PREDICTION OF TRAINING INTENSITY FROM MAXIMAL RUNNING SPEED

“CAN IT BE THAT SIMPLE?”

A MANUSCRIPT STYLE THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN
CLINICAL EXERCISE PHYSIOLOGY

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PREDICTION OF TRAINING INTENSITY FROM MAXIMAL RUNNING SPEED

“CAN IT BE THAT SIMPLE?”

By Ezekiel Reynolds

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree of Master of Science in Clinical Exercise Physiology.

The candidate has completed the oral defense of the thesis.

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ABSTRACT


Determining absolute values for training intensity often requires laboratory evaluation, impractical beyond the setting of elite athletes. PURPOSE: This study defined physiologic thresholds (ventilatory threshold (VT) & respiratory compensation threshold (RCT)) as simple percentages of maximal running velocity, and then cross validated the accuracy of the predictive equation. METHODS: Thirty-one well trained students performed incremental, maximal treadmill running with respiratory metabolism measured via open circuit spirometry. The speed at VT and RCT were determined by visual inspection of each individual test. Predictive equations representing the lower and upper 95% confidence interval for VT and RCT, respectively, were developed using linear regression. Twenty independent subjects performed the same incremental, maximal exertion test to determine maximal velocity. They then performed two 30 minute submaximal treadmill bouts at percentages of maximal velocity, defined in the predictive equation, to determine if the predicted velocity could produce conditions consistent with <VT and >RCT. RESULTS: In the validation phase for VT and RCT, respectively, <64% and >86% of maximal speed produced exercise intensity <VT and >RCT, respectively. CONCLUSION: VT and RCT can be predicted from simple percentages of the maximal running speed with reasonable accuracy, and may provide a simplified method of training prescription.
ACKNOWLEDGEMENTS

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I would especially like to thank our foreign exchange students, Giancarlo Condello and Erika Casolino, for all of the extra hours they spent in the lab helping me with data collection. The two of you were great learning tools as well as wonderful subjects in my research.

I would also like to thank Chris Dodge for making me feel unintelligent in regards to lab equipment. You could diagnose and fix the metabolic cart like spell check can correct my thesis. I am very greatful, and it was a pleasure to have worked with you.

Finally, I would like to thank my parents, Mike and Katie Reynolds, for all of their support. You have always been there to make the difficult times easy, and the easy times great.
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INTRODUCTION

Exercise capacity has traditionally been measured in terms of maximal oxygen consumption (VO$_2$ max), and two distinct submaximal thresholds, the ventilatory threshold (VT) and the respiratory compensation threshold (RCT) (Wasserman & McIlroy, 1964). Wasserman et al. (1973), and Hollman (2001), postulated that exercise prescription, which historically has been prescribed as simple percentages of maximal heart rate (HRmax) or VO$_2$ max, could be more accurately prescribed based on individual VT. This concept has been widely accepted, although the relative percent concept is still dominantly used (Katch et al. 1978, Sharhag-Rosenberger et al. 2010).

In endurance athletes, research suggests that the majority of training, approximately 80%, should be below the VT, with approximately 10% between VT and RCT, and the remaining approximately 10% above the RCT (Esteve-Lanao et al. 2005, 2007, Robinson et al. 1991, Billat et al. 2001, 2003, Seiler, 2010). In recent studies, similar results have been seen with rowers (Steinacker et al, 1998; Fiskerstrand and Seiler, 2004; Guellich et al, 2009), cyclists (Zapico et al, 2007; Schumacher and Mueller, 2002), and cross country skiers (Sandbakk et al, 2010). Seiler (2010), in a review of training intensity and distribution, concludes that an 80-10-10 ratio of low intensity to threshold/high intensity training yields excellent long-term results among endurance athletes.

Direct measurement of physiologic thresholds is practical with elite athletes or in a clinical setting. However, for the majority of fitness professionals and coaches working
with lower level athletes or with the general public, direct measurement of threshold intensity is not feasible. deKoning et al. (In Press) observed that during maximal cycle testing, VT and RCT occurred at ~50 and ~75% of peak power output (PPO), respectively. This observation suggested the question, “Can it be that simple? Can simple percentages of maximal running speed also be used to define training intensity zones?”

The purpose of this study was to determine if simple percentages of maximal running speed, at which VT and RCT occur, can be used to define training intensity benchmarks. If successful, we would be able to provide a broader range of athletes and the general public, an inexpensive and simple procedure to determine individual metabolic thresholds, and therefore, individual threshold-specific training intensities.
METHODS

This study was conducted in two phases. The purpose of Phase One was to evaluate whether physiologic thresholds (VT and RCT) could be determined as simple percentages of maximal running velocity (Vmax) during an incremental treadmill test (Woodway Desmo S, Waukesha, WI). Thirty-one physically active students performed maximal, incremental treadmill running (1% grade, start @ 5 km*h⁻¹ for 3 min + 0.8 km*h⁻¹ every minute) with measurement of respiratory metabolism using open circuit spirometry (Parvo Med, Sandy, UT). In stages where the last full minute was not completed, maximal speed was interpolated based on proportional time in stage. The speeds at VT and RCT were determined by visual inspection of each individual test (Foster & Cotter, 2006).
Figure 1. Example of Visual Inspection Method for Determining VT & RCT
Phase Two was a cross-validation study. Twenty physiologically active students performed an identical maximal exercise treadmill test as the subjects in Phase One, to determine maximal running speed.

Subjects then performed two submaximal exercise bouts; the first at 64% maximal speed, and the second at 86%, predicted to require ≤VT and ≥RCT. Blood lactate [La] (Nova Biomed, Waltham, MA), heart rate (HR) (Polar USA, Lake Success, NY), Rating of Perceived Exertion (RPE) (Borg, 1998), and Talk Test (Foster et al. 2009) measurements were made at 10, 20, and 30 minutes during the ≤VT run. During the ≥RCT run, [La] were made at 10 minutes and 20 minutes and at the completion of the test, as none of the subjects were able to complete 30 minutes.

Table 1. Demographic Information of College Aged Subjects

<table>
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<tr>
<th>Phase 1</th>
<th>Males (n=16)</th>
<th>Females (n=15)</th>
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<tbody>
<tr>
<td>Age (yrs)</td>
<td>22.5 ± 2.2</td>
<td>21.8 ± 2.5</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>182.5 ± 4.9</td>
<td>162.9 ± 6.2</td>
</tr>
<tr>
<td>Body mass (Kg)</td>
<td>81.9 ± 11.1</td>
<td>61.8 ± 7.8</td>
</tr>
<tr>
<td>VO2max(ml<em>kg⁻¹</em>min⁻¹)</td>
<td>59.3 ± 8.0</td>
<td>50.6 ± 4.4</td>
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<tr>
<td>HR max (bpm)</td>
<td>187.3 ± 10.2</td>
<td>189.5 ± 4.5</td>
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<table>
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<tr>
<th>Phase 2</th>
<th>Males (n=10)</th>
<th>Females (n=10)</th>
</tr>
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<tbody>
<tr>
<td>Age (yrs.)</td>
<td>21.6 ± 2.6</td>
<td>21.9 ± 1.8</td>
</tr>
<tr>
<td>Body mass (cm)</td>
<td>177.56 ± 5.5</td>
<td>167.9 ± 6.2</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>75.7 ± 10.1</td>
<td>61.0 ± 5.3</td>
</tr>
<tr>
<td>VO2max (ml<em>kg⁻¹</em>min⁻¹)</td>
<td>61.5 ± 5.5</td>
<td>52.6 ± 3.5</td>
</tr>
<tr>
<td>HR max (bpm)</td>
<td>188.8 ± 7.8</td>
<td>190.5 ± 5.3</td>
</tr>
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RESULTS

The mean ± SD Vmax for all subjects in Phase One was 15.4 ± 2.10 km*h\(^{-1}\). The mean ± SD running speed at VT (10.1 ± 1.6 km*h\(^{-1}\)) and RCT (12.9 ± 1.83 km*h\(^{-1}\)) represented 67 ± 9 and 84 ± 6 % of Vmax, respectively. Using the lower and upper 95% confidence intervals for VT and RCT, respectively, ≤64% and ≥86% of Vmax was predicted to produce conditions consistent with ≤VT and ≥RCT exercise intensity.

Results from Phase One are presented in Figure 2. There were no significant differences between the male and female subjects. Accordingly, analysis of the results was performed at the level of all subjects, with genders combined.

Figure 2. Percentage of Maximal Speed at Physiologic Thresholds
In Phase Two, During the ≤VT run, all but one subject met < maximal lactate steady state (MLSS) criteria as [La] did not rise more than 1mmol/L over the final twenty minutes of the test (Carter et al., 1999; Heck et al., 1985; Jones and Doust, 1998; Swensen et al., 1999). In contrast, during the ≥RCT run, every subject met > MLSS criteria, as [La] rose more than 1 mmol/L over the final twenty minutes of the exercise bout. Blood lactate results are presented in Figure 3.

Figure 3. [Blood Lactate] During the Predicted ≤VT Run and Predicted ≥RCT Run

Mean HR for all subjects at 10, 20, and 30 minutes during the ≤VT run was 152 ± 12 (80% HRmax), 158 ± 10 (83% HRmax), and 161 ± 10 bpm (85% HRmax), respectively. End exercise HR for all subjects during the ≥RCT run was 190 ± 7 bpm (100% HRmax).

RPE was measured using the Category Ratio RPE Scale (Borg, 1998). At 10, 20, and 30 minutes during the ≤VT run, mean RPE was 3.0 ± 0.60, 3.9 ± 0.58, and 4.1 ± 0.68, indicative of “moderate to somewhat hard” levels of exertion. In contrast, RPE
scores were much higher during the ≥RCT exercise bout. At 10 minutes, RPE was 5.4 ± 1.02, representative of a “Hard” level of exertion. At 20 minutes and end exercise, mean RPE was 8.3 ± 0.37, and 8.9 ± 1.14, suggesting subjects were near “Maximal” levels of exertion. None of the subjects completed 30 minutes during the ≥RCT run.

Talk Test scores were translated to a 1-3 scale, with a score of one indicating a positive talk test (e.g. the subject could speak comfortably). A score of two indicates the equivocal stage (e.g. speech is possible, but not really comfortable), and a score of three indicates a negative talk test (e.g. speech is definitely not comfortable). Talk Test responses, shown in Figure 4, indicate that most subjects were able to speak comfortably during the ≤VT run, but few of the subjects could speak comfortably during the ≥RCT run. Talk Test scores support the [La] measurements taken during the ≥RCT run, in that all subjects were unable to speak comfortably by the end of their test. [La], HR, RPE, and Talk Test results from Phase Two are presented in Figure 4.
Figure 4. [Blood Lactate], Talk Test, RPE, and HR Data for <VT and >RCT Exercise.
DISCUSSION

The present study is not the first to attempt to define a relationship between absolute dimensions (e.g. speed or power output) and physiologic markers of intensity. Monod and Scherrer (1965) were among the first to notice a hyperbolic relationship between power output and time to exhaustion in small muscle groups. They defined the critical power concept (CP) as the power output that can be maintained for a long time without fatigue. Moritani et al. (1981) hypothesized that during full body exercise on a cycle ergometer, exercise at the CP could theoretically be maintained forever. However, because of substrate depletion, dehydration, and hyperthermia, forever is shortened to a ‘long time.’ Poole et al. (1988) demonstrated that the CP could be used as a non-invasive measurement of MLSS, as exercise just below the Wcrit could be sustained for a prolonged period of time, while exercise just above the Wcrit led to a progressive increase in [La] and VO$_2$ leading to exhaustion.

In 2008, Jones et al. looked at the CP concept with the help of magnetic resonance spectroscopy imaging (MRSI) to measure muscle metabolites. Six subjects completed multiple bouts of single-leg exercise to determine CP. Subjects then performed exercise bouts at 10% above and 10% below their CP work rates. Results agreed with the theory that, exercise above, but not below, the CP results in the utilization of the finite capacity for ATP resynthesis through nonoxidative pathways, leading to exhaustion. It should also be noted that pedal rates may also play an integral role in terms of efficiency (Vandewalle et al. 1997; Weissland et al. 1997) and measurement of VT2, CP or MLSS.
Hill et al. 1995). Takano, 1988, recommended using optimal pedal rates, which are close to spontaneously chosen pedal rates (Weissland et al. 1997). Dekerle et al. (2003) looked at the relationship between CP and MLSS among 11 well-trained male students. Subjects performed multiple cycle tests to detect MLSS and CP. Dekerle et al. determined that, during cycle exercise, CP and RCT were significantly higher than MLSS, and were not indicative of exercise that could be maintained for an extended period of time.

While several studies have looked at the relationship between CP and physiologic thresholds, few have looked at running velocity. Smith and Jones, 2001, was the first study to compare Critical Velocity (CV) to the MLSS velocity, or the maximal speed that could be maintained with no more than a 1mmol increase in [La] over the final 20 minutes of an exercise test. They concluded that the CV and the MLSS likely demonstrated the same phenomenon, and could potentially be used to define the line between heavy and very heavy exercise. The present study looked to take it a step further, not only relating CV to the MLSS, or the RCT, but also the VT. This would allow us to demarcate three well-established training zones.

Previous research from our lab has advocated the use of the Talk Test (TT) as a surrogate tool for estimating VT and RCT. The TT estimates exercise intensity relative to the subjects’ ability to speak comfortably. TT results from an incremental exercise test have been used to prescribe exercise intensities during steady-state conditions. So far, the TT appears to be a viable method for prescribing exercise in athletes, healthy non-athletes, and patients with chronic disease (Foster et al. 2009). However, one theoretical problem with this approach is that, during steady state exercise, cardiac drift may lead to
overestimations of exercise intensity. To approach this problem, two recent studies (Foster et al. 2009; Jeans et al. 2011) focussed on the TT scores, cardiac drift, and whether or not exercise prescriptions during steady-state exercise needed to be down-regulated. Foster et al. (2009) determined that, in previously sedentary populations, to speak comfortably throughout a 20 minute exercise bout, absolute exercise intensity needed to be decreased from those measured during the incremental test. In contrast, Jeans et al. (2011) determined that the amount of down-regulation was less amongst well-trained individuals when compared to sedentary individuals. Responses during incremental exercise produced results consistent with ≤VT intensity during a 40 minute steady-state exercise bout. They postulated that this may be attributed to well-trained athletes making a more accurate estimate of their responses during incremental exercise, or to a fundamental difference in the response to steady-state exercise.
CONCLUSION

This study was based on observations by deKoning et al. (In Press), that VT and RCT occurred at percentages of peak power output (PPO) during cycle exercise. We hoped to find a similar link in treadmill running. The major finding of this study was that treadmill running at 64% and 86% of maximal speed produced conditions consistent with ≤VT and ≥RCT. This protocol may provide a better quality exercise prescription and training plan for runners that do not have access to laboratory settings.

However, it is difficult to assess how much under/over VT and RCT subjects were working. We can only state that, at these percentages, it is likely that individuals will be working outside the two physiologic thresholds. Also, as aerobic capacity and, more importantly Vmax increases, we can expect the absolute velocity at which VT and RCT occur to increase as well. Future research is needed to appreciate the influence of training on Vmax and the percentages at which VT and RCT occur.
REFERENCES


APPENDIX A

REVIEW OF LITERATURE
EXERCISE AND BLOOD LACTATE

The relationship between exercise and intensity has been a topic of great debate. Hill et al. (1924) grouped exercise into two distinct categories; moderate and severe. During moderate intensity, subjects never exceeded steady state exercise relative to oxygen (O$_2$) supply. They determined that at low intensities, O$_2$ demand was met by the O$_2$ supply of ventilation. During severe exercise, O$_2$ demand exceeds O$_2$ supply. As a result, blood lactate [La] levels increase exponentially to the point of exhaustion. Similar findings during the era supported this relationship between [La] and increasing exercise intensity (Bang 1936, Owles 1930).

Hollman (1959) took it a step further, defining the highest work rate that can be maintained over time, without continual accumulation of [La], as the Maximal Lactate Steady State (MLSS). The MLSS is a theoretical borderline between moderate and severe exercise. Exercise at or below this level could be sustained for long periods of time; whereas, exercise above the MLSS led to an exponential accumulation of [La] and exercise limitations. MLSS was later defined as the highest workload during which the [La] increased by no more than 1.0 mmol·l$^{-1}$ during the final 20 min of the exercise bout, usually 30 minutes in length, (Beneke and von Duvillard, 1996, Heck et al. 1985 & 1994).

In running and cycling, exercise at the MLSS has been correlated with [La] of approximately 4.0 mmol·l$^{-1}$ (Heck et al. 1990). However, recent research has shown this universal 4.0 mmol·l$^{-1}$ to be overly broad and simplistic (Foxal et al. 1991 and 1994; Foxal et al. 1996; Myburgh et al. 2001). Others have found MLSS to vary among
differing modes of exercise (e.g. rowing, speed skating, and arm ergometer exercise [Beneke, 1991; Beneke et al. 1995; Heck et al., 1994]).

**METABOLIC THRESHOLDS**

Lactic acid has to be broken down in a process known as bicarbonate buffering. Bi-products of this process are lactate and carbon dioxide (CO$_2$). Ventilation, therefore, increases exponentially with lactate accumulation due to the added influx of CO$_2$. Armed with this concept, Wasserman and McIlroy (1964) developed a method of determining metabolic acidosis by measuring the respiratory gas exchange, or expired air. By visually inspecting ventilation curves during exercise bouts, they defined two metabolic thresholds; the Ventilatory Threshold (VT) and Respiratory Compensation Threshold (RCT). The RCT is associated with the highest intensity that can be maintained without continual accumulation of blood lactate, or the MLSS. Prior to Wasserman and McIlroy (1964), subjects/patients were required to exercise to exhaustion, and blood draws were necessary to define metabolic thresholds. By defining thresholds when they occur via respiratory gas exchange, that was no longer necessary. Wasserman (1973) went so far as to say that the RCT, not maximal oxygen uptake (VO$_2$max) or maximal heart rate (HRmax), provides a clearer picture of the body’s circulatory and metabolic adaptations during exercise, an idea that has gained support in recent decades.

**RELATIVE PERCENT CONCEPT**

Training intensity has historically been prescribed as a percentage of VO$_2$max or HRmax, known as the “relative percent concept” (Katch et al.1978). The main criticism of the relative percent concept is that, much like the 4.0 mmol·l$^{-1}$ MLSS concept, it does not account for individual variance. Davis & Covertino (1975), investigating the validity
of the percent HRmax concept, observed large overestimations in training intensity. Katch et al. (1978) trained 31 individuals at 80% of their HRmax or 62% VO$_2$max. He determined that 17 of the subjects were exercising $\geq$VT, while 14 of the subjects were exercising $<$VT. He concluded that individuals working at a similar percentage of HRmax or VO$_2$max may not necessarily be equally or predictably stressed, which is the goal of any coach/trainer. Like Wasserman, Katch et al. (1978) postulated that training based on the individual VT would provide a more accurate method for determining training intensities. It should be noted that, despite a multitude of contradicting studies, the relative percent concept is still being utilized by the American College of Sports Medicine (Loyd 2001). This can be attributed to the extensive nature of metabolic testing.

**TRAINING INTENSITY**

So, once physiologic thresholds have been outlined, at what intensity should trainers/coaches prescribe their participants to exercise? Esteve-Lanao et al. (2007) did a study with two groups (Z1 and Z2) of sub elite endurance runners. Intensity was divided into three zones. Low-intensity training (LIT) allows for a stable [La] of less than approximately 2 mM. High-intensity training (HIT) refers to training above MLSS ($\geq$4 mM blood lactate). The final zone, threshold training (ThT), was defined as the region bound by the LIT and HIT ($>2$mM$<$4mM blood lactate), or exercise within the VT and RCT. Z1 divided their training 80, 12, and 8% LIT, ThT, and HIT, respectively; whereas, Z2 divided their training 67, 25, and 8% LIT, ThT, and HIT. Z1, which spent the majority of their time at LIT, showed significantly greater improvement ($-157 \pm 13$ s vs $-121.5 \pm 7.1$ s, $P = .03$) in their 8 kilometer time trial performance. These results are
supported in similar studies (Robinson et al. 1991, Billat et al. 2001, Bilatt et al. 2003, Esteve-Lanao 2005). Unfortunately, determining training intensity zones usually requires gas exchange or blood lactate technology, which is expensive and requires a trained individual to interpret data. So, if we could easily determine training intensity zones, we could more easily define training programs that follow intensity-specific training models known to be effective at the highest levels.

**THE TALK TEST**

Previous research from our lab has advocated the use of the Talk Test (TT) as a surrogate tool for estimating VT and RCT (Cannon et al. 2004, Dehart et al. 2000, Jeans et al. 2011, Persinger et al. 2004, Recalde et al. 2003, and Voelker et al. 2002). The TT estimates exercise intensity relative to the subjects’ ability to speak comfortably. TT results from an incremental exercise test have been used to prescribe exercise intensities during steady-state conditions. So far, the TT appears to be a viable method for prescribing exercise in athletes, healthy non-athletes, and patients with chronic disease (Foster et al. 2009). However, one theoretical problem with this approach is that, during steady state exercise, cardiac drift may lead to overestimations of exercise intensity. Foster et al. (2009) determined that, in previously sedentary populations, to speak comfortably throughout a 20 minute exercise bout, absolute exercise intensity needed to be down-regulated from TT results measured during the incremental test. In contrast, Jeans et al. (2011) and Foster et al. (2012) that the amount of down-regulation was unnecessary when working with well-trained individuals. Responses during incremental exercise produced results consistent with ≤VT intensity during a 40 minute steady-state exercise bout. Jeans et al. (2011) postulated that this may be attributed to well-trained
athletes making a more accurate estimate of their responses during incremental exercise,
or to a fundamental difference in the response to steady-state exercise.

**POWER OUTPUT & VELOCITY AND THEIR RELATION TO INTENSITY**

The general public is typically very curious about the absolute values associated
with exercise (e.g. speed or power output). Several studies have investigated these
components and their relation to exercise intensity. Monod and Scherrer (1965) were
among the first to notice a hyperbolic relationship between power output and time to
exhaustion in small muscle groups. They defined the critical power (CP) concept as the
power output that can be maintained for a long time without fatigue. Moritani et al.
(1981), hypothesized that, during full body exercise on a cycle ergometer, exercise at the
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It should also be noted that pedal rates may also play an integral role in terms of efficiency (Vandewalle et al. 1997; Weissland et al. 1997) and measurement of VT2, CP or MLSS (Hill et al. 1995). Takano (1988) recommended using optimal pedal rates, which are close to spontaneously chosen pedal rates (Weissland et al. 1997). Dekerle et al. (2003) looked at the relationship between CP and MLSS among 11 well-trained male students. Subjects performed multiple cycle tests to detect MLSS and CP. Dekerle et al. determined that, during cycle exercise, CP and RCT were significantly higher than MLSS, and were not indicative of exercise that could be maintained for an extended period of time.

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Direct measurement of physiologic thresholds is practical with elite athletes or in a clinical setting. However, for the majority of fitness professionals, coaches, and trainers, working with lower level athletes or with the general public, direct measurement of threshold intensity is not feasible. deKoning et al. (In Press) observed that during maximal cycle testing, VT and RCT occurred at ~50 and ~75% of peak power output,
respectively. This observation suggested the question, “Can it be that simple? Can simple percentages of maximal running speed also be used to define training intensity zones?”

**SUMMARY**

In conclusion, there is a legitimate necessity for the scientific community to provide health professionals, and the general public alike, with a cost effective, low-equipment protocol for accurately determining metabolic thresholds. Initial steps have been taken in deciphering this problem, but more research, and evaluation of said research, is needed.
REFERENCES


Owles, W.H. (1930). Alterations in the lactic acid content of the blood as a result of light exercise and associated changes in the CO₂ combining power of blood and in the alveolar CO₂ pressure. Journal of Physiology. 69, 214-237.


APPENDIX B

INFORMED CONSENT
Protocol Title: Translation of Incremental to Steady State Exercise Responses

Principal Investigator: Carl Foster, Ph.D. & Ezekiel Reynolds

Purpose and Procedure

• The purpose of this research study is to determine if incremental treadmill exercise (progressively faster speeds until fatigue) is comparable to incremental bicycle exercise.
• Participation in this study will require four 30 minute sessions over the course of four days.
• An informed consent document will be completed prior to the start of an exercise test.
• The first trial on treadmill consists of a one-minute incremental maximal test. This will begin with a three minute warm-up and then increasing speed on the treadmill until fatigue. The subject will be wearing a gas analyser apparatus that is like a scuba divers mouthpiece, with a chest strap to monitor heart rate.
• The second trial consists of a three minute warm-up and then steady state exercise for 30 minute, with small blood samples taken at 10, 20, & 30 minutes.
• Heart rate and rate of perceived exertion will be monitored and recorded throughout the length of each trial.

Potential Risks
Potential risks include muscle fatigue, muscle soreness and discomfort of wearing gas analysing apparatus and having finger stick blood samples. The risk for serious or life threatening injury is very unlikely in the healthy, physically active subjects recruited for this study.

Rights and Confidentiality

• Participation is voluntary and able to be terminated at any time, without any penalty.
• All subject data recorded will be kept confidential.
• If the results of this study are published in scientific literature or presented in a professional meeting, the data will be presented without any information that may identify the subject.

Possible Benefits
Benefits include knowledge of the fitness status by the subject and improved ways to recommend exercise training loads by exercise professionals.

Questions or concerns regarding any procedures in this study may be directed to Dr. Carl Foster. Questions or concerns regarding the protection of human subjects may be addressed to the UW-La Crosse Institutional Review Board for the Protection of Human Subjects (608-785-8124 or irb@uwlax.edu).
APPENDIX C

RATING OF PERCEIVED EXERTION SCALE
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<th>Rating</th>
<th>Description</th>
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