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JSAMS-1544; No. of Pages 6
ARTICLE IN PRESS
Journal of Science and Medicine in Sport xxx (2017) xxx–xxx
Contents lists available at ScienceDirect
Journal of Science and Medicine in Sport
journal homepage: www.elsevier.com/locate/jsams

Original research

A comparison of different heat maintenance methods implemented during a simulated half-time period in professional Rugby Union players

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ARTICLE INFO

Article history:
Received 13 February 2017
Received in revised form 6 April 2017
Accepted 1 June 2017
Available online xxx

Keywords:
Temperature
Intermittent
Warm-up
Rewarm-up
Soccer

ABSTRACT

Objectives: In thermoneutral conditions, half-time is associated with reductions in body temperature that acutely impair performance. This laboratory-based study compared active, passive, and combined methods of half-time heat maintenance.
Design: Randomised, counterbalanced, cross-over.
Methods: After a standardised warm-up (WU) and 15 min of rest, professional Rugby Union players ($n = 20$) completed a repeated sprint test (RSSA1). Throughout a simulated half-time (temperature: $20.5 \pm 0.3\,^{\circ}$C; humidity: $53 \pm 5\%$), players then rested (Control) or wore a survival jacket (Passive) for 15 min, or performed a 7 min rewarm-up after either 8 min of rest (Active), or 8 min of wearing a survival jacket (Combined). A second RSSA (RSSA2) followed. Core temperature (T_{core}) and peak power output (PPO; during countermovement jumps; CMJ) were measured at baseline, post-RSSA1, pre-RSSA2.
Results: All half-time interventions attenuated reductions in T_{core} ($0.62 \pm 0.28\,^{\circ}$C) observed in Control (Passive: $-0.23 \pm 0.09\,^{\circ}$C; Active: $-0.17 \pm 0.09\,^{\circ}$C; Combined: $-0.03 \pm 0.10\,^{\circ}$C, all $p < 0.001$) but Combined preserved T_{core} the most ($p < 0.001$). All half-time interventions attenuated the 385 ± 137 W reduction in Control PPO (Passive: -213 ± 79 W; Active: -83 ± 72 W; Combined: $+10 \pm 52$ W; all $p < 0.001$); with best PPO maintenance in Combined ($p \leq 0.001$). The fastest sprints occurred in RSSA2 in Combined (6.74 ± 0.21 s; $p < 0.001$) but Passive (6.82 ± 0.04 s) and Active (6.80 ± 0.05 s) sprints were 0.4% ($p = 0.011$) and 0.8% ($p = 0.002$) quicker than Control (6.85 ± 0.04 s), respectively.
Conclusions: While the efficacy of passive and active heat maintenance methods was supported throughout a simulated half-time, a combined approach to attenuating heat losses appeared the most beneficial for T_{core} and subsequent PPO and sprint performance in professional Rugby Union players.
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1. Introduction

In team sports it has been reported that tactical delivery dominates half-time practices.[1] However, comparable durations of inactivity (i.e., ∼15 min) influence acid-base balance,[2] glycaemia,[3–5] and muscle (T_m) and core (T_{core}) temperatures.[6–8] Intermittent sports players also demonstrate reduced exercise intensities during the initial stages of the second half[9] and fail to recover eccentric hamstring strength over half-time.[10] Half-time therefore provides an opportunity to enhance subsequent performance[8,11] but limited data exists profiling such potential interventions.

Attenuated losses of T_m protect subsequent physical performance[6,12] and have been proposed to concomitantly reduce the elevated injury risk observed when muscle strength deficiencies occur over half-time.[12] The half-time maintenance of body temperature may therefore provide an ergogenic opportunity on match-day. Indeed, impaired countermovement jump (CMJ) and repeated sprint performance was observed following a simulated half-time in which T_{core} reduced.[8] Protection of temperature mediated pathways that benefit subsequent performance[7] have typically been achieved by either passive[8] or active[6,12,13] methods.

Passive heat maintenance requires the use of heated clothing, outdoor survival jackets, and/or heated pads.[14] An outdoor survival

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http://dx.doi.org/10.1016/j.jsams.2017.06.005
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Please cite this article in press as: Russell M, et al. A comparison of different heat maintenance methods implemented during a simulated half-time period in professional Rugby Union players. *J Sci Med Sport* (2017), http://dx.doi.org/10.1016/j.jsams.2017.06.005

jacket worn over half-time attenuated a ~0.6 °C (~1.5%) reduction in T_{core} and enhanced CMJ and sprint performance thereafter.[8] Alternatively, active heat maintenance uses 5–7 min of varying modes of exercise (i.e., small-sided games, resistance exercise, whole body vibration, multidirectional speed drills, running and other exercises) to rewarm players throughout half-time.[6, 12,13] Although barriers may prevent active rewarm-ups being used in the applied setting,[1] half-time active heat maintenance strategies appear beneficial.[6,12,13]

While heat maintenance, be it from active or passive methods, appears superior to no heat maintenance at all, a systematic comparison in a single study design is currently lacking and the efficacy of a combined method (i.e., both passive and active heat maintenance in a single half-time strategy) remains unknown. Therefore, using a similar study design to previous literature,[8] the aim of this study was to examine the influence of different heat maintenance strategies used during a simulated half-time period on markers of T_{core}, peak power output (PPO; during CMJ) and repeated sprint ability.

2. Methods

Following ethical approval, 20 male professional Rugby Union players (age: 24 ± 5 years; height: 1.85 ± 0.1 m; body mass: 97.5 ± 7.8 kg) competing on behalf of a French top tier professional club volunteered to participate in this study. All players were informed of the potential risks associated with the study prior to providing informed consent. Players were following a detailed diet plan which remained consistent between trials as recommended by the team's nutritionist.

Trials were performed at the same time of the day (~10:00 h) with players wearing normal training kit and followed a randomised and counterbalanced repeated measures design. Each player completed a control and three interventions (each separated by 7 days). Trials were carried out in a temperature controlled indoor sprint track (temperature: 20.5 ± 0.3 °C; humidity: 53 ± 5%). Players reported for the trials after consuming their typical training day breakfasts (replicated across trials) and having refrained from caffeine, alcohol and strenuous exercise in the 24 h preceding each trial. Upon arrival, players remained seated for 15 min while baseline T_{core} was measured and procedures were verbally reiterated. After the warm-up (WU), a 15 min rest period was required (to represent match-day practices) before the first repeated shuttle sprint ability (RSSA) test[15] was performed. Repeated sprint ability has been associated with activity rates during Rugby Union match-play.[16] Lower body explosive ability (i.e., during CMJ) was assessed three times before and after the half-time intervention (i.e., post-RSSA1 and pre-RSSA2) before players repeated a second RSSA test (RSSA2).

All players were highly familiar with the RSSA and CMJ tests as these were regularly implemented as part of the team's testing battery. The standardised WU (~25 min) consisted of five repeats of ~40 m jogging, skipping and lateral bounding, before four repeats of ~30 m dynamic stretches (focusing on the gluteals, quadriceps and hamstring muscle groups). Plyometric strides (40 m × 2), high-knee striding into maximal sprinting (40 m × 2) and rolling start sprinting which progressively increased in intensity such that the final two repetitions were maximal (30 m × 5) were then performed.

In agreement with the manufacturer's instructions, an ingestible temperature sensor (CorTemp™, HQ Inc., USA) was consumed 3 h before trials commenced and allowed T_{core} measurement at three time-points (i.e., baseline, post-RSSA1, pre-RSSA2). The sensor transmitted a radio signal to an external receiver device (CorTemp™ Data Recorder, HQ Inc., USA); a method previously demonstrated to be valid and reliable.[17]

A portable force platform (Type 92866AA, Kistler, Germany) and methods described previously[18] were used to determine PPO during CMJ's. The participants' body mass and vertical component of the ground reaction force (GRF) elicited during the CMJ was used to determine the instantaneous velocity and displacement of the participant's centre of gravity.[19] Instantaneous power output was determined using Eq. (1) and PPO was classed as the highest instantaneous value produced.

$$\text{Power (W)} = \text{vertical GRF (N)} \times \text{Vertical velocity of centre of gravity (m s}^{-1}\text{)} \quad (1)$$

The RSSA test consisted of six 40 m (20 + 20 m separated by a 180° turn) shuttle sprints each separated by 20 s of passive recovery.[15] From a stationary start, the players started the test 0.3 m behind a pair of electronic timing gates (Brower TC-System, Brower Timing Systems, USA). Upon instruction, players sprinted 20 m and touched a second line with their foot before returning to the start line as quickly as possible. RSSA best was calculated as the fastest 40 m sprint time within each half.[15]

During the simulated half-time, players wore their normal kit and remained at rest (15 min; Control), or wore a survival jacket (15 min; Passive), or performed a 7 min rewarm-up after 8 min of rest (Active), or wore a survival jacket for 8 min before performing a 7 min rewarm-up (Combined). Each trial requiring the survival jacket used a garment designed to clinch the body, reduce convection, and trap warm, still air (Blizzard Survival Jacket, Blizzard Protection Systems Ltd., UK). The jacket also had a reflective surface which limited radiated heat loss.[20] The survival jackets used in the current study were similar to those used previously[7,8,14] and were tailored with long sleeves and were of a below-the-knee length. Trials requiring the ~7 min rewarm-up consisted of 3–4 min of low intensity jogging (over a 20 m distance) and simple ball skills (i.e., passing between team mates) which were followed by 3–4 min of medium intensity jogging and multi-directional ball skills. Mean HR during the ~7 min activity was 136 ± 4 beats min^{-1}.

Statistical analyses were performed using SPSS software (Version 21; SPSS Inc., Chicago, IL) and data are presented as mean ± SD. All RSSA data represents an $n = 20$ whereas CMJ and T_{core} responses represent an $n = 16$. Significance was set at $p \leq 0.05$. Two-way repeated measures analysis of variance (ANOVA; within-subject factors: trial × time) were used where data contained multiple time points. Mauchly's test was consulted and Greenhouse–Geisser correction was applied if sphericity was violated. Where significant p-values were identified for interaction effects (trial × time), trial was deemed to have influenced the response and simple main effect analyses were performed. Significant main effects of time were further investigated using pairwise comparisons with least significant differences (LSD) confidence-interval adjustment.

3. Results

Trial (time × trial: $p < 0.001$, partial-eta^2 = 0.658) and time ($p < 0.001$, partial-eta^2 = 0.875) influenced T_{core} (Fig. 1). Baseline T_{core} (36.78 ± 0.22 °C) was comparable ($p = 0.228$) and T_{core} increased equally ($p = 0.190$) at the post-RSSA1 time-point (+0.96 ± 0.33 °C, +0.95 ± 0.32 °C, +0.94 ± 0.36 °C, +0.90 ± 0.33 °C for Control, Passive, Active and Combined, respectively, being 37.71 ± 0.40 °C). Although the 0.62 ± 0.28 °C reduction in T_{core} observed in Control was attenuated by all half-time interventions (Passive: −0.23 ± 0.09 °C, $p = 0.001$; Active: −0.17 ± 0.09 °C, $p < 0.001$; Combined: −0.03 ± 0.10 °C, $p < 0.001$), T_{core} in Combined exceeded both Passive ($p = 0.009$) and Active ($p = 0.018$) at pre-RSSA2. The magnitude of T_{core} loss was smallest in Combined versus

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