Journal of Thermal Biology 65 (2017) 16–20

Contents lists available at ScienceDirect

Journal of Thermal Biology

journal homepage: www.elsevier.com/locate/jtherbio

Supplemental intermittent-day heat training and the lactate threshold

Stuart Gollan[a,*], Samuel Chalmers[a,b], Stephen Alderton[a], Kevin Norton[a]

[a] Alliance for Research in Exercise, Nutrition, and Activity (ARENA), Sansom Institute for Health Research, University of South Australia, GPO Box 2471, Adelaide, SA 5001, Australia

[b] Sport and Exercise Science, School of Science and Health, Western Sydney University, Australia

ARTICLE INFO

Keywords:
Performance
Hot
Acclimation
Intermittent
Running

ABSTRACT

Heat acclimation over consecutive days has been shown to improve aerobic-based performance. Recently, it has been suggested that heat training can improve performance in a temperate environment. However, due to the multifactorial training demands of athletes, consecutive-day heat training may not be suitable. The current study aimed to investigate the effect of brief (8×30 min) intermittent (every 3–4 days) supplemental heat training on the second lactate threshold point (LT_2) in temperate and hot conditions. 21 participants undertook eight intermittent-day mixed-intensity treadmill exercise training sessions in hot (30 °C; 50% relative humidity [RH]) or temperate (18 °C; 30% RH) conditions. A pre- and post-incremental exercise test occurred in temperate (18 °C; 30% RH) and hot conditions (30 °C; 50% RH) to determine the change in LT_2. The heat training protocol did not improve LT_2 in temperate (Effect Size [ES] ± 90 confidence interval=0.10 ± 0.16) or hot (ES=0.26 ± 0.26) conditions. The primary finding was that although the intervention group had a change greater than the SWC, no statistically significant improvements were observed following an intermittent eight day supplemental heat training protocol comparable to a control group training only in temperate conditions. This is likely due to the brief length of each heat training session and/or the long duration between each heat exposure.

1. Introduction

Repeated exercise in hot conditions elicits physiological and perceptual changes, termed heat acclimation/heat acclimatization (HA), that act as an ergogenic aid for aerobic performance in hot conditions. (Garrett et al., 2012; Lorenzo et al., 2010; Sunderland et al., 2008) Previous HA research has focused on physiological adaptations in thermally challenging environments, and subsequent changes of performance in similar conditions (Périard et al., 2016; Taylor, 2014). Less research has investigated performance changes in temperate conditions following HA training (Chalmers et al., 2014; Corbett et al., 2014).

The potential to improve physical output by using an environmental stimulus different to the target environment has been demonstrated with altitude training and subsequent performance at sea-level (Bonetti and Hopkins, 2009). Improved shuttle running distance in temperate conditions (i.e. < 23 °C) has been reported following a seven (7%; Buchheit et al., 2011) and 14 (44%; Racinais et al., 2014) day training camp in a hot climate. Lorenzo et al. (2010) demonstrated that 10 consecutive days of heat training (100 min sessions per day) improved VO_{2max} (5%), lactate threshold (6%), and time trial (5%) performance in a mild environment. Interestingly, Neal et al. (2015) reported an enhanced lactate threshold in temperate conditions after just five days (90 min sessions per day) of heat training. The aforementioned studies highlight the benefit of a consecutive day heat training stimulus for improving performance, For athletes it can be impractical during many parts of the competitive season to undertake consecutive days of heat training due to the multifactorial demands (fitness, strength, skill, and tactical) required on a weekly basis. Hence, a pragmatic alternative may be employing an intermittent-day (i.e. every other day) HA protocol to supplement existing conditioning sessions, which may comparatively elicit less fatigue than consecutive day heat training whilst potentially stimulating an ergogenic effect.

A separation of no more than 72 h between heat training sessions has been suggested to still retain the positive changes induced by HA (Chalmers et al., 2014), whereas seven days may be too long (Barnett and Maughan, 1993). Heat acclimation research involving heat training on intermittent days has been explored less than consecutive day programs. Whilst continuous heat training is desirable for effective adaptation, intermittent-day training may also promote adaptation, but to a lesser extent (Gill and Sleivert, 2001). Various intermittent training protocols have been employed, including; training on alternate

* Corresponding author.
E-mail address: stuart.gollan@mymail.unisa.edu.au (S. Gollan).

http://dx.doi.org/10.1016/j.jtherbio.2017.01.011
Received 15 September 2016; Received in revised form 23 January 2017; Accepted 23 January 2017
Available online 26 January 2017
0306-4565/

days (Gill and Sleivert, 2001; Weinman et al.,, 1967), every third day (Fein et al., 1975), and four times a week (Hodge et al., 2013). Sunderland et al. (2008) reported as little as four sessions of heat training (total of 150 min heat training) over 10 days was sufficient to improve the running performance of well-trained team-sport athletes in hot conditions. Kelly et al. (2016) described a brief in-season heat training program undertaken by professional Australian Football players (total of 135 min heat training), reporting that five sessions over nine days induced partial HA. This included a significant reduction in blood lactate concentration (Δ1.5 mmol/l) for the heat training group during sub-maximal exercise in hot conditions.

Work produced at the lactate threshold is a strong predictor of endurance performance and sensitive to changes in aerobic-based performance (Bassett and Howley, 2000). The changes associated with HA appear to positively influence the lactate threshold (Chalmers et al., 2014; Corbett et al., 2014; Lorenzo et al., 2010). It is conceivable that adaptations from HA can impact the blood lactate response to exercise, and thus, influence the lactate threshold. Briefly, for example, an increase in plasma volume can lead to a diluted blood lactate concentration (Corbett et al., 2014), and a reduced reliance on carbohydrate as a primary fuel source during sub-maximal exercise can have significant implications for enhancing aerobic performance (Young et al., 1985) However, it remains unknown if an intermittent-day HA protocol can translate to improved aerobic-based performance for athletes competing in a less thermally challenging environment. This is pertinent for sport scientists implementing heat training protocols because consecutive and intermittent-day protocols may promote different adaptation processes (Gill and Sleivert, 2001). Rather than provide a known dose of heat exposure that might improve performance (i.e. 1000 min) (Lorenzo et al., 2010), the current research aims to further expand knowledge surrounding brief and pragmatic supplemental heat training protocols for athletes. Therefore, the study investigated whether eight intermittent-day heat training sessions that supplemented habitual training was sufficient to improve running speed at the second lactate threshold (LT_2) in both temperate and hot conditions for trained athletes.

2. Methods

2.1. Participants

Unacclimatized and healthy volunteers were recruited to participate in the study. Participants reported four or more aerobic-based sessions prior to the study beginning (no historical data pertaining to duration, distance or RPE could be obtained). Participants maintained a training diary (duration, distance) throughout the study and reported multiple aerobic-based training sessions (≥4 sessions per week). Five participants withdrew from the study due to training commitments, and injury or illness. Nine males and three females (n=12) completed the intervention (hot group) training (age 36 ± 11 y, height 1.75 ± 0.07 m, weight 71.9 ± 9.9 kg). Seven males and two females (n=9) completed the control (temperate group) training (age 39 ± 13 y, height 1.77 ± 0.07 m, weight 71.9 ± 9.9 kg). Participants wore athletic clothing and were instructed to consistently maintain a diet they considered typical before competitive exercise. Participants were considered unacclimatized because they were residents of the study location (Adelaide, South Australia) and confirmed that they had lived consecutively in a mild environment for the preceding ≥30 days. All participants provided written informed consent and the study was approved by the University of South Australia Human Ethics Committee.

2.2. Experimental design

All sessions occurred in the winter/early spring months to minimize participants acquiring natural acclimatization (mean maximum temperature ~17 °C and relative humidity [RH] ~70%). Participants undertook four testing sessions (pre- and post-testing) and eight treadmill-based training sessions in an environmentally controlled laboratory (Munters Pty Ltd., Albury, Australia) as outlined in Fig. 1. Each participant maintained habitual training and competition volume throughout the duration of the study. Participants completed all sessions at the same time of day (± 2 h) to minimize changes in performance caused by circadian variance (Rajaratnam and Arendt, 2001).

2.3. Incremental exercise test (pre- and post-testing)

Each participant was instructed about the procedures and risks of the study. Height (SECA stadiometer, Germany) and body mass (Soehnle scales [± 0.1 g] or FV-150KA1, A & D Co. LTD, Japan [± 0.05 g]) were measured. A laboratory-based test was chosen to ensure testing occurred in a controlled environment. Pre-testing occurred in a randomised order between hot (30 °C; 50% RH) and temperate (18 °C; 30% RH) conditions (Fig. 1). Two post-intervention incremental tests occurred in both temperate and hot conditions within five days of completing the training sessions (Fig. 1). The incremental exercise tests occurred on a calibrated motorized treadmill (TMX425CP, Trackmaster, Full Vision Inc., Newton, USA) set with no incline. The protocol of the incremental exercise test was in accordance with the guidelines of Chalmers et al. (2015), using four-minute incremental stages. Fingertip blood samples were collected during each incremental bout to calculate blood lactate concentration using a Lactate ProTM analyser (Arkray, Kyoto, Japan). Participants were not permitted to consume fluid during testing and were instructed to avoid strenuous exercise in the 24 h prior to each incremental exercise test. Running speed at LT_2 was calculated using the paired standardised lactate threshold method (LT_{SDp}) (Chalmers et al., 2015). The calculation of LT_2 is modified from the method first described by Cheng et al. (1992) and later altered in the modified method (Bishop et al., 1998).

2.4. Training sessions

A minimum of five days passed from pre-testing to the first training session to negate any cumulative effects and adaptations from the pre-test in hot conditions (Fig. 1). Participants were randomly assigned to one of two groups: an intervention training group (30 °C; 50% RH) or a control training group (18 °C; 30% RH), and undertook eight training sessions within a 28 day period (Fig. 1). Each session involved 30 min of treadmill running at both high and moderate speeds (Fig. 1). The combined exercise time of the training sessions totalled 240 min. Participants from each training group completed the same relative intensity of exercise, since speeds were determined according to a target percentage of LT_2 measured during pre-testing in the corresponding environment (Fig. 1). Participants were not made aware of their running speed at LT_2 until completion of the study. Each session was separated by 72–96 h. Participants were able to consume water ad libitum and use a towel.

3. Statistical analysis

Changes in LT_2 were analyzed using repeated measures analysis of variance (ANOVA) (SPSS). Independent samples *t*-tests compared the initial demographic data (height, mass, and age) of each group. Data were also analyzed using magnitude based inferences, as these indicate the magnitude of an effect, which may be considered more relevant to the practical detection of changes in LT_2. Data were presented as mean ± standard deviation (SD), and also effect sizes (ES) with 90% confidence intervals. All data were log transformed before analysis to reduce bias arising from non-uniformity of error (Hopkins et al., 2009). LT_2 data were reported as raw values for ease of interpretation. A modified statistical spreadsheet (Hopkins, 2006) was used to calculate ES between trials using pooled standard deviation. Chances of higher or lower differences were qualitatively evaluated as follows: < 1%,