WILDERNESS & ENVIRONMENTAL MEDICINE, **28,** 94–100 (2017)

ORIGINAL RESEARCH

Upper Body Compression Garment: Physiological Effects While Cycling in a Hot Environment

Iker Leoz-Abaurrea, PhD; Roberto Aguado-Jiménez, PhD

From the Department of Health Sciences, Public University of Navarre, Navarre, Spain.

Objective.—The purpose of the present study was to investigate the effects of an upper body compression garment (UBCG) on physiologic and perceptual responses while cycling in a hot environment.

Methods.—Twenty recreational road cyclists were pair-matched for age, anthropometric data, and fitness level ($\dot{V}O_{2\,max}$) and randomly assigned to a control (CON) group (n=10) of cyclists who wore a conventional t-shirt or to a group (n=10) of cyclists who wore UBCG. Test session consisted of cycling at a fixed load (~50% $\dot{V}O_{2\,max}$) for 30 minutes at an ambient temperature of ~40ºC (39.9±0.4ºC), followed by 10 minutes of recovery.

Results.—Significantly greater (P = .002) rectal temperature (T_{rec}) was observed at the end of exercise in the UBCG group (38.3±0.2ºC) versus CON group (37.9±0.3ºC). Significantly greater heart rate (HR) was observed in the UBCG group at minute 15 (P = .01) and at the end of exercise (187±9 vs 173±10 beats/min; P = .004) for UBCG and CON, respectively. Furthermore, participants who wore UBCG perceived a significantly greater (P = .03) thermal sensation at the end of exercise. During recovery HR and T_{rec} remained significantly greater ($P < .05$) in the UBCG group.

Conclusions.—The use of an UBCG increased cardiovascular and thermoregulatory strain during cycling in a hot environment and did not aid during recovery.

Keywords: cycling, heat stress, hyperthermia, thermoregulation, exercise in the heat

Introduction

It is well known that exercise endurance can be impaired in hot compared with temperate climates.[1] Even at modest environmental temperatures (21ºC), some reduction in exercise capacity is apparent and performance is impaired progressively as the environmental heat stress increases.[2] Furthermore, when the environment becomes hot and humid, there is an increased risk of heat stroke due to a decreased capacity to evaporate sweat. In recent years, many strategies have been implemented to delay increases in body temperature during exercise, to prevent hyperthermia, and to improve athletic performance in such adverse environmental conditions. Examples include cold water immersions, fanning, external ice-pack application, and ice slurry ingestion.

The use of compression garments (CGs) during exercise have become popular, although fundamental effects on cardiovascular and thermoregulatory strain remain unclear. Claims from manufacturers include enhanced comfort perception,[3] increased muscle blood flow, and/or enhanced lactate removal.[4] Furthermore, recent developments in these garments have led to claims of thermoregulatory benefits. When male athletes exercise at 55 to 75% of the maximal oxygen consumption ($\dot{V}O_{2\,max}$) in moderate warm conditions (25ºC and 50% relative humidity), the greatest sweat rates occur on the central (upper and mid) and lower back.[5] As the evaporative cooling effect of sweat from the skin's surface is the main mechanism to reduce heat storage during exercise, clothing textiles designs that facilitate the heat dissipation in the upper body may lead to decreased body temperature increments and therefore delay the onset of hyperthermia during exercise. According to manufacturers, this type of garment reduces

Corresponding author: Iker Leoz Abaurrea, PhD, Department of Health Sciences, Public University of Navarre, Campus de Tudela, Avenida de Tarazona s/n, 31500 Tudela, Navarre, Spain; e-mail: ikerleoz88@hotmail.com.

Submitted for publication July 2016.

Accepted for publication March 2017.

heat gain, maintaining a constant core temperature due to improved sweat efficiency. A hypothetically lower heat gain also is suggested to delay hyperthermia during exercise in hot environments and therefore reduce the thermoregulatory strain. Furthermore, the use of this garment may reduce the cardiorespiratory strain during recovery, lowering heart rate (HR) values by increasing venous return due to compression.[3]

Previous studies investigating the effects of lower body CGs have not found differences in thermoregulatory responses during exercise at different ambient temperatures.[3,6,7] For instance, Goh et al[6] evaluated the effects of a lower body CG while running at 2 environmental conditions (10ºC and 32ºC), and no difference in core temperature was observed when compared with a control garment. Moreover, Barwood et al[7] did not observe any thermoregulatory benefit when examining the thermal effects of a lower body CG while running in a hot environment (35ºC) with a representative radiant heat load ($\sim$800 $W \cdot m^{-2}$). Recently, Leoz-Abaurrea et al examined the effects of an upper body compression garment (UBCG) on thermoregulatory and cardiovascular responses during intermittent cycling at a moderate intensity in a thermoneutral (23ºC)[8] and hot environment (40ºC).[9] The authors concluded that the use of UBCGs did not reduce the thermoregulatory strain during exercise at both environmental conditions. It seems, therefore, that these kinds of garments have failed to provide any thermoregulatory benefit. Additionally, the intermittent cycling protocol performed in these studies seem unlikely to happen during real cycling conditions. Intermittent exercise could be defined as repeated bouts of intense exercise separated by short recovery periods.

The aim of the present study was to evaluate the effects of a heat dissipating UBCG on thermoregulatory, cardiovascular, and perceptual responses during continuous cycling at a moderate intensity in a hot environment. It was hypothesized that the use of UBCGs would not mitigate the thermoregulatory or cardiovascular strain in recreational road cyclists during exercise in the heat.

Methods

PARTICIPANTS

Twenty recreational road cyclists, 16 men and 4 women, volunteered to take part in this study. Inclusion criteria were as follows: healthy and nonsmoking, with no history of cardiopulmonary disease, and a minimum of 2 sessions of aerobic exercise/week, $\geq$1 hour per session. Participants were matched in pairs by age, anthropometric measures, and fitness level (maximal oxygen uptake [$\dot{V}O_{2\,max}$]). One participant from each pair was assigned randomly to the UBCG (n=10) group (wearing an upper body compression garment) or to the control (CON; n=10) group (wearing a conventional t-shirt). See subject characteristics in Table 1. Testing occurred during the winter season to ensure no acclimatization to the heat. Participants were informed verbally of all procedures and any possible risks of discomforts associated with the experiment before giving written consent. The study was approved by the Ethic Committee of the Public University of Navarre, in conformity with the Declaration of Helsinki. Based on previous studies,[8,9] a minimum sample size of 10 participants was determined to achieve a statistical power of 80%.

PRELIMINARY TESTING

In a preliminary session, $\dot{V}O_{2\,max}$ of each participant was determined in a thermoneutral environment (20−23ºC) using a continuous incremental test to voluntary

Table 1. Subject characteristics of the UBCG and CON groups

Variable	*UBCG (n=10)*	*CON (n=10)*	*Mean difference[a]*	*P value*
Men/Women, no.	8/2	8/2	—	—
Age (y)	21.4±4.4	19.9±2.5	1.5 (–4.9, 1.8)	.36
Height (cm)	177±8	176±6	1 (–8, 6)	.85
Weight (kg)	68.2±9.0	73.7±6.0	–5.5 (–1.8, 12.8)	.13
Body fat (%)	17.1±5.0	18.8±7.8	–1.7 (–4.7, 8.1)	.58
HR_{max} (beats/min)	194.5±9.2	188.8±8.4	5.7 (–14.3, 2.8)	.17
$\dot{V}O_{2\,max}$ ($L \cdot min^{-1}$)	3.5±0.5	3.7±0.7	–0.2 (–0.4, 0.8)	.48
$\dot{V}O_{2\,max}$ ($mL \cdot kg^{-1} \cdot min^{-1}$)	51.5±5.4	50.4±8.0	1.1 (–7.8, 5.6)	.73

CON, control; HR_{max}, maximal heart rate; UBCG, compression group; $\dot{V}O_{2\,max}$ (L/min), absolute maximal oxygen uptake; $\dot{V}O_{2\,max}$ ($mL \cdot kg^{-1} \cdot min^{-1}$), relative maximal oxygen uptake.

Values are mean±SD.

[a] Values in parenthesis are 95% confidence interval (absolute values).