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Heated jackets and dryland-based activation exercises used as additional warm-ups during transition enhance sprint swimming performance

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ABSTRACT

Objectives: The lengthy competition transition phases commonly experienced by competitive swimmers may mitigate the benefits of the pool warm-up. To combat this, we examined the impact of additional passive and active warm-up strategies on sprint swimming performance.
Design: Counterbalanced, repeated-measures cross-over study.
Methods: Sixteen junior competitive swimmers completed a standardised pool warm-up followed by a 30 min transition and 100 m freestyle time-trial. Swimmers completed four different warm-up strategies during transition: remained seated wearing a conventional tracksuit top and pants (Control), wore an insulated top with integrated heating elements (Passive), performed a 5 min dryland-based exercise circuit (Dryland), or a combination of Passive and Dryland (Combo). Swimming time-trial performance, core and skin temperature and perceptual variables were monitored. Time variables were normalised relative to Control.
Results: Both Combo (−1.05 ± 0.26%; mean ± 90% confidence limits, $p = 0.00$) and Dryland (−0.68 ± 0.34%; $p = 0.02$) yielded faster overall time-trial performances, with start times also faster for Combo (−0.37 ± 0.07%; $p = 0.00$) compared to Control. Core temperature declined less during transition with Combo (−0.13 ± 0.25 °C; $p = 0.01$) and possibly with Dryland (−0.24 ± 0.13 °C; $p = 0.09$) compared to Control (−0.64 ± 0.16 °C), with a smaller reduction in core temperature related to better time-trial performance ($R^2 = 0.91$; $p = 0.04$).
Conclusions: Dryland-based exercise circuits completed alone and in combination with the application of heated tracksuit jackets during transition can significantly improve sprint swimming performance. Attenuation in the decline of core temperature and a reduction in start time appear as likely mechanisms.

1. Introduction

In swimming, the effectiveness of a warm-up strategy is determined by the intensity and duration of the swimming and dryland elements, and the time between warm-up end and competitive event start, here termed the transition phase.[1–3] After the pool warm-up, swimmers must change into their racing swimsuit, confer with their coach and report to marshalling ∼15–20 min prior to race start,[3] thus transition phases of 30–45 min are not uncommon.[3]

Several studies have demonstrated that reducing the transition from 45 to 20 min,[3] or to 10 min,[4] yields faster 200 m swimming performance (∼1.5% and ∼1.4%, respectively). Importantly, core temperature (T_{core}) remained elevated during the shorter transition.[3] It seems there is a greater risk of a significant decline in T_{core} with longer transitions. Indeed muscle temperature (T_{muscle}) declines immediately following exercise, with a significant reduction evident after ∼15–20 min of recovery.[5]

However, it is difficult to alter swimming competition schedules by such large (>25 min) margins. New methods need developing to assist swimmers in maintaining elevated body temperature and

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muscle activation throughout lengthy transition phases. We postulate that the decline in body temperature, in particular T_{core}, during transition could be offset by combining a sport-specific active warm-up (i.e., pool warm-up) with passive heating and/or additional active warm-up strategies. Recently the combination of active warm-up and passive heating (via heated tracksuit pants), during transition improved T_{muscle} maintenance and power output during a sprint cycling task.[6,7] There appears to be a sound basis for additional passive heating to enhance body temperature maintenance during lengthy transitions in competitive swimming. The combination of passive heating and activities such as box jumps, known to induce postactivation-potentiation (PAP) related changes,[8] during transition may yield additional performance benefits.

The objective of this study was to determine whether the application of additional passive heat and/or the completion of dryland-based activation exercises within the transition phase could improve sprint swimming performance. Specifically, we investigated if any observed differences in the maintenance of T_{core} during transition were related to overall swimming time-trial performance.

2. Methods

Sixteen national junior swimmers (age 16 ± 1 yr; $n = 11$ males, stature 1.79 ± 0.08 m, 72.2 ± 9.8 kg; $n = 5$ females, 1.67 ± 0.06 m, 61.6 ± 1.5 kg; mean ± standard deviation) provided written informed consent to participate in the study. The swimmers had a personal best 100 m freestyle time of 59.41 ± 3.48 s (mean ± 90% confidence limits). This study was approved by the University of Canberra's Human Research Ethics Committee.

Using a randomised cross-over design, each swimmer completed four testing sessions within a fortnight (two sessions per week) during an aerobic training phase, separated by 48 h. Swimmers completed all testing in either a morning (06:00–08:00 am) or afternoon (17:00–19:00 pm) timeslot as per their normal training routine, with each swimmer acting as their own control and tested within the same time slot for all their sessions. Familiarisation with the experimental protocols and equipment was completed a week prior to testing commencement.

In each session, swimmers completed a 25 min standardised pool warm-up followed by a 30 min transition phase and 100 m freestyle time-trial. The standardised pool warm-up entailed: 400 m freestyle (easy pace); 3 × 100 m individual medley (100 m: kick, drill, swim); 3 × 100 m freestyle (80, 90, 95% race pace); 4 × 50 m (15 m race pace, 35 m easy); 4 × 25 m freestyle (dive start, race pace). The 30 min transition consisted of three segments: (1) post-pool warm-up (30–21 min pre-time-trial) swimmers changed into their race swimsuit and tracksuit; (2) swimmers remained seated (21–16 min pre-time-trial) with minimal activity unless required to perform the dryland-based exercise circuit; (3) swimmers entered a simulated marshalling area for the final 15 min prior to the time-trial.

In all conditions, swimmers wore a t-shirt and tracksuit (top and pants) and remained seated throughout the transition phase (*Control* condition) unless otherwise stated. The *Control* condition was designed to mimic the contemporary race preparations undertaken by competitive swimmers. During transition, three additional warm-up strategies were investigated: *Passive*, swimmers wore a tracksuit jacket with additional heating elements sewn into the garment over the chest (pectoralis major) and lower back (latissimus dorsi and quadratus lumborum) regions (City heated jacket, Venture Heated Clothing, Melbourne, Australia), along with a t-shirt and standard tracksuit pants. The heating elements were powered by a 7.4 V lithium ion battery and set to 51 °C. The swimmers wore the heated jacket throughout transition until immediately prior to the time-trial. In *Dryland*, swimmers wore the same apparel as during Control and completed a 5 min dryland-based exercise circuit between 21 and 16 min prior to time-trial start. The circuit was designed to simulate common swimming movements in a sequence replicating the kinetic chain of a swim start: 3 × medicine ball (2 kg) throw downs (underwater arm pull through), 3 × 10 s simulated underwater butterfly kick whilst in a streamline position holding a BodyBlade® (Mad Dogg Athletics Inc., California, USA) oscillation device above the head, and 3 × 0.4 m box jumps (jumping off the start blocks). All exercises were completed at maximum effort, with the circuit completed twice and 10 s rest taken between each exercise. The *Combo* strategy involved a combination of the *Passive* and *Dryland* warm-up strategies. Swimmers wore a heated jacket throughout transition, including during the dryland circuit, and until immediately prior to time-trial start.

Swimmers were requested to maintain the same nutrition (no caffeine in the 12 h prior) and sleep routine prior to each testing session and refrain from completing heavy exercise (in the pool or gym) within two days prior and on the day of testing. With the cooperation of the coaches, training volume and intensity were also kept consistent (on a weekly basis) throughout the study duration. Quantitative feedback on swimming performance (e.g. times and stroke characteristics) was delayed until study completion.

Pool warm-ups and time-trial swims were performed in a 50 m indoor pool (pool temperature 27.2 ± 0.4 °C, air temperature 25.8 ± 0.4 °C, relative humidity 52.4 ± 1.3%). Swimmers began the time-trials from a dive start, utilising starting blocks. Overall and 25 m split-times were recorded by an elite coach (holding an Australian State-National level licence) using a manual stopwatch (SVAS003 Seiko, Tokyo, Japan). Footage from digital video cameras (Canon Legria FS21, Tokyo, Japan) positioned at the 5, 15, 25 and 45 m marks was used to determine start[9] and turn times[10] as well as mid-pool velocity ($m\,s^{-1}$), stroke rate (Hz), stroke length (m) and stroke efficiency index ($m^2\,stroke^{-1}\,s^{-1}$) for both time-trial laps through established methods.[10–12]

Ingestion of a temperature sensor (CorTemp™ Ingestible Core Body Temperature Sensor, HQ Inc., Palmetto, USA) 6 h prior to each testing session permitted measurement of T_{core}. Skin temperature (T_{skin}) sensors (DS1922L Thermochron iButton®, Maxim Integrated Products, Inc., Sunnyvale, USA) were fitted to swimmers at four sites: chest, forearm, mid-thigh, and mid-calf to estimate mean T_{skin}.[13] Capillary blood lactate concentration (La^-; Lactate Pro, Arkray, Shiga, Japan) and heart rate (Polar RS400, Polar Electro Oy Kempele, Finland) were monitored using previously described methods.[14,15] Sample points for T_{core}, T_{skin} and HR were: pre-pool warm-up, immediately post-pool warm up, pre-dryland circuit, post-dryland circuit, pre-time-trial, one and four min post-time-trial. La^- was sampled post-pool warm up, pre-time-trial, one and four min post-time-trial with peak post-time-trial La^- concentration determined from the higher of the post-time-trial sample points.

Ratings of perceived exertion (RPE) were determined using the 10-point Borg scale[16] following the pool warm-up, dryland circuit and time-trial. Swimmers views regarding competition warm-up strategies, and their opinions relating to the additional warm-up strategies were assessed via questionnaires (multiple choice and Likert format) created for this study. The questionnaires were completed (1) prior to study commencement; (2) prior to each testing session; (3) after each testing session, and (4) at study conclusion.

Statistical analysis was performed using SPSS software (version 21; SPSS Inc., Chicago, USA) with significance set at $p \leq 0.05$ and $p \geq 0.05$–$p \leq 0.10$ determined as possibly different.[17] Effect size (ES) was calculated using Cohen's d with the ranges of 0.2–0.6, 0.61–1.19 and >1.20 considered small, medium and large effects respectively.[18] Precision of estimation was indicated with 90%