RPE "Drift" in Fit and Unfit Males Cycling in a Hot and Cool Environment

Robert Pritchett
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RPE “Drift” In Fit and Unfit Males Cycling in a Hot and Cool Environment

A Thesis
Presented to
The Faculty of the Department of Physical Education and Recreation
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
Of the Requirements for the Degree
Masters of Science in Physical Education

By
Robert C. Pritchett

May 2003
Date Recommended 5-13-03

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RPE “Drift” In Fit and Unfit Males Cycling in a Hot and Cool Environment

Robert C. Pritchett May 2003
Directed by: Dr. Matt Green, Dr. Thaddeus Crews, and Dr. Randall E. Deere

Department of Physical Education and Recreation Western Kentucky University

The potential influence of aerobic fitness on RPE estimations during extended exercise bouts is not well understood. The current study compared RPE-Overall, RPE-Legs and RPE-Chest between fit (n=7) and unfit (n=6) males. Subjects completed a graded cycling test and then, in a counterbalanced order, on two separate days cycled for 60min (intensity~90% of the Onset of Blood Lactate Accumulation (OBLA) – determined via gas exchange indices) at 30±1 degrees Wet Bulb Globe Temperature (WBGT) and 18±1 degrees WBGT. Heart rate (HR), rectal temperature (Tree) and overall and differentiated RPE estimations were collected every 5 minutes. Repeated measures analyses of variance showed no significant differences (p>0.05) between groups for RPE-O, RPE-L, RPE-C. There were no significant differences between groups across time for HR or Tree. Similarly, there was no significance between group differences for core temperature increase (Tree at 60min – Tree at 0 min) or absolute HR drift (HR at 60min- HR at 5min) within cool or hot cycling trials. This suggests fit and unfit males experienced similar relative cardiovascular and thermal strain. Results indicate that, between fit and unfit males cycling at similar individualized relative intensities, overall and differentiated RPE estimations are not influenced by aerobic fitness level during 60 minutes of exercise in 18 or 30 degrees WBGT.
Acknowledgements

I would like to express my appreciation to Dr. Green, Dr Crews, and Dr. Deere for their patience, time, effort and guidance throughout the course of this project. I would also like to thank each member of my thesis committee for their commitment to overseeing that this thesis is completed with pride and that it represents the Department of Physical Education and Recreation at Western Kentucky University in a positive way.
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Chapter One

Introduction

Ratings of Perceived Exertion

The Ratings of Perceived Exertion (RPE) scale was developed in the 1960's by Gunner Borg, a professor of psychology in Sweden (Borg; 1973). The RPE scale is a convenient method for subjectively quantifying exercise intensity. RPE responses are associated with heart rate (HR) and oxygen consumption ($V_{O_{2\text{max}}}$) (Dressendorfer, Smith, Merrill 1985), which increase linearly with increased workload. RPE is commonly used during graded exercise testing to indicate subjective feelings of fatigue and strain (Balady, Berra, Golding, Mahler, Myers, Sheldahl, 2000).

Primary “central” factors contributing to RPE are ventilation ($V_E$) and HR (Noble, 1982). Central factors are those that a subject consciously and subconsciously monitors and combines through the Central Nervous System (CNS) to estimate an overall RPE. There have also been a number of studies investigating blood lactate concentrations and perceptual responses. In one such study 49 males (n=49) classified as “runners” or “non-runners” between 20 and 40 years of age were tested (Robertson, 1982). The results indicated that, although there were differences between “runners” and “non-runners” in terms of treadmill velocity and physiological differences at peak velocity, there were no significant differences in RPE, either differentiated or overall at relative sub-maximal intensities. Studies have indicated that RPE’s at ventilatory threshold or lactate threshold are consistent at approximately 13 to 14 or “somewhat hard” (Dressendorfer et al, 1985). Other researchers have shown RPE estimations at the respiratory compensation threshold are not significantly
different between males and females for cycling or treadmill exercise (Green et al, press).

Previous studies consistently indicate the onset of lactate accumulation or hyperventilation or other physiological thresholds during exercise may provide an objective anchor and generate consistent RPE responses regardless of fitness or gender (Johnson and Rowell, 1975). RPE is strongly linked with physiological changes such as HR (Elkblom and Goldbarg, 1971), core temperature and ventilation ($V_E$) (Carton and Rhodes, 1981). Because these factors demonstrate a steady increase during prolonged exercise (i.e., cardiovascular drift), it is plausible that RPE estimations may also ‘drift’ upward concurrently. However, the possible drift in RPE is not well understood. Garcin, Vandewalle, and Manod, (1999) studied the relationship between RPE and HR at three different workloads during exhausting exercise in 10 participants. Subjects exercised at an intensity that was perceived as “hard.” RPE values at the estimated time to exhaustion showed a large variability. They also studied whether RPE “estimations” in a 20-minute test could be used as an index of the endurance time for long lasting exercise at a constant workload. They found that mean RPE increased linearly with time up to exhaustive cycling as an intensity that related to “Hard” on Borg’s RPE scale. However, there was no comparison of HR or RPE between varying levels of fitness (Garcin et al, 1981).

The possibility that perceived exertion may drift upward with physiological changes has not been directly investigated. There has been limited research regarding RPE and how it might differ between fit and unfit individuals during prolonged exercise bouts when cardiovascular drift is a factor. Therefore the purpose of this study was to examine HR and
RPE responses between fit and unfit males during cycling exercise in a hot as well as a cool environment.

**Cardiovascular Drift**

When aerobic exercise is continued for longer than 10 minutes the body goes through a number of progressive changes. An increase in HR, VO₂, and VE during extended exercise at a constant workload is known as “Cardiovascular Drift.” Cardiovascular drift has several prominent characteristics including a decline in central venous pressure, stroke volume, pulmonary and systemic arterial pressure, and central blood volume (Garcin, et al 1999). A steady increase in HR attempts to compensate for stroke volume decline in order to maintain a constant cardiac output. The elevation in HR is not of a magnitude to adequately compensate for the reduction in stroke volume; as a result, cardiac output may decline up to 18% (Golnzalez-Alonso, Richardo, Rodrigluez, 1997). Increased skin blood flow, as well as exercise induced dehydration, has been proposed to impact cardiovascular drift.

**Skin Blood Flow**

Skin blood flow increases with an increase in core body temperature (Seip, Snead, Pierce, Stein, and Weltman, 1991), which has been proposed to influence stroke volume (Nose, Mack, Morimoto, Nadel, 1996). In 1975 Johnson et al reported that under normal control situation, a stable skin and forearm blood flow after 20-60 minutes of exercise did not prevent the decline in stroke volume. During this exercise period stroke volume declined by 13%, HR increased by 11% and core temperature was elevated to 37.8 °C. In other studies, skin blood flow during prolonged exercise increased and remained fairly stable beyond 60 minutes duration (Coyle, E. F, 1998, Dressendorfer et al, 1985). Authors suggested this
might have lead to an increase in skin venous volume, reduced ventricular filling pressure—and end diastolic volume—all of which may contribute to cardiovascular drift.

Rowell et al. (1986) suggested that reductions in stroke volume are due to the increases in skin blood flow (increased cutaneous blood volume). Rowell (1986) also speculated that increased skin blood flow reduces stroke volume by reducing ventricular filling by means of displacement of blood volume from the central circulation to peripheral (skin) circulation. In a study by Rowell (1986) skin temperature was taken acutely from 26°C to 38°C using water perfusion suits. Results revealed reductions in stroke volume, central blood volume and central venous pressure when skin temperature was artificially elevated (Rowell, 1986). During these extreme acute conditions the cardiovascular system was severely challenged, thereby contributed to stroke volume decline and decreased venous tone at these abnormally high temperatures. Increasing skin temperature to 38°C using the water perfusion suit was exaggerated in view of skin temperature only reaching 30-34°C during normal exercise. However, this data suggest elevations in skin temperature are associated with increased skin blood flow, which has been linked with cardiovascular drift (Rowell, Murray, Bengelmann, Kraning 1969).

**Dehydration**

The second factor that may affect cardiovascular drift is that of exercise induced dehydration. The most notable effects of dehydration are 28% reduction in stroke volume as well as elevations in core temperature (Nose et al, 1996). A reduction in stroke volume forces the cardiovascular system to cope with the dehydration and hyperthermic conditions by increasing systemic vascular resistance, thus limiting reductions in arterial blood pressure.
(Rowell, Marx, Bruce Conn, Kusumi, 1966). The above findings were found using endurance trained cyclists exercising at 62% of VO₂ max for 120 minutes in a hot environment (35°C) producing a mean of 4.9% loss of body weight (Rowell, 1966). In the same study the prevention of dehydration through fluid ingestion resulted in a more stable cardiovascular response as reflected in both stroke volume and core temperature not changing significantly during the 120 minute period of exercise. Therefore cardiovascular drift under these circumstances was attributed to dehydration rather than other physiological changes associated with prolonged exercise.

Previous research indicates that both dehydration and increased skin blood flow affect cardiovascular drift during prolonged exercise in the heat. The most striking component of these two characteristics of cardiovascular drift is the reduction in stroke volume leading to a compensatory increase in HR during extended duration exercise. Because aerobic fitness has a profound impact on the sweat response, which directly influences exercise induced dehydration, it is possible that fit and unfit subjects may demonstrate different patterns of cardiovascular drift. Because RPE corresponds well with physiological factors that drift during extended exercise, it is possible that measures of perceived exertion also drift during longer duration exercise. Because previous research is limited, the current study compared overall and differentiated RPE responses between fit and unfit males cycling in two environments.
Statement of the Problem

The Purpose of this study was to compare RPE Drift between “fit” and “unfit” subjects exercising in a hot (30 ± 1 degrees WBGT) and Cool (18 ± 1 degrees WBGT) environment.

Hypotheses

H₀: There will be no significant differences for RPE estimations between Fit and Unfit subjects cycling in a hot environment.

H₁: Fit subjects will demonstrate significantly lower RPE estimations during cycling in the heat.

H₀: There will be no significant differences for RPE estimations between Fit and Unfit subjects cycling in a cool environment.

H₁: Fit subjects will demonstrate significantly lower RPE estimations between fit and unfit subjects cycling in a cool environment.

Significance of the Study

Determining RPE drift during extended exercise bouts in different environmental conditions has potential implications for exercise prescription and fitness evaluations. Therefore, the results of the current study will examine whether “fit” and “unfit” subjects would experience different RPE drift in hot and cool environments. Prior studies have not adequately investigated the potential RPE drift during constant intensity exercise over an extended period of time in groups with different aerobic fitness levels. Therefore, the practical significance of the current study would be to determine possible differences in RPE between fit and unfit males cycling in two environmental conditions for an extended period.
Limitations

Limitations of the study, which cannot be controlled, were subject’s adherence to the exercise protocol, motivation, and failure of subjects to appear for testing.

Delimitations

Delimitations of the study, which are choices that the experimenter makes to affect a workable research problem, were gender, age, testing times, and individual fitness level of subjects.

Assumptions

It is assumed that motivation was equally provided to the subjects during all trials, and that the intensity for the environmental trials was individualized corresponding to a relative intensity (~90% of OBLA). Also the assumptions can be made that calibration of equipment prior to each test produced valid and reliable results.

Definitions of Terms

- Cycle Ergometry – Stationary cycling
- WBGT – Wet bulb globe temperature
- Rectal Temperature (Trec) – A measure of core temperature
- Heart Rate – The number of beats per minute of the heart (b/min)
- RPM - Cycle ergometry pedal revolutions per minute
- VO₂max – The maximal rate at which an individual can consume oxygen during the performance of all out, exhaustive exercise; expressed in liters per minute (L/min) or milliliters per kilogram per minute (ml/kg/min)
- RPE – Gunner Borg’s rating of perceived exertion scale
Chapter Two

Review of Related Literature

Ratings of Perceived Exertion

A common tool used to assess perception of effort is Borg’s Ratings of Perceived Exertion (RPE) scale. Gunner Borg began relating objective measures of physical output to subjective measures of exertion with a high degree of reliability in the 1960’s. Monahan (1988) stated that Borg’s 15-point scale of exertion corresponds to heart rate response. Subjects are asked to relate the way they feel at different levels of exercise intensity to the physiological changes induced by exercise at the specific intensity. Borg determined that perceived exertion has a reliability coefficient of 0.90 Borg (1973) and has also subsequently found out that sub-maximal RPE is more accurate than sub-maximal heart rate (HR) in predicting maximal work capacity (Carton et al, 1981). Noble (1982) explains that exercise using perceived exertion instead of HR allows the person to monitor his or her exercise intensity subjectively in the context of his or her symptoms rather than relying solely on physiological strata. Stamford (1976) tested 14 female subjects, who all a completed a five hour experimental test at the same hour during the day, and concluded that RPE demonstrated a strong relationship with HR and work intensity. He also concluded that category RPE’s according Borg’s scale offer a sensitive and reliable measure of stress encountered during work. In a study by Ekblom and Goldberg (1971) it was proposed that RPE was based on both local (peripheral) and central (respiratory- metabolic) perceptual signals. Thus, to understand the relative contributions of peripheral and respiratory-metabolic factors on perception of effort, Pandolf, Burse, and Goldman, (1975) proposed the use of differentiated RPE’s, (Overall, respiratory and peripheral). The physiological processes that
are thought to be associated with central signals of exertion are HR, $V_E$, respiratory rate (RR) and $VO_2$ (Mihevic, 1981). The linear relationship between HR and RPE is not true when exercising under the influence of heat. Pandolf et al. (1975) examined the influence of HR on RPE during prolonged work in the heat. It was found that RPE’s did not follow the increase in HR during exercise in the heat but did follow the increase in work. Potteiger and Weber (1994) investigated RPE and HR responses during constant load exercise in different environmental conditions. Each subject exercised at a constant load until exhaustion in three different environmental temperatures: 30 °C, 22 °C, and 14 °C. However because subjects exercised at a constant work load for only 30 minutes it is possible that the relatively short duration of exercise bouts hindered the detection of RPE differences. If the majority of the affects of cardiovascular drift influence RPE later in an exercise bout, Pottiger et al (1994) may not have detected these changes using 30 min bouts. In the current study subjects exercised for 60 minutes at a constant work load that allowed a more thorough investigation of the RPE response during extended exercise.

HR “Drift”

It is well documented that endurance can be impaired in hot compared with temperate climates (Booth, Marino, Ward, 1997) and that time to exhaustion is influenced by alterations of the initial body temperature (Cheung and McLellan 1988). A critically high body temperature has been proposed as the main factor limiting endurance performance in hot environments (Elkblom and Goldbarg, 1971). It is well established that heat stress reduces stroke volume (SV) and increases heart rate during moderately intense exercise to the extent to which cardiac output might be compromised (Rowel et al, 1966). Rowell et al. (1966)
showed significantly lower cardiac output (~1.0 l/min), central blood volume, and SV during exercise in a 43°C than in a 26°C environment at 63-73% VO₂ peak. This reduced cardiac output was due to the larger reduction in SV compared with parallel increases in HR. However, Gonzalez-Alonso et al (1999) investigated whether fatigue in trained athletes, with the different initial internal temperature, would elicit the same critical core temperature and muscle temperature. Subjects were immersed in warm water tanks until they reached the internal temperatures of (~36, 37, 38°C). They found that despite the difference in esophageal temperature of 24°C between the pre-cooling trial and the post-cooling trials VO₂ increased over time. In contrast, cardiac output, SV, and HR responses were graded in proportion to the magnitude of hyperthermia. Similarly, significant reductions in cardiac output (3.3l/min) attributed to the greater reduction in SV have recently been reported with abrupt elevations in body temperature, HR, and skin blood flow (Gallaway and Moughan, 1997). Gonzalez-Alonso et al. (1999) also stated that it is possible that an increase in core temperature contributes to reductions in SV during moderate intensity exercise primarily by influencing HR. It also appears that the heat stress mediated lowering in SV in euhydrated subjects is associated with combined elevations in internal temperature acting on HR and skin blood flow (Gonzalez-Alonson 1999). However, few studies have examined HR and core temperature and how they may affect RPE drift. It is known that HR and core temperature (Trec) drifts are magnified during exercise in a hot environment. Little research has focused on potential RPE increases during exercise bouts greater than 30 minutes in duration. Additionally, the potential influence of fitness has not been addressed in this paradigm. The purpose of this study was to compare RPE Drift between “fit” and “unfit” males cycling at individual relative intensities in hot and cool environments.
Chapter Three

Methodology

Description of Subjects

Fit (n=6) and unfit (n=7) males provided written informed consent prior to participating. All were screened for safety using the Physical Activity Readiness – Questionnaire (Balady, 2000) and a health status questionnaire. All procedures were approved by the local institutional review board for the protection of human subjects. Descriptive data was collected in the initial lab session including age (y), height (cm), and mass (kg). Body fat percentage was also estimated using Lange calipers (Cambridge, Maine) and a 3 site skin fold method (chest, abdomen, and thigh) (Pollock et al. 1980)

Laboratory Testing: Lab session One

Each subject completed a maximal exertion cycle ergometry test on a Monark 824E cycle ergometer (Varberg, Sweden) using a standard protocol. Each subject pedaled at 25 watts for the first 3 minutes to allow for adequate warm up. The resistance was then increased each minute by 25 watts. Subjects maintained a cadence of 60 revolutions per minute (rpms) set by using a metronome (Franz MFG. Co., New Haven, Conn., USA). Tests were terminated at volitional exhaustion or when subjects could not safely continue or could not maintain the required 60 rpms. This protocol permitted the collection of data allowing an estimation of the Onset of Blood Lactate Accumulation, followed by a measurement of maximal oxygen consumption (VO$_2$max). During testing VO$_2$, VCO$_2$, Ventilation (V$_E$), and respiratory exchange ratio (RER) were assessed using a Vacumed Vista mini-cpx (silver) metabolic measurement system (vacuumed, Ventura, CA) interfaced with Turbofit
software™. Calibration of the system was completed prior to each test using a gas of known composition. Subjects were fitted with an appropriately-sized air cushion mask (VacuMed, Ventura, CA) secured using head straps. Sampling was set for a 20 second means with data updates every 15 seconds. HR (b/min) was assessed using a Polar heart rate monitor (Samford, Connecticut) also interfaced with the metabolic system.

A copy of Borg’s 15-point category Ratings of Perceived Exertion Scale was in view of participants throughout testing. Prior to exercise, the RPE scale was verbally anchored by indicating that RPE “6” corresponds to feelings of exertion during seated rest while RPE “20” corresponds to feelings at maximal exertion. Subjects were instructed to provide RPE estimations corresponding to subjective feelings of overall exertion (RPE-O), leg exertion (RPE-L) and breathing/chest exertion (RPE-C). These RPE estimations were requested in a counter balanced order during the last 15 seconds of each minute during testing.

**Cycling in the Heat:**

Subjects reported to the lab 2-5 days after completing the maximal exertion cycle ergometry test. Upon reporting to the lab subjects drank 200ml of water (NCAA Prevention of heat Illness, June 1975). Twenty minutes after consuming the water, subjects were required to insert a rectal thermister 8cm beyond the rectal sphincter. A heart rate monitor was placed on the chest at the level of the sternum. Individuals were then weighed using a balance type scale (Health o meter, Inc Illinois USA). Weight was recorded to the nearest 0.1kg. Resistance on the bike was determined from the maximal exertion cycle ergometry test. The point of onset of blood lactate accumulation (OBLA) was estimated using the point of an abrupt increase in $V_{E}/V_{O2}$ with no concurrent increase in $V_{E}/V_{CO2}$. The resistance was set at the point corresponding to 90% of OBLA. Subjects were required to pedal at a
cadence of 60 rpms, throughout the test. The environment was controlled at 30 +/- 1 degrees WBGT. HR and Trec were recorded every five minutes. Also every five minutes subjects were asked to indicate their overall feelings of exertion RPE-O, feelings of exertion in their chest RPE-C and in their legs RPE-L by using a copy of Borg’s RPE scale, which was placed in full view of the subject throughout the entire test. These RPE’s were requested in a counterbalanced order.

Subjects were weighed immediately after the test. Mass was recorded and used for the calculation of sweat rate.

Cycling in the Cool:

The cool cycling trial was conducted in exactly the same manner as cycling in the heat with the exception that the environment was controlled at 18 ± 1 degrees WBGT. The hot and cool trials were counterbalanced to control for the effects of ordering.

Statistical analyses

Descriptive characteristics between groups were compared using a multivariate analysis of variance (MANOVA). RPE-O, RPE-L and RPE-C estimations between groups were analyzed independently for hot and cool condition using repeated measures ANOVA. HR response between groups was analyzed for hot and cool trials separately using repeated measures (time) ANOVA for each variable. Rectal temperature response was analyzed for hot and cool trials separately using repeated measures (time) ANOVA for each condition. Differences were considered significant at p≤0.05. Sweat rates were compared between groups using a t-test for each condition.
Chapter Four

Results

Descriptive characteristics are presented for each group in Table 1. There were no significant differences between groups for age, height or body fat. Body mass was significantly greater for the unfit group. VO_{2}max was significantly greater for the fit group. Between groups comparisons for the cool trial showed no significant differences for HR response (Figure 1), Trec (Figure 4), RPE-O, RPE-L, or RPE-C (Figure 6). Similarly, for the hot trial there were no significant differences between groups for HR response (Figure 1), Trec (Figure 2), RPE-O, RPE-L, or RPE-C (Figure 5). Sweat rate was significantly greater for fit subjects. (Figure 7)
Rating of Perceived Exertion

The purpose of the current study was to compare RPE Drift between fit and unfit subjects cycling in a hot and cool environment.

Previous research has shown that RPE is not affected by training state (Demello, Kirk, Cureton, Robin, Boineau, 1987; Carton and Rhodes, 1981). Trained and untrained subjects perceive the intensity of exercise at the lactate threshold (LT) as “somewhat hard” or equivalent to a Borg scale rating of 13 (Demello et al 1987). RPE at Lactate threshold (LT) falls at different relative intensities or percentage of VO₂max for trained and untrained subjects regardless of the individual fitness level (Demello et al, 1987; Carton and Rhodes, 1981). The correlation was demonstrated in a study by Demello et al. (1987) where trained and untrained subjects exercise on a treadmill at their lactate threshold. There was no significant difference for RPE at lactate threshold for trained and untrained individuals. In the current study subjects exercised at an intensity individualized per each person’s aerobic fitness level (~90% OBLA). Results show no significant differences between groups for RPE-O, RPE-L, RPE-C, which is similar to previous studies demonstrating the consistency of perceptual measures of effort when exercise intensity is established according to relative criteria (Monohan, 1981 and Noble, 1982).

RPE estimations did “Drift” throughout the duration of the test in both the trials. The results of the current study were similar to previous studies that have evaluated RPE estimations throughout 30 minute exercise bouts. For example, Morgan (1973) reviewed a
series of experiments involving the interaction of RPE, selected psychological states and metabolic responses to cycle ergometry. The findings indicated that normal subjects are capable of identifying differences in work load by means of RPE, and the subjective estimates mirror metabolic costs of work being performed during a 30 minute work bout. Demello et al (1987) investigated the effect of training state and gender on RPE at LT, to determine whether RPE during moderate sub-maximal exercise is closely related to LT or % VO$_2$max. In the study they used fit and unfit males and females. Subjects completed two sub-maximal treadmill tests consisting of subjects running at LT until exhaustion and a subsequent test in which subjects were required to run at 60% of VO$_2$max for 30 minutes. The results of the study showed RPE was not affected by training state as trained distance runners and untrained subjects perceived a relative intensity similarly. Current results show mean RPE beyond 30 minutes for unfit subjects was higher than mean RPE for fit subjects. This trend was visually observed; however, no significant differences were detected. These results lead to speculation that because unfit subjects were not as well adapted to the extended exercise duration they would perceive exercise as more strenuous near the end of the bout than would the fit subjects, possibly due to greater fatigue.

There were no significant differences between groups across time for heart rate or rectal temperature. The suggestion is that fit and unfit subjects experienced similar relative cardiovascular and thermal strain within trials. Similarly, there was no significant between-group difference for absolute HR drift (HR at 60 minutes minus HR at 5 minutes). However, core temperature increase (Trec at 60 minutes - Trec at 0 minutes) was significantly greater in fit subjects. The increased core temperature
occurred due to greater absolute heat production due to a greater resistance required to achieve 90% of OBLA. Result suggests that, between fit and unfit males cycling at similar individualized relative intensities, overall and differentiated RPE estimations are not influenced by aerobic fitness level during 60 minutes of exercise in 18±1 or 30±1 degrees WBGT.

Cardiovascular drift, as evidenced by HR and core temperature, was similar for each group within hot and cool trials (Figure 1, 2, 3 and 4). While cardiovascular drift was evident, in the current study, it was obvious that fatigue was more pronounced in the unfit subjects. Differences were not significant. However, the observation that RPE’s drifted more in unfit subjects could be at least partially attributed to the fact that this group of subjects were not accustomed to exercise sessions of this duration.

The prescription of exercise for endurance training is traditionally based on %VO₂max or a percent of maximum HR. Because of its relation to HR and other physiological strata, RPE is also used for exercise prescription (Noble, 1982). The implications of the current study suggest that RPE might require modifications when used for prescribing intensity during extended exercise bouts. Because RPE tends to “drift” from the onset of exercise and noticeably more beginning at 30 minutes (especially in unfit subjects) modifications of RPE could be necessary during this type work. Previous research has failed to rigorously investigate potential drifts in RPE beyond 30 minutes with very sparse comparisons of groups with varying fitness. The current investigation shows that RPE drifts in fit as well as unfit males during 1 hour cycling bout when exercising in an 18±1 degree WBGT environment. However the drift is slightly less pronounced during the first 30 minutes of cycling in fit and unfit males. In a 30±1 degree
WBGT environment RPE drift was similar in fit and unfit subjects throughout a 60 minute cycling bout.

The current study has improved on previously reviewed literature by increasing the duration of the exercise bouts and including differentiated RPE’s (overall, legs and chest) as opposed to limiting perceptual measures to overall feelings of exertion.

Future research in this area should examine RPE “drift” beyond 30 minutes and how it might compare with the blood lactate response. The current investigation examined RPE Drift up to 60 minutes. Because endurance events often extend beyond this duration, future investigators should examine RPE characteristics beyond this point.
Appendices
### Appendix A

**Table 1: Descriptive Characteristics of Subjects (n=13)**

<table>
<thead>
<tr>
<th></th>
<th>Fit (n=6)</th>
<th>Unfit (n=7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>25.2 ± 3.63</td>
<td>22.5 ± 0.84</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>178.96 ± 5.94</td>
<td>183.31 ± 9.70</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>72.36 ± 6.54*</td>
<td>86.77 ± 6.97</td>
</tr>
<tr>
<td>Body Fat (%)</td>
<td>9.78 ± 3.51</td>
<td>11.50 ± 5.70</td>
</tr>
<tr>
<td>VO_{2} Max (ml/kg/min)</td>
<td>61.64 ± 2.51*</td>
<td>43.43 ± 5.16</td>
</tr>
</tbody>
</table>

* p < 0.05 between groups  
Values are means and Standard deviations
Appendix B

HR response for fit vs. unfit in a hot environment

Figure 1: HR Response (hot)
Appendix C

HR response for fit vs. unfit in a cool environment

Figure 2: HR Response (cool)
Appendix D

Rectal temperature response for fit vs. unfit in a hot environment

Figure 3: Trec response (Hot)
Appendix E

Rectal temperature response for fit vs. unfit in a cool environment

Figure 4: Trec response (cool)
Appendix F

RPE responses for Fit vs. unfit in a hot environment

Figure 5: RPE overall, Legs and Chest
Appendix G

RPE response for Fit vs. unfit in a cool environment

Figure 6: RPE Overall, Legs and Chest
Appendix H

Sweat rates for fit vs. unfit in hot and cool environments

Figure 7: Sweat rates in ml/hour

- p< 0.05 between Groups
- * indicates significant difference
Appendix I

ACSM Risk Stratification (ACSM, 2000)

<table>
<thead>
<tr>
<th>Name</th>
<th>Date: / /</th>
<th>Gender: Female or Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Do you have any of the following conditions?

- [ ] 1. Family history of Heart disease: Heart attack, heart surgery, or sudden death before age 55 (father/brother/son) or 65 (mother/sister/daughter)
- [ ] 2. Cigarette Smoker: current or have quit within the past 6 months
- [ ] 3. High Blood Pressure: SBP ≥ 140 or DBP ≥ 90 (confirmed on 2 occasions or on Blood Pressure medication)
- [ ] 4. High cholesterol: total > 200 (or HDL < 35, or > 130, or on medication for high cholesterol)
- [ ] 5. Diabetes (adult or juvenile) or Glucose Intolerance
- [ ] 6. Obesity (Body Mass Index ≥ 30, or waist circumference > 39 inches)
- [ ] 7. Sedentary Lifestyle (less than 30 minutes total “physical activity” most days)

Total risk factors =

Do you have any of the following?

- [ ] Pain, discomfort, tightness, or heaviness in the chest, neck, jaw, arms, or other areas
- [ ] Shortness of breath at rest or with mild exertion
- [ ] Dizziness or loss of consciousness
- [ ] Difficulty breathing when lying down or any difficulty breathing during physical exertion
- [ ] Swelling at the ankles
- [ ] Irregular or fast heart rate
Intermittent leg pain or limping especially upon exertion
Known heart murmur
Unusual fatigue or shortness of breath with usual activities

Total signs/symptoms =

<table>
<thead>
<tr>
<th>Stratification</th>
<th>(only persons considered as low risk may participate in this study)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low Risk</strong></td>
<td>Younger individuals (males: younger than 45, females: younger than 55) who have no signs/symptoms and no more than 1 risk factor.</td>
</tr>
<tr>
<td><strong>Moderate Risk</strong></td>
<td>Older individuals (males: 45 and older, females: 55 and older) or those who have 2 or more risk factors.</td>
</tr>
<tr>
<td><strong>High Risk</strong></td>
<td>Individuals with 1 or more signs/symptoms or known cardiovascular, pulmonary or metabolic disease.</td>
</tr>
</tbody>
</table>
Appendix J

Screening questions: Acute Exercise and Emotion Study

If you answer “yes” to any of the following questions you may not participate in this study. Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly.

1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?

2. Do you feel pain in your chest when you do physical activity?

3. In the past month, have you had chest pain when you were not doing physical activity?

4. Do you lose your balance because of dizziness or do you ever lose consciousness?

5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?

6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

7. Do you know of any other reason why you should not do physical activity?

In addition:
➢ If you are or may be pregnant do not participate.
➢ If you are not feeling well because of a temporary illness such as a cold or fever—wait until you feel better.
➢ If your health changes so that you answer YES to any of the above questions do not participate.
➢ Only males between the ages of 18 and 44 and females between the ages of 18 and 54 are eligible to participate in this study.

Physical Activity Readiness-Questionnaire, Canadian Society for Exercise Physiology, Inc. (1994).
Appendix K

Informed Consent Statement Comparison of Sweat Response During Cycling in 91 degrees and 65 degrees

The purpose of this research project is to compare the amount of lactate in sweat during cycling in a hot room (approximately 91 degrees) and in a room with a normal temperature (approximately 65 degrees).

Requirements
As a volunteer in this research project you will be asked to do the following:

1) Perform 3 separate exercise trials; a single maximal exertion cycling test and 2 sub-maximal exercise sessions on a stationary bike (1 in a hot room and 1 in a normal temperature room). The 2 sub-maximal exercise sessions will be approximately 60 minutes each.

YOU SHOULD NOT PARTICIPATE IF YOU:
1 - ARE TRYING TO CONCEIVE CHILDREN
2 - YOU ARE TAKING DRUGS (PRESCRIPTION OR ANY OTHER)
3 - HAVE A FAMILY HISTORY OF HEART, VASCULAR, OR KIDNEY DISEASE.

The exercise trials will be completed on 3 separated days and will be as follows:

A) *Maximal Exertion Cycling Session.* During this trial you will exercise on a stationary bicycle for approximately 12-18 minutes depending on your current fitness level. During the exercise, testers will make it more difficult by increasing the resistance on the bike every minute. The first part of the test will be extremely easy but the test will get slightly harder every minute and will get very hard after several minutes. You will pedal at the same speed throughout testing. When you feel you can no longer continue at the required pace, the test will be stopped and you will be monitored during a low intensity cool-down. The test may also be stopped when testers feel it is not safe for you to continue. During this bike test you will be required to wear a breathing mask. It will cover your nose and mouth but will permit you to freely breath room air.

*Maximal* refers to the most intense exercise you are capable of performing

B) Cycling in a Hot Room. During this session you will be exercising in a hot room (approximately 90 degrees) at a **sub-maximal intensity on a stationary bike for 60 minutes total. The resistance will be set based on your performance on the first bike test. You will be required to wear a rectal thermometer during this trial. This consists of a small flexible wire (similar to
a strand of spaghetti) which allows your body temperature to be measured during exercise to protect you from getting too hot. You will be responsible for inserting the probe approximately 2.5 to 3 inches.

C) Cycling in a Normal temperature Room. During this session you will be exercising in a normal temperature room (approximately 65 degrees) at a **sub-maximal intensity on a stationary bike for 60 minutes total. You will be required to wear a rectal thermometer during this trial. This consists of a small flexible wire (similar to a strand of spaghetti) which allows your body temperature to be measured during exercise to protect you from getting too hot. You will be responsible for inserting the probe approximately 2.5 to 3 inches.

**Sub-maximal refers to an exercise intensity below “maximal” exercise intensity as described above.

During all sessions you will also be required to wear a heart rate monitor around your chest near the area of your sternum (breastbone). The monitor resembles a small belt. During all exercise session you will also be asked to tell testers a number for how difficult the exercise feels. During testing (especially during the maximal cycling trial) you will experience severe fatigue particularly near the completion of the test. Also, you should expect to experience increased respiratory rate, increased heart rate, possible lightheadedness, and other uncomfortable symptoms associated with very intense physical exertion. The cycling sessions in the hot and normal temperature room are sub-maximal and will be less strenuous than the maximal test but you should expect to experience increased respiratory rate, increased heart rate, leg fatigue, and other symptoms associated with exercise training during these sessions. You will NOT be allowed to drink water, sports drinks, or any other fluid during any of the exercise sessions. You may drink all the fluids you want before and after the tests.

2) Before performing the maximal cycling exercise session you will be measured for descriptive data including age, height, weight, and percent body fat. Percent body fat will be estimated by measuring skinfold thicknesses at your chest, abdomen, and thigh. This process requires testers to pinch your skin and use a small device to measure how thick the pinched skin is.

3) During cycling trials B and C in the hot and normal room, sweat samples from your lower back will be collected at 5 different times while you are exercising. This consists of a small plastic bag taped to the lower part of your back. As you sweat, this bag will collect the sweat. During the exercise trial, this sweat collector will be removed periodically and a new collector placed in the same location.

4) Prior to participation you MUST complete a physical activity readiness questionnaire (PAR-Q), a questionnaire tool for classifying your level of risk, and the informed consent. These forms will be used to evaluate the safety of your
participation as well as your willingness to participate. Any questions you may have about your participation or the forms you complete are welcomed and will be answered to your satisfaction. If these forms indicate it may not be safe for you to participate, the information will be confidential, however, you will not be allowed to continue.

Risks Due to Participation
Potential risks to your health and well-being because of your participation include 1) cardiovascular injury (heart attack or stroke), 2) severe acute fatigue, 3) lightheadedness, dizziness, nausea, 4) all other possible risks associated with intense and sub-maximal physical exertion.

*The American College of Sport Medicine (2000) suggests the following regarding the potential for risk/injury as the result of participating in an exercise test of this nature

Risk of Death during or immediately after < 0.01% (1 in 10,000)
Risk of heart attack during or immediately after < 0.04% (4 in 10,000)
Risk of hospitalization as a result of testing < 0.2% (2 in 1,000)

*Because your health history and current lifestyle habits have been evaluated prior to your participation, your risk is likely lower than those described above.

Safety of Participation
We will take every precaution to ensure your safety. It is very important that you fully disclose anything that would increase your risk for exercise. IT IS IMPORTANT THAT YOU DO NOT CONSUME HEAVY FOODS FOR APPROXIMATELY 3 HOURS PRIOR TO EACH LAB SESSION. DRINK PLENTY OF FLUIDS AND AVOID ALCOHOL FOR 24 HOURS BEFORE PARTICIPATING IN THE EXERCISE TRIALS. ALSO, YOU SHOULD REPORT TO THE LAB EACH TIME WELL-RESTED (NO STRENUOUS EXERCISE FOR 24 HOURS PRIOR TO THE LAB SESSION). Also, do not 1) take medication of any kind, 2) consume any caffeine the days when you are participating.

IF YOU FEEL ILL AT ANY TIME DURING, BEFORE OR AFTER THIS STUDY LET THE INVESTIGATORS KNOW IMMEDIATELY!! IF YOU ARE TRYING TO CONCEIVE CHILDREN, YOU SHOULD NOT PARTICIPATE IN THE STUDY!!

Benefits of Participation
Benefits to you by participating in this research are - you will received information regarding your aerobic fitness (VO₂ max), ventilatory threshold, percent body fat, and information regarding your sweat rate (how much you sweat).

Right to Withdraw
It is your right to withdraw from the study at any point in time. Withdrawing from the study will not adversely affect you in any manner. You should also understand that the investigator might ask you to withdraw from the study.

**Privacy**
Any information collected about you will be completely confidential. Your participation in the study will not be recognized nor will any personal information about you be made public. Only the primary investigators will have access to any personal information throughout the study. Should data be presented it will only be presented as group data and individual results will NOT be reported.

**Voluntary Consent**
If you fully understand what will be asked of you (should you decide to participate), please read and sign the following statement:

I freely and voluntary and without undue inducement or any element of force, fraud, or deceit, or any form of coercion, consent to be a subject in this research project. I understand that my participation is strictly voluntary and that I am free to withdraw my consent and discontinue participation at any time without penalty or prejudice. I also understand that my confidentiality will be protected and that my name will not be associated with the study results. I have been given the right to ask and have answered any questions that I may have regarding this research. I also understand that any other questions that I may have regarding this research or any procedure may be addressed to Dr. Matt Green the Department of Physical Education and Recreation (745-6035). If you are uncomfortable contacting Dr. Green in the Physical Education Department, you may contact Phillip Myers in the Office of Sponsored Programs (745-4652) who is a member of the Western Kentucky University Review Board for the Protection of Human Subjects. I have read and understand the above.

Signature: ___________________________ Date: ___________________________

Address: ___________________________ Telephone #: ___________________________

Witness ___________________________ Date: ___________________________


Appendix L

Subject ___________ Date ___________
Age _______ Height _______ Weight _______
Chest _______ Abdomen _______ Thigh _______
Sum of Skinfolds ___________ Estimated Body Fat %

Maximal Exertion Bike Test (60 rpms)

<table>
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<tr>
<th>Minute</th>
<th>Resistance</th>
<th>HR</th>
<th>RPE-O</th>
<th>RPE-L</th>
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<tbody>
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<td>RPE-C</td>
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<td></td>
<td></td>
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</tr>
<tr>
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</tr>
<tr>
<td>Time (hr)</td>
<td>Resistance</td>
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<td></td>
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<tr>
<td>----------</td>
<td>------------</td>
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</tr>
<tr>
<td>8-9</td>
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<tr>
<td>16-17</td>
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</tbody>
</table>

\[ \text{VO}_2 \text{ max} \quad \text{90\% of OBLA} \quad \text{Resistance for 60 min} \]

\[ \text{Threshold (% of Max)} \quad \text{Resistance for 60 min} \]

\[ \text{Peak HR} \]


Green JM, Crews TR, Bosak AM, Peveler WW. Overall and Differentiated RPE at the Respiratory Compensation Threshold: Effects of Gender and Mode. *European Journal of Applied Physiology (At press).*


