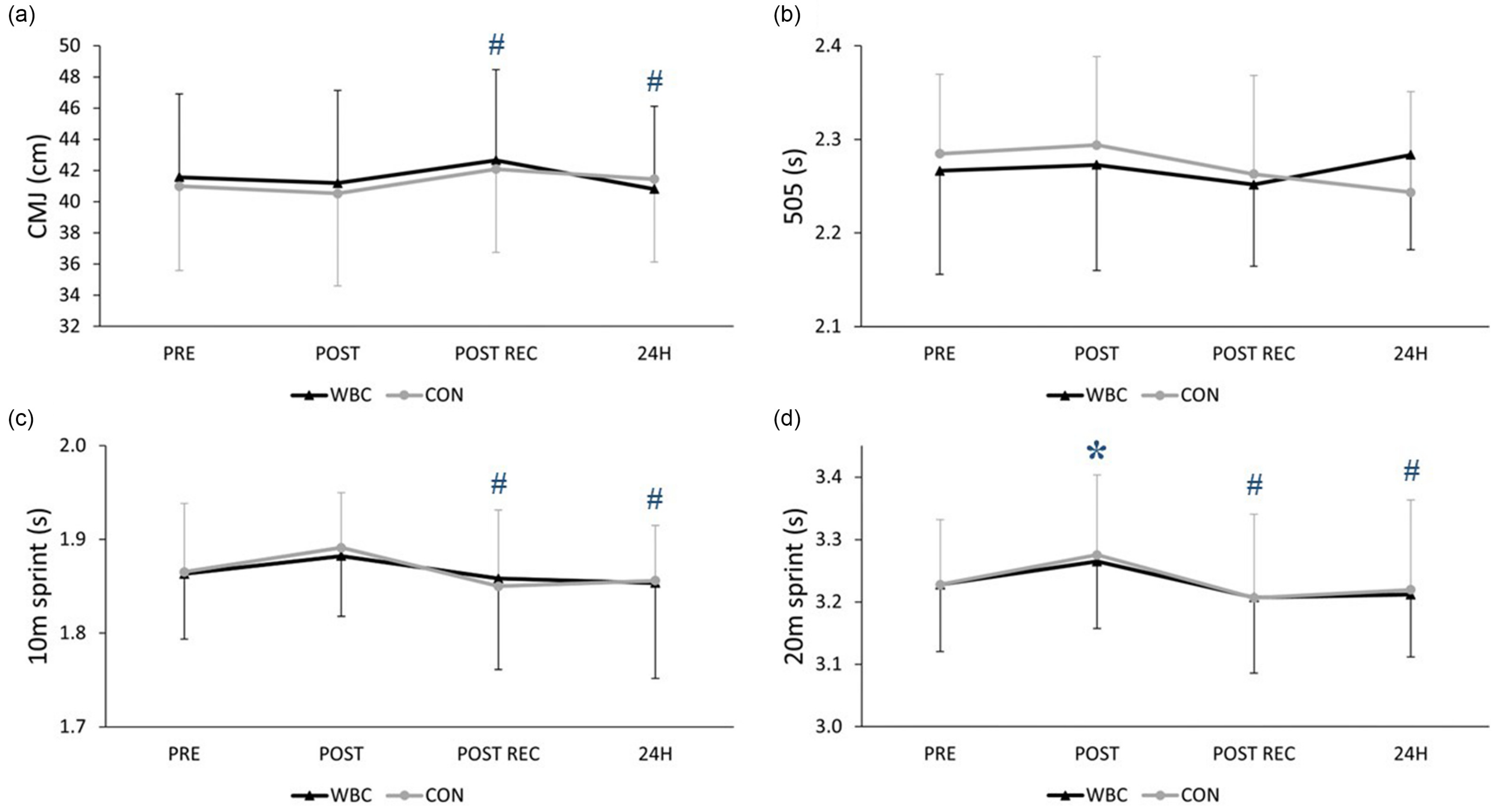

Figure 2 — Time course of (a) jump height, (b) change-of-direction times, (c) 10-m sprint times, and (d) 20-m sprint times throughout the study period. Data are presented as mean (SD). The pooled effects of time are marked as follows: *Significant difference with PRE; #significant difference with POST. Statistical significance is set at $P < .05$. 505 indicates 505 change-of-direction time; 24H, 24 hours postmatch; CMJ, countermovement-jump height; CON, placebo intervention; POST, postmatch; POST REC, postrecovery; PRE, prematch; WBC, whole-body cryotherapy intervention.

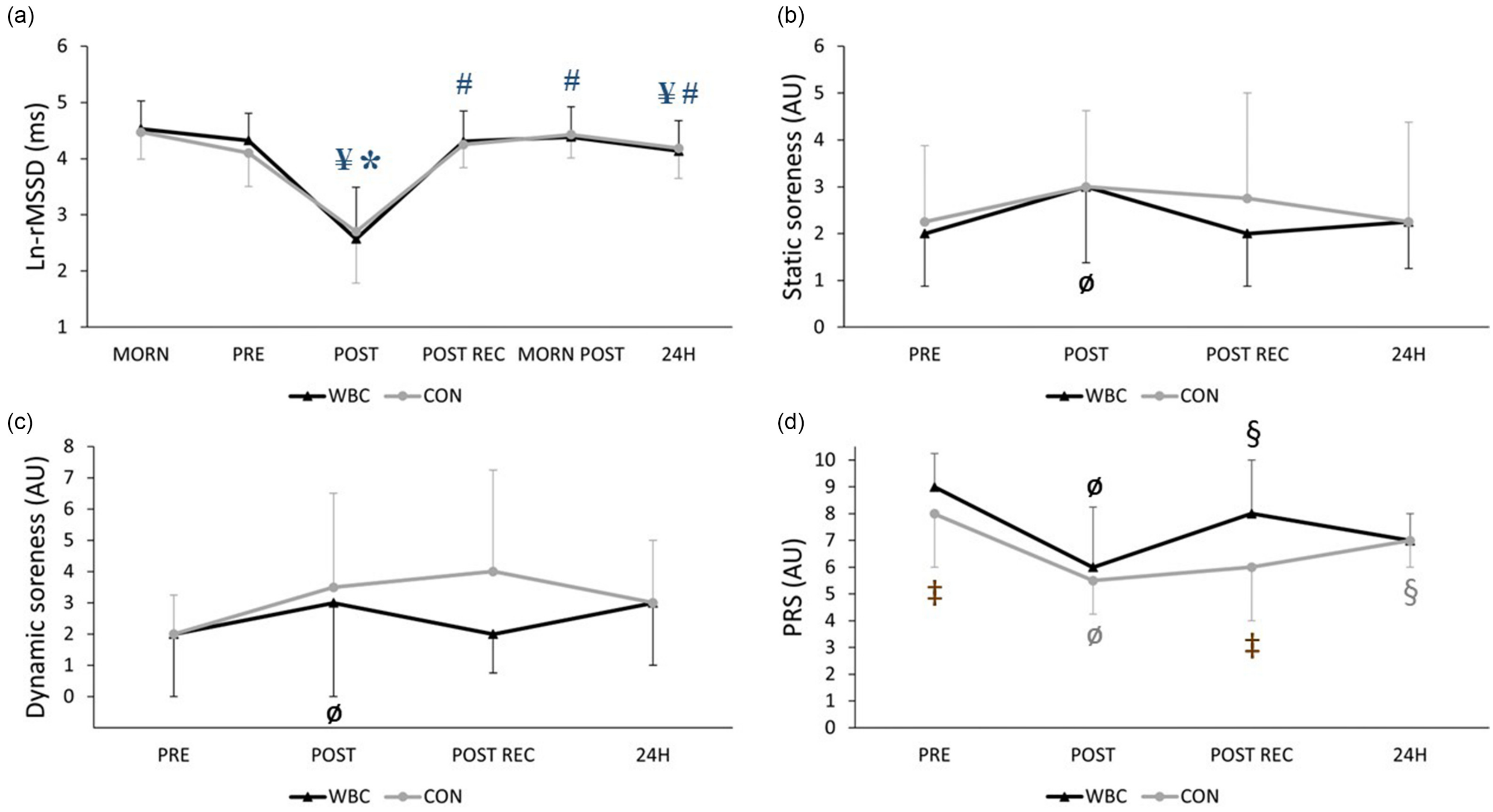

Figure 3 — Time course of (a) heart-rate variability, (b) static muscle soreness, (c) dynamic muscle soreness, and (d) perceived recovery throughout the study period. Data are presented as mean (SD) for continuous data (ie, Ln-rMSSD) and as median (interquartile range) for ordinal data (ie, static and dynamic soreness, PRS). The pooled effects of time (ie, linear mixed-model post hoc analyses) are marked as follows: ¥Significant difference with match-day morning; *significant difference with PRE; #significant difference with POST. For within-intervention comparisons (ie, nonparametric post hoc analyses), statistically significant differences are reported in black for WBC and gray for CON and marked as follows: ØSignificant difference with PRE. §Significant difference with POST. ‡Statistically significant difference between interventions. Statistical significance is set at $P < .05$. 24H indicates 24 hours postmatch; AU, arbitrary units; CON, placebo intervention; Ln-rMSSD, log-transformed squared root of the mean sum of the squared differences between R-R intervals; MORN, match-day morning; MORN POST, morning postmatch; POST, postmatch; POST REC, postrecovery; PRS, Perceived Recovery Status Scale; PRE, prematch; WBC, whole-body cryotherapy intervention.

of performance recovery (ie, peak torque, maximal voluntary contraction, reactive strength index,[24,25] CMJ height, rate of force development[25]) following a marathon race[24] and lower-body resistance exercise,[25] respectively. However, the different type of samples, fatigue-inducing protocols and WBC interventions (ie, 3-min bout followed by a 4-min bout, separated by 15 min) employed in these studies[24,25] make comparisons with the present data challenging. In summary, the impact of WBC on performance measures during postexercise recovery remains unclear,[4,5] with no beneficial effects observed in the present study.

In addition to impairing performance, exercise-induced fatigue can suppress parasympathetic activity, indicating the presence of changes in cardiovascular homeostasis that can negatively impact postexercise recovery.[8] In the present study, no differences in Ln-rMSSD were found between WBC and CON, indicating a comparable effect of the 2 interventions on autonomic recovery. These findings differ from what has been observed in other sports, as a positive effect of WBC on postexercise parasympathetic reactivation was reported in synchronized swimmers (WBC generated acute increases in low-/high-frequency power and their ratio [$P < .05$] compared with control)[26] and endurance-trained runners (low-/high-frequency power and total power generally decreased at 14–38 h in the control condition [$P = .007–.049$], but were increased [only high-frequency power at 14 h, $P = .023$] or unchanged [$P \geq .097$] in WBC).[27] However, cooler temperatures were employed in these studies (3[26] and 2.5 min[27] at −110 °C, respectively, both preceded by precooling at −10[26] to −60 °C[26,27]) compared with ours (−75 to −85 °C), which may explain these differences. Accordingly, previous research reported that only a 3-minute exposure to WBC at −110 °C (but not −10 or −60 °C) was able to stimulate the autonomic nervous system.[28] Therefore, further research exploring the use of lower temperatures may be necessary to determine whether WBC has a beneficial effect on parasympathetic reactivation following basketball match play.

Even when the use of a given recovery strategy fails to produce performance or physiological advantages, practitioners may still choose to adopt it, due to its contribution in enhancing subjective aspects of recovery.[6] Accordingly, a previous meta-analysis indicated that utilizing cryotherapeutic interventions may induce a *moderate* (Hedges $g = 0.53$) decrease in postexercise muscle soreness,[2] which is, for the most part, consistent with findings from other review articles.[4,5,29] However, no beneficial effects of WBC (compared with CON) were observed in the present study for either static or dynamic muscle soreness at any time point. On the other hand—while the present data show a potentially beneficial effect of WBC on perceived recovery in the short term (ie, postrecovery)—previous research investigating various WBC protocols (2–3 min, −70 to −195 °C) has yielded mixed findings in terms of perceived recovery/fatigue, without any apparent trend depending on methodological aspects (eg, WBC temperature or duration).[4] Overall, these discrepancies between past and present data may be explained by the emphasis of previous research on analyzing samples (eg, physically active, recreationally trained or endurance/resistance-trained participants and motocross riders) and fatigue-inducing protocols (eg, lower-body resistance exercise [drop jumps, hamstring-focused tasks], long-distance running)[4] that differ greatly from the present study, which limits their applicability in basketball. Conversely, the stimulus provided by match play in our investigation represents an ecologically valid way to induce fatigue in basketball. Nevertheless, it appears that playing ~33 minutes over a single match was insufficient to elicit lasting fatigue in highly trained, youth basketball players (ie, muscle soreness and perceived recovery recorded at postrecovery and 24 h postmatch were statistically comparable with prematch, in both interventions). Consequently, comparing the effectiveness of recovery strategies may become challenging if markers of fatigue have already subsided, as suggested by previous research.[9] Another reason that might explain differences with past research is that participants in previous studies may have been influenced by biased subjective assessment[6] in favor of WBC, due to the lack of a placebo intervention in most investigations.[4] Finally, a cautionary note is warranted when discussing the beneficial effects of WBC on perceived recovery in the present study, as the higher PRS values observed at baseline in WBC (indicating superior perceived recovery at prematch) compared with CON suggest that the participants' baseline status may have influenced perceived recovery immediately after WBC.

This study represents the first attempt to determine the impact of WBC on postexercise recovery in basketball. When interpreting the present findings, a general consideration related to the use of cold-based interventions should be noted. Specifically, previous research has shown that habitual exposure to cold temperatures may result in blunted physiological responses (eg, lower decreases in skin temperature, attenuated shivering, reduced cold sensations).[30] Accordingly, the effectiveness of WBC in the current study might have been diminished due to participants routinely employing it as a recovery strategy throughout the competitive season. Therefore, readers are advised to consider this factor when interpreting data from the current study.

Although our investigation provides useful insight, some limitations should be acknowledged. First, the participants involved in this study competed in youth male basketball leagues, and therefore, our findings might not apply to players of different sex, age, or competitive level. Second, biochemical markers of muscle damage, inflammation, and hormonal status were not included, in order to provide a practical and noninvasive evaluation of postmatch fatigue. Future research including the measurement of these markers could offer additional information concerning the mechanisms underlying responses to WBC exposure. Lastly, a specific WBC intervention (4 min, −75 to −85 °C) was examined in this study. Future research establishing the optimal temperature, duration, timing, and number of WBC exposures (ie, single or multiple) is needed to develop evidence-based guidelines that can be used by basketball practitioners during daily practice.

Practical Applications

The 4-minute exposure to WBC (−75 to −85 °C) used in the present study appeared to be generally ineffective for improving recovery in well-trained, youth basketball players, acutely and up to 24 hours following a simulated match. Therefore, although future basketball-specific research utilizing different WBC protocols is warranted, practitioners should be aware of the limited benefits in terms of performance, physiological, and perceptual recovery when employing the current protocol.

Conclusions

The present findings indicate that a single whole-body cryotherapy (WBC) exposure (4 min, −75 to −85 °C) was ineffective for improving recovery of performance, cardiac autonomic activity, and muscle soreness in high-level, youth male basketball players following a simulated match. On the other hand, WBC might have a potentially beneficial effect on perceived recovery in the acute phase (ie, postrecovery), although caution is advised when interpreting these findings, given the observed differences at baseline (ie, prematch) between WBC and the placebo intervention.

Acknowledgments

The authors would like to thank all the players and coaches from the "Stella Azzurra Basketball Academy" U15 and U17 basketball teams for participating in the study and extend their gratitude to Damiano Polverari, Davide Limongi, Anna Pallotta, and Massimiliano Vanacore for their technical assistance during data collection. The authors would also like to thank the "Fit And Go—Fleming" fitness center (Rome, Italy) for providing the WBC device for this study.

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