

Original Research

Performance and Perceptual Responses of Collegiate Female Soccer Players to a Practical External and Internal Cooling Protocol

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ABSTRACT

International Journal of Exercise Science 8(4): 331-340, 2015. This study examined practical pre- and mid practice cooling interventions on running performance, perceived exertion (RPE), and thermal sensation (TS) during soccer. During two formal pre-season practices female, NCAA Division II soccer players participated in three, 15 min scrimmage bouts followed by a 4th 10 min bout. Following the 1st, 2nd, and 3rd bouts, 8 field position players completed competitive sets of two, 30 yard sprints against other team members with time recorded between 5 and 30 yards. After the 4th bout, players completed an indoor shuttle running beep test (BT). In the treatment group (COOL) ice towels (IT) were applied to the head and neck regions and draped across both legs for 10 min following a standardized warm-up and for 10 min during a 15 min break between the 2nd and 3rd scrimmage sessions. Sport beverage slurries (350 mL; -0.3 °C, ~6% carbohydrate) were also served during IT cooling for COOL; while the control (CON) received no IT and drank the same uncooled sport beverage. No main effect was found for sprint performance (COOL = 3.55 ± 0.16 s; CON = 3.51 ± 0.07 s; $P = 0.51$) or numbers of reps completed in the BT (COOL = 17.6 ± 5.6; CON = 17.3 ± 6.0; $P = 0.88$). RPE did not differ following any performance test, but TS was lower following the 3rd sprint bout ($P = 0.04$) and the BT ($P = 0.005$) for COOL. COOL promoted lower TS, but had no effect on performance.

KEY WORDS: Ice towels, slurry, sprint, beep test, thermal sensation

INTRODUCTION

Soccer is commonly played in hot and humid conditions including collegiate level soccer in the US, as the season begins in late summer. Intentional body cooling to improve athletic performance is a relatively novel concept. However, experimentation with new techniques is growing, with a single recent investigation incorporating 10

different cooling modalities (8). Evidence supports multiple external (1, 23) and internal (i.e. ice slurry ingestion) (15, 20, 24) body cooling methods improve endurance running performance. However, investigations using similar methods to cool athletes during intermittent sprint sports like soccer have found equivocal results (3, 6, 7, 9-11).

Multiple factors likely contribute to the inconsistencies of findings. For example, some studies have been conducted in environments with lesser heat stress or cooling intervention of insufficient length, likely reducing the thermoregulatory benefits of cooling and mitigating performance differences (6, 9, 11). The methods of cooling may have also not been profound enough to elicit detectable changes in performance as multiple cooling strategies have been shown to decrease heat storage to a greater extent than single methods (4). Additionally, the ergogenic benefits of cooling appear to be dependent of the testing modality and competitive nature of the testing environment. Pre and mid-event cooling of team sport athletes show beneficial effects during indoor treadmill or cycling sprint tasks (4, 5, 7). However, only submaximal effort running distance appears to be improved during actual training or competition scenarios (10, 14) or in laboratory protocols using over ground versus treadmill running (13).

An additional concern for implementing cooling techniques away from the laboratory is the practicality of the cooling method. For collegiate soccer coaches and athletic trainers to implement cooling strategies during competition the method of cooling must be of fairly short duration (half-time lasts 15 min), not interfere with warm-up protocols, be fairly inexpensive and reusable, and portable for away games. Past investigations have used 60 min of cold shower (9), hooded cooling shirts requiring circulated chilled water from an external source (6), and ice-baths (13) which are fairly impractical. Frozen vests are likely the most researched cooling method (4, 7, 11, 13, 19). Vests are manageable with

small sample sizes in controlled laboratory settings, but finding refrigerated space and transporting vests to outfit an entire team would likely be more difficult and costly than using frozen towels, particularly during away matches. As an alternative ice slurries (21) and towels soaked in ice water (8) have shown utility in decreasing core temperature and are manageable during competition scenarios.

The purpose of this study was to determine if ingesting frozen carbohydrate-electrolyte slurries and incorporating ice towel cooling before and during the middle of a practice designed to simulate game activities would improve sprint performance during and repeat sprint running test performance at the end of practice. Additionally, perceptual measures including thermal sensation and rate of perceived exertion were assessed. NCAA Division II female soccer players served as participants.

METHODS

Participants

Sixteen female NCAA Division II soccer players (no goal keepers) from a university in the southeastern US were initially recruited for this study prior to pre-season practices. However, due to injuries not related to the study that impacted the ability of the athletes to complete all tasks in one or more of the experimental practices; only 8 participants (age = 20 ± 1 years; height = 165 ± 7 cm; weight = 63.9 ± 5.1 kg; estimated percent body fat = $23.0 \pm 3.4\%$) were able to complete all trials and tasks. All participants passed a physician supervised physical prior to participation and provided written consent prior to participation. Height was recorded using a

stadiometer (Detecto, Webb City, MO) and mass was assessed to the nearest 0.1 kg using a digital scale (Tanita BWB-800, Tokyo, Japan). Body fat percentage was estimated from skinfold thickness (Lange, Cambridge, MD) measured at three sites (triceps, suprailiac, thigh) (18). All procedures in this study were approved by the local university's Human Subjects Committee.

Protocol

Each trial was incorporated into an official pre-season practice date (mid-August). Coaches were present and led standardized warm-ups, provided player feedback during simulated match play, and administered the shuttle run test as would occur in a normal practice. Participants were instructed to avoid alcohol and caffeine for 24-h prior to each session. Players were fed subway style sandwiches, a bag of chips, and consumed water or sport beverages *ad libitum* between 12:00 and 1:00 PM during each testing day. Athletes were also instructed to consume a 500-mL bottle of water provided by the investigators 1 h before reporting to the laboratory to help promote euhydration. The athletes performed their customary game day dynamic warm-up routine, short sprints, ball drills, and stretching before each practice. The two experimental practice sessions began in the evening (~6:15 PM), 5 days apart, during the second week of preseason camp. An evening practice session was held the night before the first experimental practice and an exhibition game against a local women's club team in which all players played at least 30 min took place the night before the second experimental trial.

A counter-balanced crossover design was incorporated. Participants completed a control (CON) or cooling intervention (COOL) trial in their first session. During COOL participants received an external cooling intervention (described below) over a 10 min period immediately after the team warm-up and during a 15 min break mid-practice designed to simulate a collegiate half-time. Athletes played four, 10 vs. 10 or 11 vs. 11 (depending on injuries) bouts of simulated match play (SMP). Players were separated into 2 teams based on experience and skill level by the coaches. The first 3 SMP lasted 15 min, and the fourth bout lasted 10 min. Play took place on a 45 x 64 m pitch with a rubberized pellet surface and regulation goals. SMP were a normal part of the athletes' practice regimens and the head and assistant coaches coached the SMP as they normally would. Wet bulb globe temperature was recorded (TH-8, Physitemp Instrument Inc., Clifton, NJ) every 10 min at field level, and were similar between the two practices (practice 1 = 25.9 ± 1.4 °C; practice 2 = 25.3 ± 0.7 °C). Average relative humidity was ~70% based on difference in wet and dry temperature. Both practices began with partly cloudy conditions and sunset commenced approximately 2/3 of the way through the practice sessions.

Following the 1st, 2nd, and 3rd SMP sessions participants completed 2 sets of 30-yd sprints. Actual sprint distance time was recorded from 5-30 yds by an automated timing gate system (Brower TC Timing System, Draper, UT) as opposed to the whole distance to reduce variability of sprint start technique. Each attempt was separated by ~10 s to keep the time between sets standardized at roughly 90-

INTERNAL AND EXTERNAL COOLING DURING SOCCER PLAY

	TS TS	TS		RPE TS		RPE TS		RPE TS		RPE TS		
Activity (Duration)	WU (10-15)	COOL (10)	SMP1 (15)	Sprint1	SMP2 (15)	Sprint2	HT COOL (15)	SMP3 (15)	Sprint3	SMP4 (10)	Recovery* (12)	BT

Figure 1. Visual depiction of protocol. Standardized warm-up (WU); Cooling intervention or control treatment applied (COOL); Simulated match play (SMP); Half-time (HT); Beep test (BT); Thermal sensation (TS); Rate of perceived exertion (RPE). * = Players returned to locker room from field and changed into tennis shoes from cleats as customary for BT.

110 s between trials for each player. Coaches helped choose 10 field players with the most experience. The 8 athletes who had their performance recorded lined up in numerical jersey number order to standardize procedure and raced against a teammate whose performance was not recorded, to encourage maximal effort. Following the 4th SMP players were given 12 min to change into their tennis shoes and completed a shuttle running beep test (BT) (17) inside a gym adjacent to the soccer pitch. The BT consisted of the athlete's running back and forth on a 20 m course. Each shuttle was followed by a shorter auditory signal from a pre-recorded audio track. The test was terminated when the player missed reaching the finishing line before the beep on consecutive shuttle attempts. All players were familiarized with the BT as it was regularly performed during normal practices.

The first aspect of the COOL treatment included applying ice towels (IT) kept in coolers with water and ice (~1-3 °C) to the players' head and lower body. Two sets of towels were applied during each cooling intervention (5 min each x 2 for 10 min total) (8). Players in both COOL and CON sat on their normal game day aluminum bleachers. A small IT was draped over the head/neck region and a large IT was placed

over the players' thighs after pulling the player's shorts up to maximize exposure to the skin. Cooling sites were chosen based on past investigations that have shown neck cooling (22) improves distance running performance and leg cooling (5) is beneficial during repeated sprint cycling. The second COOL intervention included ingestion of a 350 mL ice slurry composed of a commercially available sports drink prepared in powder form with ~6 g of carbohydrate per 100 mL (Gatorade Frost, PepsiCo, Chicago, IL). The slurry was prepared in a commercial slurry maker (FrigoGranita NHT2UL, Cecilware Inc., NY, USA). The slurry pre-mix was prepared 5-6 h before the practice and was allowed to chill in a refrigerator until it was mixed in the slurry maker ~1.5 h before practice began. The slurry maker was transported to the practice field 30 min before practice and continued to run with temperature regularly monitored. The slurries were served in paper cups between -0.2 and -0.4 °C in both trials. For CON an equal volume (350 mL) of the same carbohydrate-electrolyte beverage was served in the same style of paper cup at the same time points. The CON beverage was also prepared at the same time before practice. To keep from diluting the CON beverage no ice was added. The cups were prepared and placed on a table near the

bleachers as is customary during games 5-10 min before the half-time break began. The CON beverage temperature was 15.4 °C before the first practice and slightly warmer during the second practice (20.9 °C). Players ingested their CON or COOL beverage during the same time periods the IT were applied (i.e. after the warm-up and during the simulated half-time). Ad libitum water consumption took place periodically during practice during non-cooling time periods.

Perceptual measures were assessed intermittently throughout each trial. Rate of perceived exertion (RPE) was collected using a 0-10 scale (2) prior to practice in the locker room to ensure the athletes were familiar with the scale. RPE was also collected after each sprint bout and post BT. A novel thermal sensation (TS) was also administered in the locker room for familiarization purposes, and administered pre and post warm-up, post cooling interventions, post sprint bouts, and post BT. The responses ranged from 10 (extremely hot) to -10 (extremely cold) with 0 serving as "comfortable". Following both practices players completed a questionnaire in which 10 cm visual analog scales were used to assess beverage taste (0 = terrible; 10 = delicious), stomach discomfort (0 = no discomfort; 10 = severe discomfort), if "cold" headaches were caused by the beverage consumed (0 = no headache, 10 = severe headache), and practice session difficulty (0 = not difficult; 10 = extremely difficult).

Statistical Analyses

All data are reported as mean and standard deviation. Repeated measures ANOVA was used to determine if a main effect for

treatment existed for 30 yd sprint (6 sprints for each session). RPE and TS at each time point and BT level of completion and post-practice visual analog scale items were all compared using paired sample *t*-tests. An alpha level ≤ 0.05 was used to determine statistical differences. SPSS version 20 was used in all analyses.

RESULTS

No main effect was found for sprint performance based on treatment (COOL = 3.55 ± 0.16 s; CON = 3.51 ± 0.07 s; $P = 0.51$). Performances for each sprint bout are displayed in Figure 2. Likewise, BT performance did not differ ($P = 0.88$) between treatments (COOL = 17.6 ± 5.6 reps; CON = 17.3 ± 6.0 reps). RPE did not differ following any performance test (Figure 3). Players did not rate the difficulty of the practices differently (COOL = 68 ± 24 mm; CON = 69 ± 12 mm; $P = 0.94$).

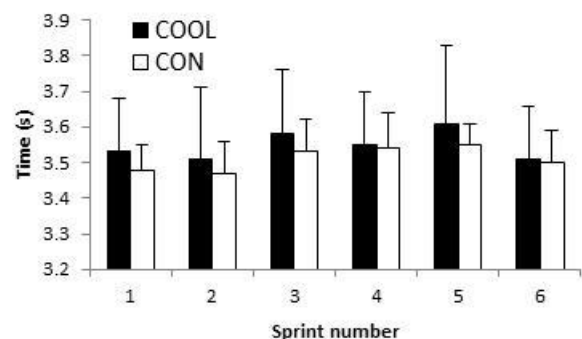


Figure 2. Time to complete each 25-yard sprint bout (Mean \pm SD).

TS responses are displayed by each time-point in Figure 4. TS was lower following cooling before the start of the SMP ($P = 0.007$) and after cooling during the half-time break ($P < 0.001$). TS neared, but was not significant following the first ($P = 0.08$) or second ($P = 0.08$) set of sprints, but was

significantly lower for the 3rd sprint bout ($P = 0.04$) and the BT ($P = 0.005$).

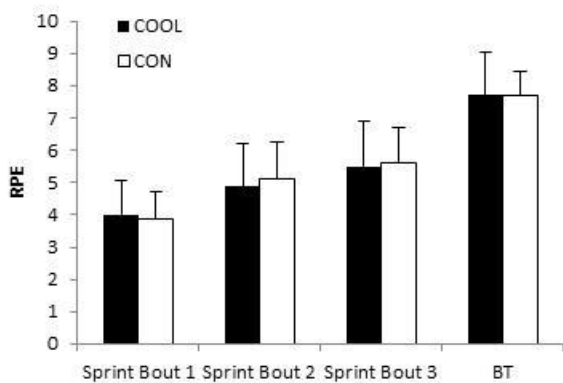


Figure 3. Rating of perceived exertion (RPE) following each sprint bout and beep test (BT) (Mean ± SD).

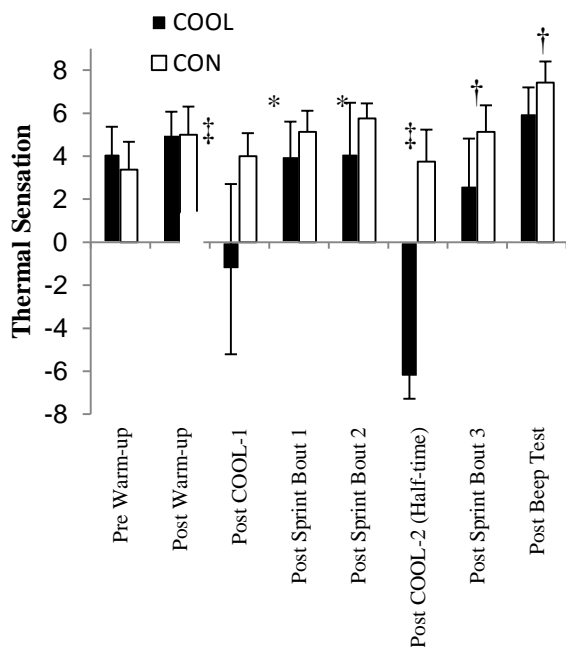


Figure 4. Thermal Sensation (TS) during practice sessions. Scale ranged from 10 “extremely hot” to -10 “extremely cold” (Mean ± SD). † $P < 0.05$; ‡ $P < 0.01$. * $P = 0.08$.

Stomach discomfort approached a statistical difference ($P = 0.06$) with COOL (36 ± 26 mm) being rated as causing less discomfort than CON (56 ± 30 mm). There was no difference ($P = 0.11$) in taste ratings

(COOL = 67 ± 20 mm; CON = 58 ± 24 mm). Cold associated headache was greater ($P = 0.02$) in COOL (27 ± 26 mm) than CON (6 ± 6 mm).

DISCUSSION

Multiple investigations have attempted to use pre- and mid-event cooling to improve performance in repeated anaerobic effort sports with mixed results. However, many of these studies have incorporated cooling interventions that may be costly and difficult to transport and apply to the athlete during soccer matches (3, 6, 11, 19) or that would be unlikely to be used such as cold water immersion (5, 12). The aim of this study was to determine whether using practical cooling methods pre and mid practice would increase single and repeated sprint performance or alter rate of perceived exertion and thermal sensation between periods of simulated match play. The methodology was designed with an impetus to incorporate a practical and cost efficient cooling strategy using readily available products that could be implemented in ~10 min by one or two equipment managers or athletic training staff before and during half-time of a collegiate soccer match.

We are aware of only one other investigation in which running performance parameters have been assessed in well-trained soccer players during real world, coach led practice conditions. Duffield, Coutts, McCall and Burgess (10) found pre-cooling with ice vest, ice towels, and slurries failed to increase the time spent in high intensity level running but increased overall distance covered in professional male soccer players

during practice (20 min interval running and 18 total min of 5 vs. 5 small-sided games) using global positioning satellites (GPS) to track performance. The authors found similar results (total distance covered improved without marked difference in sprint performance variables) when no sport-specific activities were included during a 20 min period of voluntary effort interval training with collegiate lacrosse players who received a similar pre-cooling only intervention (14) and when testing club rugby players completing an intermittent walk-jog-sprint protocol on an indoor rubberized surface using timing gates to assess sprint performance with pre- and mid-exercise cooling (13). Furthermore, Zhang, Nepocaty, Katica, Collins, Casaru, Balilionis and Bishop (25) found that sprinting times were not affected by halftime cooling using cold towels. However, Zhang et al. (25) did find that total distance covered in the Yo-Yo test was significantly greater following forearm cooling and neck cooling when compared to passive cooling.

With regards to the importance of the athletes' motivation levels (10) impact on self-selected work output of soccer players receiving pre-cooling treatments, it is critical to note that studies reporting ergogenic effects of cooling for team sport athletes have mostly come from laboratory, not field based, protocols that likely lack in ecological validity for soccer athletes. To further assess ecological validity Duffield, Coutts, McCall and Burgess (10) repeated their cooling interventions during league play competition and found that the small increases in performance effect sizes with pre-cooling were less evident during games versus practices and considerably less

profound than their laboratory based investigation (13). The strengths of the current study were that testing took place in the athletes' natural training conditions during the pre-season, fatigue was induced by simulated match play, and the sprints and BT were conducted during competitive and coach-led practices.

In agreement with the majority of previous field studies, pre- and mid-event cooling failed to enhance sprint ability based on statistical analysis (Figure 2). However, from a practical standpoint, observation of individual responses are important. The greater variance for COOL in Figure 2 is explained by two participants' results. One athlete performed considerably and consistently better across all 6 sprints during CON while the other outlier exhibited less dramatic but repeated improved performance with COOL. These two participants' also displayed the same trends in their BT performance while the remaining players' sprint performance and BT repetitions were very similar between trials. These outlier performances may be explained by reactions to the treatments or possibly be attributed to minor but non-reported injuries. Further individual analysis suggests that COOL either elicited a slight negative effect or had no effect for most participants (average difference between treatments was less than 0.07 s for the remaining 6 participants). Total distance covered was not assessed, but the number of repetitions successfully completed in the BT at the end of each practice was nearly identical in each treatment. COOL also failed to alter RPE at any time point (Figure 3), and players rated the difficulty of each practice session at a similar level using a 10 cm visual analog scale.

An examination of difference in methodologies may help explain contrasting results from our study to other laboratory centered investigations. For example, Brade, Dawson and Wallman (3) measured cycling performance outcomes for team sport athletes exercising in a much hotter conditions (35 °C) with no report of fan-based convection. Castle, Macdonald, Philp, Webborn, Watt and Maxwell (5) also used cycle ergometers (twenty, 5-s maximal effort sprints every 2 min) to assess performance of team sport athletes with 3 different pre-cooling interventions. Visual time point examination of each sprint with differing treatments revealed non-linear trends in fatigue over time and exhibited considerable performance variability that may have been related to an unfamiliar exercise modality. Clarke, Maclaren, Reilly and Drust (7) used a treadmill protocol to induce fatigue following a 60 min session of vest cooling. Following 90 min of the treadmill protocol, the authors then used treadmill self-selected running speed for a 3 min "easy" effort to assess voluntary work level followed by a 12.9 km/h and 20% grade treadmill run to exhaustion test to compare performance. Both of these tasks likely fail to represent soccer related physical activity requirements.

Collectively the data from the current and other field studies suggest single sprint performance is unlikely affected during competitive soccer play. However, total distance covered during simulated match play may be improved with cooling interventions, and several studies have found that pre-cooling prior to high intensity, short duration endurance exercise improves performance and delays fatigue

in the heat (1, 16, 23). Acute impairment or enhancement of short distance sprint performance requires a considerable intervention. With this consideration and past findings, we hypothesized that BT performance improvement would be more plausible with COOL versus single sprint attempts, but no convincing evidence was found. Thermal sensation was assessed following 10 or 15 minute SMP and performance tasks (20 -45 min post COOL) and displayed trends of increasingly lower TS for COOL as practice progressed (Figure 4). This finding was not surprising as the majority of cooling strategies result in mitigated perception of heat stress (8) and perception of thermal stress is likely linked with voluntary work output. The BT and RPE may have not been sensitive enough to detect subtle voluntary distance covered during SMP and GPS tracking of total activity might have revealed COOL total distance covered as has been shown in other investigations (10, 13, 14, 25).

Several trends were evident through anecdotal observations and our post-survey questionnaires concerning the athlete's attitudes toward the COOL treatment. Subjectively, the IT and slurries were greeted enthusiastically by the majority of the players. However, there were several individuals who reported the IT were too chilling, and that run-off water from the IT resulted in saturating the players' long socks and shoes with water. Several athletes also noted that they did not prefer sport beverages during training because of concerns about gastrointestinal distress. Stomach discomfort was not exceedingly high, but discomfort rated lower during slurry ingestion with no differences in taste rating for the same beverage served in a

chilled condition. We are unsure about why the differences in stomach discomfort occurred, but slurry ingestion may be a possible alternative to encourage match time consumption of carbohydrate beverages for some athletes.

This investigation had several limitations. Due to conflicts in practice scheduling times we were unable to complete a planned familiarization session. We consented 16 healthy players before pre-season practice began; however, only 8 players were able to complete all performance tasks due to minor, non-study-related injuries that limited players from participating in the sprint tasks or BT during at least one practice reducing the power of our study. Although the playing environments were warm, humid, and consistent between trials, a WBGT of 25 °C may not represent more extreme environment in which soccer players may compete. Ad libitum water ingestion during practice may have also influenced perceptual measures.

In conclusion, the COOL intervention was welcomed by most players and promoted subtle improvement of subjective feelings concerning TS during simulated match play, but had no effect on the running performance tasks completed in our paradigm. The COOL intervention used in this study is a practical and cost effective option for athletes that want to incorporate cooling interventions in hot weather.

CONFLCT-OF-INTEREST STATEMENT

The authors have no conflicts of interest to declare.

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