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SHORT REPORT

Does the diurnal increase in central temperature interact with pre-cooling or passive warm-up of the leg?

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Summary Seven male subjects volunteered to participate in an investigation of whether the diurnal increase in core temperature influences the effects of pre-cooling or passive warm-up on muscular power. Morning (07:00—09:00 h) and afternoon (17:00—19:00 h) evaluation of maximal power output during a cycling sprint was performed on different days in a control condition (room at 21.8 °C, 69% rh), after 30 min of pre-cooling in a cold bath (16 °C), or after 30 min of passive warm-up in a hot bath (38 °C). Despite an equivalent increase from morning to afternoon in core temperature in all conditions (+0.4 °C, $P < 0.05$), power output displayed a diurnal increase in control condition only. A local cooling or heating of the leg in a neutral environment blunted the diurnal variation in muscular power. Because pre-cooling decreases muscle power, force and velocity irrespective of time-of-day, athletes should strictly avoid any cooling before a sprint exercise. In summary, diurnal variation in muscle power output seems to be more influenced by muscle rather than core temperature.

Introduction

Previous studies have shown that a warm environment only increases power output in the morning when core temperature is at its lowest,[1] but none have investigated the effects of pre-cooling on the diurnal variation in power output. Furthermore,

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an increase in cycling power output was observed with an increase in skin temperature before modification in core temperature.[2] Thus, the purpose of the present study was to determine the effect of localised heating or cooling of the exercising limbs (a more pronounced thermal stimulus for the leg than environmental temperature) upon morning and evening power output, relative to control conditions.

Methods

Seven male physical education students (27 ± 2 years, 1.74 ± 0.1 m and 70.7 ± 11 kg) gave written informed consent to participate in this study. The protocol was approved by the appropriate human research ethics committee. Subjects were classified as either ''neither type'' ($n = 4$) or ''moderately evening type'' ($n = 3$) from their responses a self-assessment questionnaire determining morningness—eveningness.[3]

All subjects completed six sprint tests on 6 separate days. Three were conducted in the morning (07:00—09:00 h) and three in the afternoon (17:00—19:00 h). The tests were held in a neutral environment (21.8 ± 0.9 °C, 69 ± 2% rh) after either a 30-min rest in the laboratory (control), a 30-min cold bath at 16 °C (pre-cooling, PC), or a 30-min hot bath at 38 °C (warm-up, WU). Pre-cooling and warm-up were performed in a thermal bath with only the legs from feet to pelvis immersed.

Three and a half minutes after the exit of the bath, rectal temperature (T_{rect}) and leg skin temperature were measured with a clinical electronic thermometer (MT 1691 BMWC, Microlife Ltd., Taiwan, precision 0.1 °C, insertion depth 2 cm, see reference 1) and a cutaneous probe (YSI 409B, Yellow Springs Instruments, OH, USA), respectively. One and a half minute later, subjects performed a maximal sprint lasting ~7 s against a friction resistive load set at 60 g kg^{-1} body mass applied on the periphery of the flywheel. The subjects were instructed to accelerate as fast as possible while remaining in the seated position. The best of three trials was used for calculation.

The total force developed by the subject was calculated from both the force developed against the friction load (constant) and the force developed against inertia to accelerate the flywheel. The data were collected every 8 degrees of pedal revolution by an acquisition card (DAQ-Pad 6020E, National Instruments, TX, USA) and analyzed by software developed in our laboratory with a LabVIEW interface (LabVIEW, National Instruments, TX, USA).

Maximal power (P_{max}), maximal force (F_{max}) and maximal velocity (V_{max}) were calculated from the pedal revolution with the highest power development, the highest force production and the fastest velocity, respectively. The F_{max} was generally obtained at the start of the sprint, when the subject develops a high force in order to initiate the rotation of the flywheel from a stationary position (very low velocity), whereas the V_{max} was generally obtained at the end of the sprint. The coefficient of variation within the two best trials of each session was lower than 5%.

Each variable was tested for normality using Skewness and Kurtosis tests with acceptable Z values not exceeding plus or minus 1.5. Upon confirmation of normality, the effect of pre-cooling and passive warm-up were analyzed by two-way ANOVA with repeated measures (conditions × time-of-day), while the effect of time-of-day was specifically analysed in each condition by a one-way ANOVA. Data are displayed as means (±S.D.) and the statistical significance was set at $P < 0.05$.

Results

Body mass did not vary between morning (70.7 ± 10 kg) and afternoon (70.6 ± 10 kg) sessions ($P = 0.59$). Rectal temperature was significantly higher in the afternoon than in the morning (+0.4 °C, $P < 0.05$) for all test conditions (Fig. 1A). However, the diurnal increases in leg skin temperature (+0.4 °C), P_{max} (+12%), F_{max} (+5%) and V_{max} (+6%) were only observed in the control condition (all $P < 0.05$, Fig. 1B—E).

The warm bath significantly increased rectal temperature (+0.5 °C, $P < 0.05$), whereas PC significantly decreased skin temperature (−5.6 °C), P_{max} (−14%), F_{max} (−8%) and V_{max} (−11%) (all $P < 0.05$, Fig. 1B—E). Time-of-day interacted with WU effect on P_{max} ($P < 0.05$) as WU increased P_{max} in the morning only (+4%, $P < 0.05$).

Discussion

Our data showed for the first time that a direct local heating of the leg only increased muscular power in the morning blunting its diurnal variation. Despite similar core temperature