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The effects of acute versus chronic training status on pacing strategies of older men in a hot, humid environment

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ABSTRACT

The combined effects of age and training on the regulation of exercise performance may be confounded by the additional challenge of thermoregulation. Thus, the objective of this study was to compare the pacing strategy of older men who have recently completed 12 weeks of exercise training (acute) to men who have been regularly (>3 times/week) training for at least 6 months (chronic) in a hot, humid environment and to observe disparity, if any, between acute and chronic exercise training on thermoregulation. Eleven chronically trained men (OT) completed a familiarisation trial before returning after 7–10 days to repeat the protocol. Similarly, eight untrained men (OU-PRE) were familiarised and repeated the protocol before completing 12 weeks of exercise training. Post-training, the eight acutely trained men (OU-POST) returned to the laboratory for a third trial. All trials were conducted on a cycle ergometer at the same time of the day in a climate controlled chamber with a mean dry bulb temperature and relative humidity of 32.0 °C and 68%, respectively. OT consumed more water than OU-POST and OU-PRE ($P<0.01$) whilst no differences were observed in the OU with training. Voluntary activation of the knee extensors decreased by 11.3% ($P<0.05$) in the OU-PRE after the cycling time trial. However, the decrease in voluntary activation observed in the OU-POST and OT after the cycling time trial were not significant. The OT maintained a higher power output compared with the OU-POST and OU-PRE except for the last sprint, whilst no significant differences in power output were observed between the OU-PRE and OU-POST. The rate of rise in core temperature was significantly higher in the OT compared with OU-POST ($P<0.001$) and OU-PRE ($P<0.001$). With more experience in training, the OT used an alternative hydration strategy compared with the OU-POST and OU-PRE to mitigate the effects of possible exercise hyperthermia, ultimately attaining a higher, but non-critical core temperature at the end of the cycling time trial. Twelve weeks of exercise training may not manifest in improved exercise performance *per se*, but could translate to improved performance of activities of daily and independent living.

1. Introduction

Humans regulate core temperature (T_c) in the heat largely by the evaporation of secreted sweat (Kenney and Munce, 2003). Thus the ability to thermoregulate is reduced when air temperature exceeds 35 °C and relative humidity becomes higher than 60% (Nielsen, 1996). Earlier studies examining exercise performance in the heat conclude that exercise is ultimately terminated by a critical limiting temperature of ≥ 39.5 °C (González-Alonso et al., 1999; Nielsen et al., 1993), but more recent evidence suggests that the rate of rise in core temperature is a critical factor in regulating exercise (Marino et al., 2004; Tucker et al., 2006). Tucker et al. (2006) demonstrated a decrease in power output shortly after the start of self-paced exercise when body temperature was not critically elevated, providing evidence that the regulation of exercise is anticipatory to maintain homoeostasis and avoid a catastrophic event (Marino, 2004). This anticipatory down-regulation of exercise performance is thought to be selectively driven by the central nervous system (CNS), since the force output and central activation of the exercised muscles were reduced without a concomitant decrease in non-exercise muscles when rectal temperatures were ≈ 38.8 °C (Saboisky et al., 2003).

Exercise in the field comprises a known endpoint which participants complete to the best of their capacities and abilities at a self-chosen pace by regulating intensity. Ulmer (1996) proposed that knowledge of the endpoint (teleoanticipation) is an integral part of regulating fatigue, allowing a system to perform optimally by incorporating feedback and feedforward processes to avoid the premature termination of exercise.

The effect of age on thermoregulation include reduced sweat gland secretion and reduced skin blood flow, smaller increases in

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cardiac output, less redistribution of blood flow from renal and splanchnic circulations, and a decreased thirst sensation and reduced fluid intake during exercise in a warm environment (Kenney and Chiu, 2001; Kenney and Munce, 2003). Despite these age-related changes, healthy older adults largely retain the ability to thermoregulate, although factors such as body composition and exercise training can affect thermoregulatory responses to exercise (Kenney and Munce, 2003).

Exercise in the heat presents numerous physiological challenges and leads to alteration in pacing strategies (Tucker et al., 2006). It is not clear how the altered pacing strategy is manifested, although neuronal activity in a hot, humid environment might indicate how pacing is handled centrally. Smith and Billaut (2010) demonstrated that exercise in hypoxic conditions elicited an earlier and larger degree of cerebral deoxygenation than normoxic conditions suggesting that changes to prefrontal cortex oxygenation contributes to the impairment of exercise performance. At present there are no data which describe the differences or changes in cerebral blood flow which could shed light on the evolution of pacing in different age groups in different environments.

Population ageing is a growing phenomenon worldwide with global life expectancy at birth rising by almost 20 years, from 46.5 years in 1950–1955 to 66.0 years in 2005–2010 and is projected to increase another 10 years in 2045–2050 (Department of Economic and Social Affairs, 2001). Ageing is characterised physiologically by a decline in performance of, but not exclusively, the cardiovascular (Wei, 1992) and skeletal muscle systems (Doherty, 2003). These deteriorations can also be associated with disease, disability, and ultimately death, although the benefits of physical activity in attenuating the negative impact of ageing are well-documented (Cotman and Berchtold, 2002; Nelson et al., 2007; Seals, 2014). Aerobic exercise can ameliorate the effects of age on heart rate variability (Galetta et al., 2005) and vascular function (DeSouza et al., 2000) but minimally impacts peak heart rate (Tanaka et al., 2001). Resistance exercise has favourable outcomes on body composition, muscle structure and the neuromuscular system (Jubrias et al., 2001), with these changes occurring either at the periphery and/or centrally (Cannon et al., 2007; Sale, 1988). This aging demographic has also led to an increase in the popularity of Masters sports and competition with more than 28,000 athletes participating in the World Masters Games in 2009 (History of the World Masters Games, 2014). The motivation for participation can be linked to achievement and social goals (Hodge et al., 2008), and Masters athletes have displayed remarkable exercise performances, but the decrease in performance with age is still evident (Tanaka and Seals, 2008).

Pacing and thermoregulatory responses have been studied in athletic and active younger age groups. However, to date the literature has not dealt with the pacing phenomenon in older individuals. Despite the rapidly increasing ageing population, there are few studies examining the pacing strategy of older adults during endurance exercise in the heat. Given the increase in participation of older adults in sports and competitive events where environmental temperatures can exceed 50 °C (Peiser and Reilly, 2004), the objective of this study was to compare the pacing strategy of older men who have recently completed 12 weeks of aerobic and strength training (acute; further described in Section 2.8) to men who have been regularly (>3 times/week) training for at least 6 months (chronic) in a hot, humid environment and to observe disparity, if any, between acute and chronic exercise training on thermoregulation. It was hypothesised that the best cycling performance will be elicited with chronic training, and the physiological and thermoregulatory parameters will be reflected in these performances.

2. Methods

2.1. Participants

Nineteen males (aged 50–64 years) were recruited from the local community. All the participants were healthy, non-smokers. After a thorough explanation of the study, all participants signed a letter of informed consent that was approved by the Human Research Ethics Committee of the University. The trained men (OT; 50–61 years) had participated in regular training at least three times per week for the last 6 months while the untrained men (OU; 53–64 years) had not participated in any regular exercise for at least 6 months. Their mean ± SD physical characteristics are

Table 1
Mean ± SD (range) of age and physical characteristics for 19 male participants.

	Acute		Chronic	**Effect size, *d***		
	OU-PRE $N=8$	OU-POST $N=8$	OT $N=11$	OU-POST: OU-PRE	OT: OU-POST	OT: OU-PRE
Age (yr)	58.7 ± 4.2 (52.5–63.7)	–	57.5 ± 3.4	–	–	−0.21
Height (cm)	176.8 ± 0.07 (168.0–190.0)	–	172.2 ± 0.05 (164.2–185.0)	–	–	−0.02
Mass (kg)	87.3 ± 8.9 (75.6–96.9)	86.9 ± 8.3 (76.0–97.2)	77.7 ± 8.9 (66.3–89.7)	−0.03	-0.83^{*}	-0.85^{a}
DXA						
Total fat (%)	30.3 ± 2.8 (27–36)	28.8 ± 1.5 (27–31)	21.1 ± 6.9 (4–28)	−0.39	$-1.08^{\dagger}$	-1.25^{c}
Total lean mass (kg)	59.8 ± 5.6 (51.3–67.3)	61.3 ± 6.1 (53.1–68.3)	60.3 ± 6.9 (50.9–69.6)	0.18	−0.11	0.06

OU-PRE = untrained men; OU-POST = acutely trained men; OT = chronically trained men
Significance between OT and OU-POST indicated by * $P<0.05$ and † $P<0.01$.
Significance between OT and OU-PRE indicated by ^{a} $P<0.05$ and ^{c} $P<0.001$.
Effect size: ≤ 0.19 = trivial, 0.20–0.49 = small, 0.50–0.79 = moderate, and > 0.80 = large (Cohen, 1988).