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TRAINING COMPARISON: 95%VO2PEAK vs. RACE PACE INTERVALS

Laura Young

The University of Montana

TRAINING COMPARISON: 95%VO_2PEAK VS. RACE PACE INTERVALS

By

Laura M. Young

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Approved by:

Dr. David A Strobel, Dean
Graduate School

Dr. Steven E Gaskill, Chair
Health and Human Performance

Dr. Charles Palmer
Health and Human Performance

Dr. Arthur H Woods
Biological Sciences

Young, Laura, Mater of Science, Spring 2008 Health and Human Performance

Exercise Science

Training Comparison: 95%VO_2peak vs. Race Pace Intervals

Chairperson: Steven E Gaskill

Interval training intensities are typically based on percentages of VO_2max, heart rate max, or lactate threshold. Intervals based on current race pace have not been evaluated. **PURPOSE:** This study examined intervals at 95% VO_2peak compared to race pace intervals on VO_2peak, ventilatory threshold, and time trial performance in recreationally active subjects. **METHODS:** 34 subjects were randomly assigned to either a 95% peak group (n =16, age: 22 ± 2 yr, mean ± SD) or a race pace group (n = 18, age: 22 ± 3 yr). Pre- and post- study, all subjects performed a ramped protocol test to exhaustion on a treadmill or electronically braked cycle ergometer for determination of VO_2peak and ventilatory threshold. Both groups performed a 2.5 mile treadmill time trial or a 20 kilometer cycle time trial. The training intervention for the 95%peak group was 4 x 4 minute intervals at 95% of VO_2peak with 2 minute rest periods. The RP group performed intervals with 2 minute rest periods at speeds 1% faster than their average time trial speed and increased 2% each week. Both groups were matched for total work in ml/kg/min. Lab controlled interval sessions were held three times per week for eight weeks. A mixed design two way (time x interval type) ANOVA with LSD post-hoc tests were calculated (alpha p = <0.05). **RESULTS**: There were no significant differences between 95%VO_2peak and Race Pace groups in changes of VO_2peak, VT, or time trial performance. However both groups improved in all three variables.

	VO_2peak ml/kg^{-1}min^{-1}		VO_2peak % change	**VT** ml/kg^{-1}min^{-1}		VT % change	**Time Trial** minutes		TT % change
	PRE	POST		PRE	POST		PRE	POST	
95%peak	45.2±8.7	48.7±9.1*	+6±7%	30.9±6.3	34.5±8.8*	+17±19%	22.9±4.2	20.9±2.9*	-9±5%
Race Pace	46.4±7.1	49.1±8.1*	+9±13%	30.2±7.1	35.3±9.4*	+13±20%	22.2±2.1	20.3±1.9*	-8±7%

* Indicates statistically significant within subjects pre vs. post

CONCLUSIONS: These results suggest that RP intervals were just as effective at improving VO_2peak, ventilatory threshold, and time trial performance as 95%VO_2peak intervals. These data provide athletes with another option for training. Further research is needed to evaluate race pace intervals efficacy on physiological function, performance, and long term use.

Keywords: interval training, VO_2peak, ventilatory threshold, time trial, recreationally active

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Chapter One

Introduction

Physical preparation is a key principle to successful performance and research and practical applications have demonstrated that interval training is an effective tool in that preparation. The majority of interval training programs have based intensity on physiological markers such as percentage of heart rate maximum, percentage of heart rate reserve, or lactate threshold. Other markers such as percentage of peak power output and lactate threshold have been used to increase power, strength, and time trial performance (Fox et al., 1975; Gibala, 2007; Burgomaster, Heigenhauser, & Gibala, 2007; Hickson, Bomze, & Holloszy, 1976; Laursen, Shing, Peake, Coombes, & Jenkins, 2002; Laursen, Shing, Peake, Coombes, & Jenkins, 2005; MacDougall et al., 1998; Stepto, Hawley, Dennis, & Hopkins, 1998). Helgerud et al (2007) believes VO_2max is probably the single most important factor in determining success of athletes (Helgerud et al., 2007). Therefore Helgerud and other researchers have used VO_2max and $V.VO_2max$ as training intensities. (Bently et al., 2005; Denadai, Ortiz, Greco, & de Mello, 2006; Duffield, Edge, & Bishop, 2006; Esfajani & Laursen, 2006; Dupont & Berthoin, 2004; Gibala, 2006; Helgerud, 2007; Roels et al., 2005; Tabata et al., 1995).

There is a belief by some coaches, based on anecdotal evidence, that interval intensity based on current performance pace can be just as effective as or more effective than traditional intervals. Using current performance speed to establish interval intensity and improve performance has not been researched.

The goal of this research was to determine the efficacy of current race pace intervals and compare them to the most commonly studied intervals at 95% of VO_2max. Thirty-four subjects underwent an eight week interval training program. At the end of the training period the effectiveness of race pace (RP) intervals was compared to 95% VO_2peak intervals on time trial performance, peak oxygen carrying capacity, ventilatory threshold, peak power output, and vertical jump height. The results of this study provide insight to a new method of training and improve the understanding of interval training and the effectiveness of race pace intervals.

Statement of Problem

Current research has not investigated current racing speed intervals to improve aerobic capacity and time trial performance and other fitness markers.

Hypothesis

H1. There will be no difference between in time trial performance between subjects when interval training is at 95% of VO_2max versus those whose interval training is based on current performance speed.

Limitations

I. There is an inherent error with any instrumentation. To limit this error, all equipment was carefully calibrated and all testers were proficiently trained and supervised.

II. The sample was non-randomized. The University of Montana Health and Human Performance 499 class recruited subjects for this study.

The Delimitations

I. Subjects: All subjects used in the research study were required to undergo a health screening evaluation for cardiovascular risk factors. All subjects having more than one cardiovascular risk factor were excluded.

II. Specific Intensity Levels: This research study had participants exercise at intensities determined on the basis of individual peak oxygen carrying capacity determined by an incremental exercise test.

III. Exercise Mode: All subjects will be limited to either a treadmill or stationary cycle as mode of exercise.

Definition of Terms

VO_2max: The maximal oxygen intake in liters per minute determined by meeting all three of the following criteria: 1) RPE greater or equal to 19 based on Borg scale of 6 to 20. 2) RER above 1.1. 3) Increase in workload without a subsequent rise in VO_2.

VO_2peak: The highest oxygen intake in liters per minute achieved at volitional fatigue.

Wingate Test: A 30 second maximal effort anaerobic cycle ergometer test designed to measure mean power, peak power, and percent decline of power output of watts.

TRIMPS: A method of estimating or quantifying the total stress of a training session based on intensity and time of session; used to control the weekly training stress and reduce overtraining.

Interval Training: Training that alternates short bouts of intense effort with periods of active recovery.

HIT/HIIT: High intensity interval training.

IT: Interval training.

Ventilatory Threshold (VT): The exercise intensity at which the increase in ventilation or carbon dioxide output (VCO2) increases more rapidly than oxygen uptake (VO2) during an incremental exercise test.

Respiratory Exchange Ratio: The ratio of expired carbon dioxide to consumed oxygen (VCO_2/VO_2). This ratio can be used to estimate substrate utilization by the exercising subject.

Oxygen Consumption (VO_2): The oxygen uptake required to sustain exercise at a given level of intensity. Oxygen is necessary for cellular respiration production and energy required performing work.

Easy Training Zone: Training that is low intensity and is easy for distance exercises and recovery sessions.

Rating of Perceived Exertion (RPE): Subjective level of intensity an individual feels during exercise. The rating is using the Borg scale 6 to 20 where 6 is very, very, light and 20 is maximal effort.

RPM: Revolutions per minute.

Race Pace Intervals: Intervals performed at slightly higher speeds (1 -5%) or heart rates (1 to 5 percent) higher than current individual race pace.

Wingate Test: A 30 second "all out" maximal effort test designed to measure anaerobic power.

F. Importance of the Study

There has been no prior study using current race pace as interval intensity and few studies have compared males and females, or cycles versus treadmills. We evaluated the effect of interval training on power by monitoring changes in vertical jump and peak power output. The results of this study support current performance speed as interval intensity. There may be an impact on how interval training is prescribed for athletes or for individuals interested in competing in a single event such as a citizen race, a marathon, or any other endurance event train. This study furthers the understanding of interval training and how race-specific training can advance both cardiovascular measures and performance.

Chapter Two
Review of Literature

History of Interval Training

One of the first forms of interval training was called 'Fartlek Training'. This training, common in long distance running involved, short, fast bursts of intensive exercise mixed in with slow, easy exercises. Fartlek was a casual unstructured type of preparation that translated from Scandinavian means "speed play." This technique requires athletes to pick up their tempo as they feel ready during easy runs. Often runners would take turns leading the intervals and use local features such as telephone poles, mile posts, or trees for length markers (Greene & Pate, 2004). Fartlek provided variation to the training and runners had the freedom to exercise at self-selected intensities. Schedules and limits of formal interval training were not imposed, only internally selected speed and intensity. The psychological benefits of Fartlek training were enjoyment and reduction of monotony (Howe, 2006).

Since the introduction of Fartlek in the 1930's the use of interval training has migrated into an essential component of every training program. From endurance to power sports and every discipline in between, interval training is used in one form or another (Billet, 2001; Billat, Slawinksi, Bocquet, Chassaing, Demarle, & Koralsztein, 2001; Laursen, Shing, Peake, Coombes, & Jenkins, 2005).

Interval Training Techniques

Today interval training can be defined as a technique that alternates short bouts of high exertion with periods of low intensity recovery (Sharkey & Gaskill, 2006). The major benefit of interval training (IT) is it allows athletes to train faster and harder without burnout or overtraining while still increasing speed, power, and physiological function. Since highly competitive athlete's often share characteristics attributed to their success such as: (1) a high maximal aerobic power; (2) an ability to maintain a high percentage of their VO_2max for sustained periods; (3) a high power output or speed at lactate threshold; (4) the ability to withstand high absolute power outputs or speeds and resist the onset of muscular fatigue; (5) an efficient/economic technique; (6) the ability to utilize fat as a fuel during sustained high work rates. A training program with high intensity and high specificity is needed to improve these characteristics (Hawley, Myburgh, Noakes, & Dennis, 1997). There are currently a number of conflicting hypotheses on which interval training method is optimal but there are several interval methods in use by coaches which have not been scientifically tested. One untested method bases interval training on current race speed.

Race specific training is intended to enhance athletic performance. It focuses on improving time and no other variables. There is anecdotal evidence that race specific training is effective at improving performance and physiological function. The training adaptations from race specific training could be just as effective as other methods designed to improve aerobic and anaerobic performance.

Interval Training Adaptations

Physiological Adaptations

Physiological adaptations, which occur as a result of training, can be categorized into two main areas: central and peripheral (Laursen, Blanchard, & Jenkins, 2002)

Central adaptations improve delivery of oxygen to working muscles. Initially increased blood volume occurs, followed by larger stroke volumes, greater cardiac output (CO), and improved circulation. Training increases heart size and in particular the left ventricle to support these changes. Other supportive changes such as increased elasticity, greater contractile force, and increased vascularization of the heart muscle occur (McArdle, Katch, & Katch, 1991) (American College of Sports Medicine, 2006) (Birch, 2005) ((Powers & Howley, 2004).

Another central adaptation is enhanced thermoregulatory efficiency. To prevent overheating the body increases circulatory flow and sweating rate to lower core body temperature, remove waste products, and accelerate nutrient transfer (McArdle, Katch, & Katch, 1991) (American College of Sports Medicine, 2006) (Birch, 2005)((Powers & Howley, 2004).

Peripheral adaptations improve utilization and synthesis of energy in working muscle (Laursen, Blanchard, & Jenkins 2002). Key peripheral adaptations include increased ability to extract and use oxygen, often measured by the arterial-venous oxygen difference (a-vO_2). Improved blood flow, greater plasma volume, and increased capillarization of skeletal muscle beds, increased mitochondrial density and enzymes all potentially increase the a-vO_2 difference. Studies by Burgomaster et al (2004, 2005, and 2006) have suggested higher concentration of enzymes like Citrate synthase and Betahydroxycacyle-CoA dehydrogenase (B-HAD) are indicative of improved muscle oxidative potential. A recent study by Talanian and colleagues (showed that after seven sessions interval training at 90% of VO_2peak, most subjects' maximal B-HAD activity increased 32% in two weeks. This suggests mitochondrial enzyme activity rises with training.

Observations by Burgomaster in 2005, 2006 have shown that Wingate training changes fatty acid metabolism and B-HAD activity (Gibala, 2007). Training also increased glucose transporters, significantly increased resting glycogen content, and reduced glycogen utilization rate (Gibala, 2007).

Metabolic adaptations

During high intensity efforts, the body obtains energy from the anaerobic or adenosine trisphosphate –creatine phosphate system (ATP-Pcr). Since only a small amount of ATP is stored in muscle cells at one time, after 30 seconds of "all out" maximal intensity effort, the entire ATP-Pcr system is exhausted (McArdle, Katch, & Katch, 1991). After that time, work output must fall and additional energy systems are required to continue with exercise (McArdle, Katch, & Katch, 1991) (American College of Sports Medicine, 2006) (Birch, 2005)((Powers & Howley, 2004). High intensity and anearobic training have been shown to target this system and increase peak power output.

Anaerobic glycolysis is the next energy system affected by training. As a bi-product of high intensity metabolism, lactate accumulates quickly in muscles and body fluids causing accumulation of excess hydrogen ions which lowers pH levels and slows glycolysis. This is the common cause of burning and pain associated with fatigue. hining status, the amount of lactate tolerated can reach a concentration as high as 25 mmols in power athletes. Seven to ten mmols of lactate is a typical lactate level during moderate intensity exercise (Sharkey & Gaskill 2006) (American College of Sports Medicine, 2006) (Powers & Howley, 2004) (Birch, 2005).

It is also believed that low pH decreases muscles fibers' calcium binding capacity and possibly slows muscle contraction (Burke et al., 2006). Exercise intensity must slow from a lower pH and prevent lactate buildup in muscles and in blood. The onset of blood lactate (OBLA) is sometimes used to measure training status. OBLA is delayed with improved peripheral and metabolic adaptations. Elite level athletes can perform at 80 to 90% of maximal capacity before OBLA (Powers & Howley 2004) (Birch, 2005).

The aerobic glycolysis pathway is also affected by training. The body can preserve fuels such as glycogen and ATP through increased aerobic glycolysis and Beta oxidation. Preservation of stored glycogen and ATP while maintaining blood glucose is of great importance because it prevents fatigue and increases reliance on abundant fuel sources (American College of Sports Medicine, 2006) (Powers & Howley, 2004) (Birch, 2005).

Neuromuscular adaptations

Interval training may improve the ability of athletes to sustain high rates of carbohydrate oxidation through the recruitment of additional motor units (Halwey, Myburgh, Noakes & Dennis, 1997). Interval training stimulates specific neurological patterns of muscle fibers, predominately the fast twitch (FT) muscle fibers (Saltin et al., 1976) (Henriksson & Reitman, 1976) (Krustrup, Hellsten, & Bangsbo, 2004) (Halwey, Myburgh, Noakes, & Dennis, 1997). Training improves the utilization and synthesis of all energy systems. Intensities above 100% of max are rapid at eliciting responses, with intensity and duration the most important components of training (MacDougall et al., 1998)

Studies on mode, timing, and types of interval training.

High Intensity Intervals

The research on high intensity intervals has been categorized into two major outcomes. One theme is when intervals were prescribed as a percentage of VO_2max, VT, or heart rate max the investigators were testing for improvements in cardio respiratory indices. Helgerud (2007) stated high intensity training was an effective method for improving VO_2max, especially when compared to low intensity training. Helgerud's study tested four different intensities performing equivalent work. Group 1 performed long duration training at 70% of heart rate max. Group 2 completed long duration training at lactate threshold. Group 3 performed 15 x 15 second intervals at 90 to 95% of heart rate max, and Group 4 performed 4 x 4minute intervals at 90 to 95% of heart rate max. The low intensity groups (1 and 2) increased 1 to 3%, while the interval groups (Group 3 and 4) increased 5 to 9 percent in VO_2max suggesting interval training were more effective (Helgerud et al., 2007).

A similar study by Duffield, Edge, and Bishop in 2006 had 10 female cyclists perform two minute intervals with one minute rest periods, three days per week for eight weeks. The interval intensity started at 130% of their baseline max and increased 10% each week. As expected, significant increases in VO_2max, power at VO_2max, and power at lactate threshold occurred. On average, VO_2peak increased from 2.3 to 2.78 L/min^1/kg/min (Duffiield, Edge, & Bishop, 2006).

A study by Hickson et al (1976) also showed high intensity and high training volume was an effective method to increase fitness. After ten weeks of training, with an average of six days per week, recreationally active and sedentary individuals were able to increase their VO_2max to levels of competitive athletes. This study found it possible to make large increases in aerobic fitness in a short time, in contrast to the belief that these changes occur slowly and over extended periods of time.

The studies by Helgerud , Duffield, and Hickson lasted for eight to ten weeks, but research has shown six sessions of intervals can increase muscle oxidative potential (Burgomaster et al., 2005). In Burgomaster's study, each session had four to seven intervals of 30 second "all out" bouts with a four minute recovery. After six sessions, subjects increased their endurance capacity from 81 to 169%, essentially doubling their time to fatigue (Burgomaster et al., 2005).

A study by Gibala (2006) had 16 men perform six IT sessions in two weeks. The goal of the study was to compare sprint interval training to endurance training. One group completed four to six, 30 second "all out" cycling intervals at 250% of VO_2max with a four minute recovery. The other group cycled for 90 to 120 minutes at 65% VO_2max. At completion, both groups decreased their time to complete 30 km. No group had a significant improvement over the other group but the results showed that sprint intervals were just affective as traditional endurance training (Gibala et al., 2006).

Studies on Exercise Mode

Many IT studies were performed with cyclists or runners, but intervals are applicable to all exercise modes. Bently (2005) was able to increase VO_2max in swimmers using intervals. Swimmers performed 4 x 400 meter or 16x100 meter intervals to an Aqua pacer. The Aqua pacer allowed swimmers to adjust their speed by keeping in time with auditory sounds and using visual makers at the bottom of a pool. At completion of training, significant differences were found in VO_2max from pre to post-test values.

Dupont and Bethoin stated that "Intermittent training is especially important for developing speed and explosive work" and Mahamed Habib Cherif of the Tunisian Basketball Federation suggests that interval training should be used to improve specific endurance on the basketball courts (Dupont & Bethoin, 2004) (Cherif, 2004). He stated, "Training sessions should be created that closely mimic actual playing conditions. In any given situation, short, vigorous exercises can therefore be proposed" (Cherif, 2004).

Interval training can benefit clinical populations as well as athletes. Intervals are essential in clinical setting such as cardiac rehabilitation, physical therapy, and injury recovery. As seen with post-coronary patients, short intervals can be used to reduce angina when strength and endurance is low after a surgery or cardiac events. Intervals are standard for patients with peripheral artery disease, who can tolerate walking for several minutes. High intensity intervals also have the potential to speed up the rehabilitation process in stable coronary artery disease patients (Helgerud et al., 2007).

Studies on Time Trial Performance

Another theme in IT studies is when training intensity was prescribed as percentage of lactate threshold, peak power output, or V.VO_2max (velocity at VO_2max), were testing for changes in time trial performance. Improvements in performance are credited to central adaptations, local adaptations or anaerobic adaptations. Laursen, Shing, Peake, Coombes, and Jenkins in 2005 attempted to understand these adaptations by training cyclists and triathletes at three intensities. Group one performed eight intervals at VO_2max for duration of 60% time to exhaustion with a 1:2 recovery ratio. Group two performed eight intervals at the same intensity with a recovery period based on HR returning to 65% of max. Group three (anaerobic group) performed twelve 30 second intervals at 175% of peak power output. Group 3 had a recovery period of 4.5 minutes. A control group was asked to maintain their regular low-intensity training program. The results showed groups 1, 2, and 3 had improvements in time trial performance and significant increases in VO_2peak, VT, and max heart rate. This was attributed to an increased ability to tolerate lactate. Increases in time trial performance were attributed to greater VO_2peak, enhanced glycogenolytic flux, and an improved capability to buffer hydrogen ions. The increase in VT was believed caused by an enhanced fat oxidation. Laursen was able to suggest that aerobic intervals (groups one and two) had greater improvements in VO_2peak and VT, while the anaerobic group's (group three) adaptation were from increases in lactate threshold. All methods were effective at improving time trial performance, suggesting more than one mechanism is responsible for improved performance.

Burgomaster in 2005 suggested that HIT increases aerobic endurance through mitochondrial potential since VO_2max did not change after six interval sessions in their study. This was considered a local adaptation since subjects only trained for six IT sessions (Burgomaster et al., 2005). A study by Laursen, Blanchard and Jenkins in 2002 had a similar outcome. They conducted a study in which males performed 20 X 1 minute bouts of cycling at their PPO. At the end of the training period PPO significantly increased, VT significantly increased, but VO_2peak did not increase. Only a total of four training sessions in two weeks were completed which may no have been long enough to induce a changes. This supports the idea that short training periods can produce peripheral adaptations, but may not be long enough make central adaptations (Laursen, Blanchard, & Jenkins, 2002).

Esfarjani and Laursen in 2007 concluded that the greatest increases in VO_2max and 3000m running performance will depend upon intensity, duration, and frequency. In their study, the greatest improvement came from high intensity intervals with a longer duration compared to max intervals with a shorter duration. Group one completed five to eight intervals at velocity of VO_2max (V.Vo_2max) for at least 60% of T_{max} with a 1:1 work: rest period. T_{max} was the time a subject could sustain V.Vo_2max. Group two performed seven to twelve, 30 second bouts at 130% of V.VO_2max with a 4.5 minute recovery period. Testing results showed both groups significantly improved in time trial performance, VO_2max, V.VO_2max, and Tmax but only Group one had a significant improvement in lactate threshold. Group one had greater but not statistically significant improvement over Group 2 in all dependent variables. The greater improvement by Group one was attributed to longer duration, a shorter rest period, and a slightly higher training volume. Certain intensities appear strong enough to provide aerobic and performance enhancement but extremely high intensities may plateau sooner.

High volume and high intensity contradict the results of Burgomaster et al, in 2005, 2006 and Gibala in 2006. Burgomaster and Gibala have shown significant increases in power, performance, and aerobic fitness with a very small training load. In several of their studies 6 to 24 Wingate tests over 14 days were used as intervals. In these studies the training load was extremely low, yet subjects had significant improvements in aerobic and anaerobic indices.

Stepto, Hawley, Dennis, and Hopkins in 1999 showed time trial performance could be improved by low volume training but dependent on intensity. In this study five groups performed six intervals at 80%, 85%, 90%, 100%, and 175% of peak anaerobic power (PPO). The groups training at 85% and 175% PPO had statistically significant improvements from pre to post, while the other groups did not.

Rozenek (2007) was able to support that very high work to rest ratios were not beneficial to physiological improvement. In this study three IT training groups and a control group performed intervals at 100% V.VO_2max with a work to rest ratio of 1:1, 2:1, or 4:1. Only 5 of the 12 subjects in the 4:1 group completed the study because it was too intense, supporting that rest and recovery are influential to training design.

Power

A long held belief is that skeletal muscle cannot adapt metabolically and morphologically to both strength and endurance training. This paradigm exists since the adaptations from strength training are different than those from endurance training. An example of this was a study conducted by Tabata (1995). In this study, Tabata measured the effects of aerobic training on anaerobic performance. Subjects trained at a 70% of VO_2max five days a week for six weeks. At the end of the training period each subject's VO_2max increased but showed no improvement in anaerobic performance. In the same experiment Tabata looked at the effect of moderate intensity versus high intensity intervals on anaerobic capacity and VO_2max. Group one (aerobic) trained five days per week for six weeks at 70% of VO_2max.   Group two (HIT) trained 5 days a week for six weeks at very high intensities for interval duration of two to three minutes. Subjects were encouraged to perform seven to eight intervals per day. If subjects could not match the required intensity based on watt output, the training ended for the day.   Similar to the first experiment Tabata showed that moderate intervals had no effect on improving anaerobic capacity but unlike the first experiment high intensity intervals were effective at increasing anaerobic capacity and aerobic capacity was well. This training method showed that aerobic and anaerobic performance could be increased simultaneously (Tabata et al., 1995).

In review by Laursen, Blanchard, and Jenkins, eight HIT studies involving trained cyclists, all had inteval intensities based off percentage on peak power output (PPO). The review stated six of the eight studies had an improvement in PPO and time trial performance, validating the effectiveness of intervals on power and race improvement. (Laursen, Blanchard, & Jenkins 2002).

Vertical Jump

The ability to use explosive power and power endurance can be estimated through a vertical jump test. This test gives insight to the muscle fiber composition of individuals. It has been estimated that the percentage of fast twitch fibers is greater in individuals with a greater vertical jump height (Sharkey & Gaskill, 2006). Many IT studies have used invasive methods to detect changes in fiber type, but a vertical jump test is sensitive enough to suggest shift in fiber type from training.

Chapter 3

Methodology

Setting

All testing and training took place at the University of Montana Health and Human Performance Laboratory in McGill Hall, room 131.

Recruitment

The volunteers (n=50: 25 female, 25 male) were recruited by the Health and Human Performance senior project class during spring semester, 2007. Subjects were required to be within the ages of 18 and 30 with no cardiovascular risks factors, not pregnant, and without injuries or orthopedic limitations. Participants needed to be non-sedentary and at least recreationally active individuals. After recruitment the subjects were randomly assigned to a treadmill or a stationary bike for the entire testing and training period.

Baseline Testing

All participants underwent preliminary exercise testing for the determination of VO_2peak, heart rate maximum, and ventilatory threshold. Subjects also performed an endurance time trial, a 20 second Wingate test, and a vertical jump test. Additionally height, weight, age, and three site skin folds were measured to estimate body fat percentage. All subjects were given a familiarization period before beginning each test and were instructed to come into the lab well rested and non-fasted.

Descriptive Measurements

Each subject's weight without shoes was recorded prior to any testing on a calibrated Salter Brecknell MS300 scale (Rocky Mountain Scale Works Missoula, MT) in kilograms to the nearest tenth. Each subject's height was also measured to the nearest centimeter using a tape measure posted flat against a wall.

Vertical Jump Test

The vertical jump was performed on the same day as and before the VO_2peak test. Using the "Just Jump!" pressure activated/ultrasonic platform (Probotics Inc. Huntsville AL), each subject was instructed to jump as high as possible for maximum vertical jump height. The subject was allowed to practice as much as desired before taking 4 separate measurements. Vertical jump height was calculated from flight time (meters = ½ g $(t/2)^2$ where g= 9.8^{m} $/sec^2$ and t/2 is the time from liftoff to peak height. The highest vertical jump height was recorded.

Graded Exercise Test

Each subject completed a graded exercise test for the determination of peak oxygen consumption (VO_2peak). Subject's were fitted with a heart rate monitor, mouth piece and head gear connected to an open-circuit computerized gas analysis system (Parvo Metics, Sandy, Utah) to calculate oxygen (O_2) consumption and carbon dioxide (CO_2) production and heart rate every 15 seconds during the test until exhaustion. Each subject performed this on a treadmill or stationary cycle depending on which exercise mode they were randomly assigned to.

Graded Exercise Test on Treadmill

Subjects assigned to treadmill mode began a warm up at self selected pace on a Quinton treadmill. After a five minute warm up, the test was initiated. The treadmill increased by incremental stages that raised speed and grade every minute. The treadmill began with a speed at 3.5 miles per hour (MPH) and 2% grade. The speed increased .33 MPH every minute and increase 0.5% grade every minute. Heart rate was recorded every 15 seconds using a heart rate monitor (Polar). Rating of perceived exertion (RPE) according to the Borg scale was recorded every minute during the test until volitional fatigue. Verbal encouragement was given throughout the test.

Graded Exercise Test on Cycle

Subjects assigned to cycle mode completed a graded test on an electronically braked cycle ergomemeter to determine VO_2peak. Subjects were given a familiarization period and seat height was recorded. After a self-selected warm-up, subjects could choose a protocol from their perceived fitness level that began the test at 50 or 75 watts. The test then increased 25 watts per minute throughout the test. Using Cardgirus software, subjects needed to keep their cadence above 60 rpm. Resistance was automatically adjusted cadence to maintain required watts. The test continued to volitional exhaustion when the subject's cadence fell below 60 rpm and the test was terminated. Verbal encouragement was given throughout the test.

Determination of Ventilatory Threshold

To determine VT for each subject, a combined method of ventilatory equivalent (VEQ method), excess carbon dioxide method (ExCo2) and modified V-slope method were used (Gsakill et al, 2001). The VEQ method is the intensity of activity which causes the first rise in the ventilatory equivalent of oxygen (VE/VO2) without a concurrent rise in the ventilatory equivalent of carbon dioxide (VE/VCO2). The ExCO2 method is the intensity of exercise which causes an increase from steady state to an excess production of CO2 (ExCO2) calculated as (($VCO2^2/VO_2$)-VCO_2). The V-slope method is the intensity of exercise which, in a plot of the minute production of CO_2 over the minute utilization of $O_{2,}$ is the exercise intensity corresponding with the increase in the slope if $VO_{2-}VCO_2$ (Gaskill et al., 2001).

Time Trial

Depending on mode assigned, each subject performed a time trial on a treadmill or stationary cycle. This test was used to determine current race pace for each subject. All subjects were fitted with a heart rate monitor (Polar) and RPE (Borg) was recorded every five minutes during the trial. Each time trial was designed to take the average subject around 20 minutes to perform and was given verbal encourage throughout the trial. The trial was performed on a different day with at least 1 day of rest from date subject performed the graded exercise test.

Treadmill Time Trial

Each subject assigned to treadmill training, completed a 2.5 mile time trial. Every subject used the same calibrated treadmill (Quinton) for pre and post training. The test began by having each subject warm up at a self selected pace for 5 minutes. Subject's were blinded to their time and speed, but allowed to see their distance travelled. Subject's self controlled the treadmill speed to their "race pace" and then began the timer when the subject was ready. Each subject was allowed to slow down or speed up the treadmill at will. The test was performed at a 1% grade to simulate outdoor running. Heart rate and RPE were recorded every 5 minutes. The timer was stopped at the completion of 2.50 miles. Time to completion was recorded and average speed was calculated.

Cycle Time Trial

The cycle time trial was performed on a stationary braked cycle with an electronic cycle ergometer (Cardgirus Madrid, Spain). The Cardigirus software includes a time-trial program. The subject began with a five-minute warm-up at self-selected intensity. A countdown appeared on the computer monitor and the clock then started. During the trial subject's could electronically control the gears gearing to adjust watt output. The subject's weight was entered into the program to calculated required watts for 20 kilometers. RPE and heart rate was collected every five minutes during the trial. The course was set to a continuous .50% grade. The computed program provided a visual display of a running clock, current speed, current watt output, distance travelled, and distance needed to complete. The timer was stopped with the completion of 20 kilometers. Time and average watts to complete 20 kilometers was recorded.

Anaerobic Power/Wingate Test

Peak power output and capacity were assessed using a 20 second maximal Wingate Test using a pan-loaded Monarch cycle ergometer. This test was performed after the subject time trial. Resistance was set at 7.5% of body weight and was preloaded onto the weight pan for immediate application at the beginning of the test. The subject's feet were firmly strapped to the pedals and the seat height was adjusted for optimal comfort and pedaling efficiency. Resistance and seat height were recorded. Subjects were instructed to reach optimum pedaling velocity during the last second of a 5 second countdown, after which the full load was applied and the electronic revolution counter activated. An electronic software program (SMI Power, St. Cloud, MN) was used to measure fly wheel revolutions and calculate peak power output, mean power output, and minimal power output in watts. The percentage decline and peak watts per kilogram of body mass were calculated. Subjects were given verbal and visual instruction as well as verbal encouragement.

Exercise Prescriptions

Each subject was assigned into one of four interval prescriptions plans. (1) 95% VO_2peak intervals on cycle (2) Race Pace intervals on cycle (3) 95% VO_2peak intervals on treadmill (4) Race Pace intervals on treadmill.

Group 1 had intensities at 95% VO_2peak on a cycle. The training workload was 95% of the maximum watt output recorded from their VO_2peak test. For training subject's could choose between several pedaling options. For example, an interval intensity of 250 watts could be set at 2.5 kilograms resistance with a pedaling cadence (rpm) of 100, or a resistance of 3 kilograms and cadence of 83 rpm.

Group 2 had interval intensities determined from the 20 kilometer time trial. The training intensity was initially set at a 1% higher than average watts. The average cadence recorded during the time trial, was used establish interval cadence. Training cadence was set equal or faster than race cadence. For example if subject had a race cadence of 95 rpm, they would be assigned interval intensities with a cadence of at least 95 rpm and the resistance adjusted to match established watts. Each subject was given several cadence options above race cadence.

Group 3 had interval intensities at 95% VO_2peak on a treadmill. The training intensity was calculated from the VO_2peak test. The max speed in miles per hour (mph) and grade recorded in percent was recorded and matched to peak heart rate obtained. Training was set to match a

Group 4 had interval intensities determined from their 2.5 mile time trial. Total time elapsed was divided by 2.5 to establish average race speed in mph. The initial training intensity was set at 1% faster than average race speed in mph. The initial training intensity was increased 1% each week.

Experimental Protocol

After preliminary testing, participants underwent an 8 week training intervention. The participants trained using the same exercise mode used for preliminary testing (treadmill or cycle). Each interval training group trained 3 days a week. Interval Groups 1 and 3 (95%VO_2peak) performed 4 x 4 minute intervals. Interval groups 2 and 4 (race pace) performed an equivalent workload of lower intensity 4 minute intervals (approximately 5-7 repeats). During the training period subjects were asked to abstain from any additional aerobic or anaerobic training. Subjects previously involved in exercise routines were allowed to continue their program but not add any additional training loads.

Measuring Total Work

Determination of the physiological stress during training sessions was necessary to equally compare the groups. Quantifying total stress was used by the methods of Esteve, Lanao et al in 2005. The subjects recorded all physical activity into three zones. The zones include light intensity (zone 1) that is below ventilatory threshold, moderate intensity (zone 2) that is between the ventilatory threshold and the respiratory compensation threshold, and high intensity (zone 3), which is above the respiratory compensation threshold (Esteve-Lanao, San Juan, Earnest, Foster, & Lucia, 2005). All four groups then had total work calculated for the eight week training period.

Post Testing

Following the last training session, subjects performed a second set of experimental tests that were identical in all respects to the preliminary tests. The subjects used the same treadmill or cycle used during baseline testing. All tests were performed after at least 2 days of rest from the last training session. The time trial was performed within the same week, but separated by at least 48 hours from the VO_2peak test. Tests were conducted at approximately the same time of day as baseline testing.

All tests were performed under similar conditions and supervised by the same administrator (Laura Young) in order to reduce the experimental error.

Statistical Procedures

All descriptive data (age, height, weight, sum of three skin folds and body fat percentage) were reported as mean ± standard deviations. Between group dependent variables (peak power output, vertical jump height, VO_2peak, time trial, and ventilatory threshold) were analyzed using a two by two mixed design repeated measures (time x group) ANOVA. For within group dependent variables were compared between groups using a one-way ANOVA. All p-values less than 0.05 were considered statistically significant.

A Training Comparison: 95%VO_2peak vs. Race Pace Intervals

Young, L. M[1]., Palmer, C[1]., Woods, A. H[2]., & Gaskill, S.E[1].

Health and Human Performance, The University of Montana, Missoula, MT[1]

Biological Sciences, The University of Montana, Missoula, MT[2]

Address for correspondence:

Steven E. Gaskill

Associate Professor

The University of Montana

Department of Health and Human Performance

McGill Hall

Missoula, Montana 59812

Tel: (406) 243-4268

Fax: (406) 243-6252

Email: steven.gaskill@umontana.edu

INTRODUCTION: Interval training intensities are typically based on percentages of VO_2max, heart rate max, or lactate threshold. Interval training based on current race pace has not been evaluated. **PURPOSE:** This study examined intervals at 95% VO_2peak compared to race pace intervals on VO_2peak, ventilatory threshold, time trial performance, peak power output, and vertical jump height in recreationally active subjects. **METHODS:** 34 subjects were randomly assigned to one of four training groups (TM-95%, Cycle-95%, TM-RP, Cycle-RP). Pre- and post- study, all subjects performed a ramped protocol test to exhaustion on a treadmill or electronically braked cycle ergometer for determination of VO_2peak and ventilatory threshold and a 2.5 mile treadmill time trial or a 20 kilometer cycle time trial. The training intervention for the 95% groups was 4 x 4 minute intervals at 95% of VO_2peak with 2 minute rest periods. The RP groups performed intervals with 2 minute rest periods at speeds 1% faster than their average time trial speed and increased 2% each week. All groups were matched for total work in ml/kg/min. Lab controlled interval sessions were three times per week for eight weeks. A-priori contrasts (1 tailed, dependent) were used to evaluate changes by interval type, mode of training, and gender. A two-way mixed design ANOVAs (time by group) were calculated to measure between group interactions (alpha $p < 0.05$). Results are presented as mean ± standard error (SE). **RESULTS**: There were no significant differences between any of the four groups from pre to post in all dependent variables. However within groups, all subjects significantly improved in VO_2peak, VT, time trial performance, and vertical jump height. No group was significantly able to increase peak power output. **CONCLUSIONS:** These results suggest that RP intervals were just as effective at improving VO_2peak, ventilatory threshold, and time trial performance as 95%VO_2peak intervals independent of gender and exercise mode. These data provide athletes with another option for training. Further research is needed to evaluate race pace intervals efficacy on physiological function, performance, and long term use.

Keywords: interval training, vo_2peak, ventilatory threshold, peak power output, vertical jump height, time trial, recreationally active

INTRODUCTION

Paragraph Number 1 Most interval training programs that improve endurance performance have based training on physiological markers such as percentage of VO_2max, percentage of lactate threshold, or peak power output (Esfarjani & Laursen, 2007; Gibala, et al., 2006; Helgerud, et al., 2007; Krustrup, P., Hellsten, Y., & Bangsbo, 2004; Laursen, Blanchard, & Jenkins, 2002; Laursen, Shing, Peake, Coombes, & Jenkins, 2005; Midgley & McNaughton 2006; Midgley, McNaughton, & Wilkinson, 2006; Smith, Coombes, & Geraghty, 2003). The effectiveness of these interval intensities have been well documented for improving cardio respiratory or anaerobic physiology and time trial performance (Burgomaster, Heigenhauser, & Gibala, 2006; Creer, Ricard, Conlee, Hoyt, & Parcell, 2004; Laursen, Shing, Peake, Coombes, & Jenkins, 2005; Laursen, Shing, Peake, Coombes, & Jenkins, 2002; Sharkey & Gaskill, 2006; Tabata, et al., 1995). Even after much study disagreements remain over which interval training method is optimal. Additionally, there are several interval methods currently in use which have not been scientifically tested. One method, called “Race Pace” training bases interval training intensity on current race speed rather than physiological markers.

Paragraph Number 2 Race pace training is similar to “tempo training” and is intended to enhance time trial performance. It focuses on improving speed without regard to other variables such as heart rate, lactate or percent of VO_2max. This method was successfully used in the early 1980's with the U.S. Nordic Combined Ski team. The ski team trained two to three times per week using race specific interval training and tested race speed monthly. Over the course of two years the team was able to decrease their average race speed from approximately 170 seconds per kilometer (352.9m/min) to 145 seconds per kilometer (413.8m/min) (Sharkey & Gaskill, 2006).

Paragraph Number 3 Lauren and Jenkins (2002) suggest that performance improvements can be credited to either central adaptations, which increase oxygen levels throughout the body, or peripheral adaptations, which increase substrate utilization in working muscles. Neuromuscular adaptations such as technique improvement, efficiency, motor unit and muscle fiber adaptations are additional factors that improve performance. Most interval training studies have focused on central and peripheral adaptation because these are the primary factors in performance improvement. Race pace intervals, while likely to improve central and peripheral physiology, are designed to the principle of specificity to training, thus also having an effect on neuromuscular coordination, technique and recruitment of specific muscle fibers. Specificity of training elicits the most important training responses for performance which include the recruitment of utilized muscle fibers and the support systems, so the transfer of training adaptations is limited.

Paragraph Number 4 No prior study using race pace has been published and these results may impact prescription of interval training for athletes and amateurs competing in an event such as a citizen race, a marathon, or endurance event. The results also further the understanding of interval training and how race-specific training can improve transfer of physiological measures into performance gains.

PURPOSE

Paragraph Number 5 The objective of this study was to compare the efficacy of race pace (RP) intervals to 95% VO_2peak intervals (95). Changes in time trial performance (TT), VO_2peak, the VO_2 at the ventilatory threshold (Tvent), peak power output (PPO), and vertical jump (VJ) were evaluated.

METHODS

Paragraph Number 6 Fifty recreationally active subjects volunteered to participate in this study with 34 subjects completing all testing and training. Prior to participation all subjects completed a health screening evaluation and signed a consent form approved by the University of Montana institutional review board (IRB). Any subject with more than one cardiovascular risk factor, or who was pregnant, injured or with any orthopedic limitation was excluded. All subjects were randomly assigned to either 95%VO_2peak or race pace intervals and then were randomly selected again to an exercise mode of a treadmill or stationary cycle for the duration of the eight week training period. Subjects were in one of these four groups: 95%VO_2peak intervals on a treadmill (TM-95%), 95% VO_2peak intervals on a cycle (Cycle-95%), race pace intervals on treadmill (TM-RP), race pace intervals on a cycle (Cycle-RP).

Paragraph Number 7 The repeated measures study design evaluated the effect of eight weeks of interval training on peak oxygen consumption (VO_2peak), VO_2 at the ventilatory threshold (Tvent), performance (mode specific time trial), and power test (20 second Wingate test and vertical jump test). Height, weight, age, and three site skin folds to estimate body fat percentage were also collected. All subjects were given a familiarization period before beginning each test and were instructed to come into the lab well rested and non-fasted.

BASELINE TESTING

Paragraph Number 8 **Vertical Jump Test** Vertical Jump Test: The vertical jump test was performed on the same day but before the graded exercise test. Using the "Just Jump!" pressure activated/ultrasonic platform (Probotics Inc. Huntsville, AL, USA), each subject was instructed to jump as high as possible for maximum vertical jump height. Vertical jump height was calculated from flight time (meters = ½ g $(t/2)^2$ where g= 9.8m/sec^2 and t/2 is the time from liftoff to peak height. The highest vertical jump height in four separate trials was recorded.

Paragraph Number 9 **Graded Exercise Testing** Each subject completed a graded exercise test for the determination of VO_2peak and Tvent. Subject's were fitted with a heart rate monitor (Polar Electro Inc. Lake Success, NY, USA) mouth piece and head gear connected to an open-circuit computerized gas analysis system (Parvo Metics, Sandy, Utah, USA) to calculate oxygen (O_2) consumption and carbon dioxide (CO_2) production every 15 seconds during the test until volitional exhaustion. The metabolic cart was calibrated with known concentrations of CO_2 and O_2 and for flow rates prior to each test.

Paragraph Number 10 Subjects assigned to treadmill mode began a warm up at self-selected pace on a treadmill (Trackmaster, Newton, Kansas, USA). After a five minute warm up, the test was initiated. The treadmill began with a speed at 3.5 miles per hour (mph) and 2% grade. The speed increased .33 mph every minute and increased 0.5%

grade every minute until volitional fatigue. Verbal encouragement was given throughout the test.

Paragraph Number 11 Subjects assigned to cycle mode completed a graded test on an electronically braked cycle ergometer (Cardgirus, Madrid, Spain) to determine VO_2peak. After a self-selected intensity during a 5-minute warm-up, the test was initiated starting at 50 or 75 watts depending on fitness. The test then increased 25 watts per minute until the subject could no longer keep their cadence above 60 rpm at which point the test was terminated. Verbal encouragement was given throughout the test.

Paragraph Number 12 **Time Trial** At least 24 hours after the graded exercise test each subject performed a time trial, 2.5mi on TM or 12km on cycle designed to take the average subject around 20 minutes to complete. Subjects wore a heart rate monitor and were given verbal encouragement throughout the test. Depending on mode assigned, each subject performed a time trial on a treadmill or stationary cycle.

Paragraph Number 13 For all subjects assigned to treadmill training, each subject completed a 2.5 mile time trial on a calibrated Trackmaster treadmill (Newton, Kansas, USA) The treadmill grade was set at a 1% grade to simulate outdoor running. The test began by having each subject warm up at a self-selected pace for 5 minutes. Subjects were blinded to their time and speed, but allowed to see their distance travelled. Subject's adjusted the treadmill speed to their "race pace" and then the timer was started when the subject was ready. Each subject was allowed to slow down or speed up the treadmill at will. Average speed was then recorded.

Paragraph Number 14 A virtual 12 km time trial was performed on an electronic cycle ergometer (Cardgirus Madrid, Spain) using the Cardgirus time-trial software program.

The subject began with a five-minute warm-up at a self-selected intensity. A countdown appeared on the computer monitor and the clock then started. During the trial subject's could electronically control the gears to adjust watt output. The course was set to a continuous 5% grade and the program provided a visual display of a running clock, current speed, current watt output, distance travelled, and distance needed to complete 20 kilometers. Average watts and time to completion were recorded.

Paragraph Number 15 **Wingate Test**

Peak power output and capacity were assessed using a 20 second maximal anaerobic power test on a pan-loaded Monarch cycle ergometer. This test was performed after the subject's time trial. Resistance was set at 7.5% of body weight and was preloaded onto the weight pan for immediate application at the start of the test. Subjects were instructed to reach optimum pedaling velocity during the last second of a 5 second countdown, after which the full load was applied and the electronic revolution counter activated. An electronic software program (SMI Power, St. Cloud, MN, USA) was used to count fly wheel revolutions and calculate peak power output.

TRAINING PROGRAM

Paragraph Number 16 All subjects trained 3 days a week. TM interval Groups were matched for VO_2 based on the relationship between heart rate and expected $VO_{2.}$ Cycle interval groups were matched for total watts. During the training period subjects were asked to abstain from any additional aerobic or anaerobic training.

Paragraph Number 17 **Exercise Prescriptions** The cycle-95% group had their training workload set at 95% of the maximum watt output recorded from their VO_2peak test. The cycle-RP group was prescribed intervals at an initial intensity set at 1% higher than average time trial watts. Training cadence was set equal or faster than race cadence.

Paragraph Number 18 The TM-95% group had interval intensities calculated from their graded exercise test with 95% VO_2peak converted to the appropriate TM speed and grade.

Paragraph Number 19 The TM-RP group had initial interval intensity set at 1% faster than their individual average time trial speed.

POST TESTING

Paragraph Number 20 Following the last training session, subjects performed a second set of experimental tests that were identical in all respects to the baseline tests. The subjects used the same treadmill or cycle used during baseline testing, and all tests were performed after at least two days of rest from the last training session. The time trial was performed within the same week, but separated by at least 48 hours from the graded exercise test. Tests were conducted at approximately the same time of day as baseline testing.

Paragraph Number 2 1 All tests were performed under similar conditions and supervised by the project director in order to reduce the experimental error.

STATISTICAL ANALYSIS

Paragraph Number 22 Statistical analyses were performed using the software program SPSS, version 14.0 and Microsoft Excel, version 2007. For pre-post comparisons, a-priori contrasts (1 tailed, dependent) were used to evaluate the pre- to post-training changes by interval type, mode of training, and gender. To evaluate interactions between groups, two-way mixed design ANOVAs (time by group) were calculated. Statistical significance was set at $p < 0.05$. When higher significance was found we report it in the results. The results are presented as mean ± standard error (SE).

RESULTS

Paragraph Number 23 The mean weight and percent body fat of all 34 subjects' pre and post training were statistically indistinguishable therefore improvements in VO_2peak and Tvent could not be attributed to weight loss or changes in body fat.

Paragraph Number 24 Mean VO_2peak values for subjects are presented in Figure 1. Both interval groups significantly improved their VO_2peak from pre to post testing, but there were no significant differences between the two groups (p=.50) [Figure 1A]. When we evaluated gender within training mode, both male groups (RP and 95) improved significantly while female groups (RP and 95) improved but not significantly from pre to post (p=.22, p=0.25) [Figure 1B]. When we evaluated mode (cycle or TM), the TM-95 and TM-RP improved significantly, while Cycle-95 and Cycle-RP improved but not significantly from pre to post (p=0.7, p=0.16) [Figure 1C]. However there were no significant differences between improvements by any group when compared against all modes and genders (p=.50, p=.06) [Figure 1B, 1C.]

Paragraph Number 25 The mean Tvent values, pre- and post-training are presented in Figure 2. The Tvent for only 26 subjects values were evaluated in this variable because Tvent was immeasurable (TM-95 n=4), (TM-RP n=7), (Cycle-95 n= 6), (Cycle-RP n=9). Both interval groups significantly improved their Tvent from pre- to post-training but there were no significant differences between the two groups (p=.18) [Figure 2A]. When we evaluated gender within training mode, all groups improved but males (RP) and both female groups (RP, 95) did not significantly improve (p=.33, p=.25, p=.43) [Figure 2B].

When mode (cycle or TM) was evaluated all groups improved but the TM-95, Cycle-95, and Cycle-RP did not significantly improve (p=.22, p=.31, p=.10) [Figure 2C]. There were no significant differences between improvements by any group compared against mode or gender for all groups (p=.18, p=.16) [Figure 2B, 2C].

Paragraph Number 26 The mean values for pre- and post-training time trial performance are presented in Figure 3. Both interval groups significantly improved their TT from pre- to post-training, but there were no significant differences between the two groups (p=.86) [Figure 3A]. Likewise when we evaluated mode (cycle or TM) or gender within training mode, all groups significantly improved from pre to post but there were no significant differences between improvements by any group (p=.48, p=.14) [Figure 3B, 3C].

Paragraph Number 27 The mean values for peak power output, pre- and post-training are presented in Figure 4. Overall and within, both interval mean PPO was not significant from pre- to post-training (overall p=.14, 95 p=.37, RP p=.06). There were no differences between the two groups (p=.48) [Figure 4A]. When gender within training mode was evaluated, all groups improved but males-RP and females-95 did not significantly improve (p=.15, p=.31) [Figure 4B]. When we evaluated mode (cycle or TM) all subjects improved but TM-RP and Cycle-95 did not significantly improve (p=.46, p=.46), however there were no differences between improvements overall or by any group (p=.48, p=.14) [Figure 4B, 4C].

Paragraph Number 28 The mean values for vertical jump height, both pre- and post-training, are presented in Figure 5. All subjects in both groups significantly improved their average jump height from pre- to post-testing, but there were no significant differences between the two groups [Figure 5A]. When separated by gender, all four groups had significant improvements from pre- to post-training [Figure 5B]. When mode (cycle or TM) all groups improved but TM-95, TM-RP, and Cycle-RP did not significantly improve (p=0.06, p=0.07, p=0.07) [Figure 5C]. When all groups were compared there were no significant differences between improvements by any group for mode or gender (p=.22, p=.37) [Figure 2B, 2C].

DISCUSSION

Paragraph Number 29 The first major finding of this study was that eight weeks of race pace interval training significantly improved the VO_2peak, ventilatory threshold, vertical jump, peak power output and time trial performance of 34 subjects regardless of the interval type, mode of training or the subject's gender. These results showed that race pace intervals are just as effective as the commonly prescribed 95% VO_2max intervals and are an equally effective way to improve performance and fitness measures within an eight week training period.

Paragraph Number 30 Males and subjects on treadmills had the greatest increase in VO_2peak. This increase was not significantly greater than any other group but this suggests that the response from aerobic training was greater in males than in females and possibly greater in subjects training on treadmills than on cycles. Also males had a greater improvement in VO_2peak over females, but the improvement change nearly approached significance (p=0.6). Since both 95 subjects and RP subjects improved, training mode does not appear to have a strong effect on increasing VO_2peak suggesting both methods were equally effective.

Paragraph Number 31 The only groups to significantly increase their Tvent from pre to post were males-95, and TM-RP, while all other groups improved but not significantly from pre to post-training. Given that all subjects increased VO_2peak, smaller sample sizes might have attributed to an insignificant response in VT since many subjects Tvent could not be calculated and were excluded from the results.

Paragraph Number 32 All subjects groups by mode and all groups by gender significantly increased their time trial performance from pre to post. In general all subjects had a very similar response independent of training mode or gender suggesting that 95% and RP training had a strong effect on improving time trial performance since it was the only variable where all subjects in all groups significantly improved from pre to post-training.

Paragraph Number 33 Overall, all subjects improved in vertical jump height suggesting a possible effect on muscle fiber type. Cycle- 95 subjects improved more on vertical jump height than all other modes although all other modes were very close to having a significant improvement from pre-to post-training (TM-95p=0.06, TM-RPp=0.07, Cycle-RPp=0.07). Gender had no effect on vertical jump height for any group with all groups improving from pre to post-training. It has been suggested that changes in vertical jump height are sensitive enough to detect changes in muscle fiber type from training (Gaskill, Sharkey, 2006) suggesting that individuals in the Cycle-95 group increased fast twitch fiber function more than the respective groups.

Paragraph Number 34 An interesting and unexpected finding is we are unable to explain why at this time there was no clear improvement by subjects overall in peak power output. An improvement in PPO should have occurred since subjects improved in vertical jump height. Previous authors have shown that males will improve in power and anaerobic capacity more quickly than will females when given similar training. As previously stated males did have greater improvements in VO_2peak over females, supporting the idea that males when given a similar training stimulus as women have greater improvements. However, our finding had female-RP subjects improve more in PPO than male-RP subjects regardless of cycle or TM mode. However greater improvement by females over males was not significant ($p=.48$). Since the 95% groups increased their PPO more than the RP groups, this suggests that while both interval methods had an equal affect overall, 95%VO_2peak training may have an a larger effect on power.

Paragraph Number 35 In general race pace interval subjects were training at intensities well below the intensity of the 95%VO_2peak interval group for the majority of the training period. Interestingly all subjects were able to similarly increase their VO_2peak and Tvent by the completion of the study. We believe that the principle of specificity was working in favor of the race pace interval subjects who were improving neuromuscular coordination when training only slightly faster than current race pace. These improvements in economy may have initially compensated for smaller gains in aerobic capacity. As the intensity of training gradually increased for the race pace interval group, the training stimulus gradually increased, eventually resulting in similar gains in VO_2max, Tvent, and time trial speed for both groups even with the overall lower intensity of training completed by the race pace group compared to the 95% VO_2max group. This study supports the idea that sub-maximal intensities, specific to race speeds, can elicit adaptations just as effectively as high intensity interval training. This has also been seen in studies by Tabata et al (1995) where subjects trained at moderate intensities (70% of VO_2max) and were still able to significantly improve their VO_2max.

Paragraph Number 36 Race pace intervals might ultimately be more effective over long term training than high intensity interval training. This has been supported by anecdotal evidence but has yet to be tested. This theory suggests that since race pace subjects train at a lower intensity than most interval regimens they may have a lower likelihood of injury, overtraining and burnout. Also, race pace intervals are more applicable to various groups and easier to prescribe. Laboratory tests or invasive baseline measures are not required and only a stop watch and the knowledge of current race speed are needed. One suggestion is that race pace intervals allow a greater number of race specific intervals to be completed at a lower intensity resulting in less overall stress for more race specific training time. It has also been shown that high intensity interval training may cause subjects to plateau after 6-10 weeks of training and those athletes need to continually be re-tested in order to maintain a specific percentage of maximum.

Paragraph Number 37 Our experience during the study was that race pace intervals were easier to prescribe and were more easily tolerated by individual athletes since more RP subjects completed the training that 95 subjects. Another interesting note was that male dropout rate was significantly higher than female dropout rate with 14 out of 25 (56%) male subjects completing the study, and 20 out of 25 (80%) females completing the study. There was a general consensus, both verbally and in reported ratings of perceived exertion during the interval training, that race pace intervals were less difficult while also giving the athlete the perception of continual progress as they increased their speed without increased effort.

Paragraph Number 38 The researchers felt that if the study had continued for longer than 8 weeks, the race pace intervals would have been more effective over a longer training period as athletes seemed able to gradually increase their training speed without major increases in perceived exertion. The 95% VO_2peak interval group consistently reported that the intervals were more difficult and motivation was harder to maintain. Further research is needed to confirm that race pace interval will continue to help an athlete improve beyond the 8 weeks of this training study and to explain possible mechanisms for performance and fitness improvements.

Paragraph Number 39 In summary, across an eight week training period, 95% VO_2max and race pace interval training programs were equally effective in improving time trial speed, VO_2max, Tvent, and VJ in both males and females regardless of exercise mode oncycles or treadmills.

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Table 1. Characteristics of Subjects (Mean ± SD)			
	Weight (kg)	Height (cm)	Age (yr)
All Subjects(n= 34)	70.14 ± 11.35	169.79 ± 11.54	21.94 ± 2.72
95%VO_2peak group (n = 16)	80.31 ± 8.28	172.09 ± 16.63	22.86 ± 2.28
By mode – Cycle (n=8)	73.48 ± 15.51	175.06 ± 7.78	20.75 ± 1.98
M (n=8)	70.60 ± 12.60	167.70 ± 15.34	22.75 ± 1.39
By gender- Males (n=8)	76.75 ± 3.71	170.40 ± 18.35	22.67 ± 3.37
Females (n=8)	64.32 ± 7.54	167.37 ± 6.99	20.50 ± 1.69
Race pace group (n = 18)	63.31 ± 6.87	168.18 ± 5.93	21.30 ± 2.87
By mode – Cycle (n=10)	68.32 ± 9.56	166.41 ± 14.75	21.40 ± 4.36
TM (n=8)	68.64 ± 8.36	169.79 ± 11.54	23.00 ± 4.36
By gender- Males (n=6)	82.99 ± 9.92	173.36 ± 16.40	23.00 ± 1.31
Females (n=12)	61.09 ± 5.63	167.37 ± 5.29	21.83 ± 3.41

Figure 1.

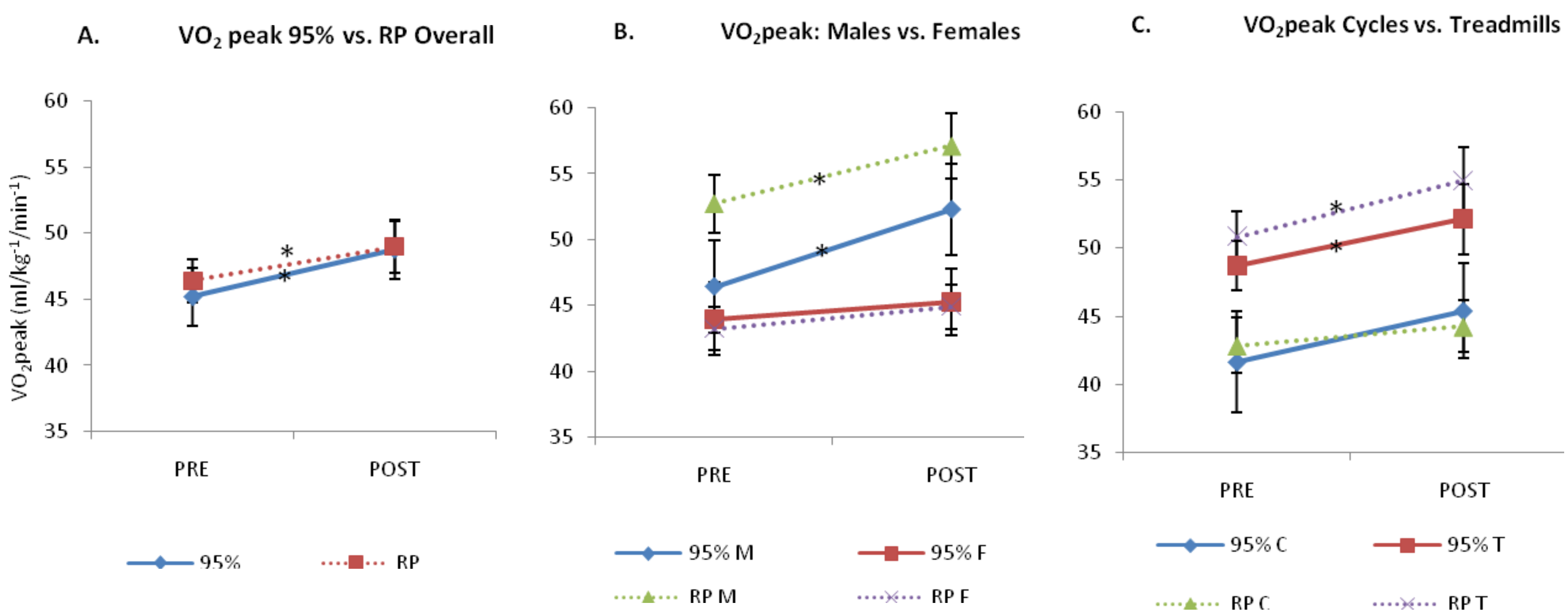

Figure 1: Mean values for VO_2peak pre- and post-training. A: Mean VO_2peak for all subjects separated by interval mode. B: Mean VO_2peak for all subjects grouped by interval mode (95% or RP) and gender (M or F). C: VO_2peak grouped by interval mode (95% or RP) and exercise mode (cycle or treadmill). Error bars show baseline and post-training standard error of each group. * Significant change across time within group.

Figure 2.

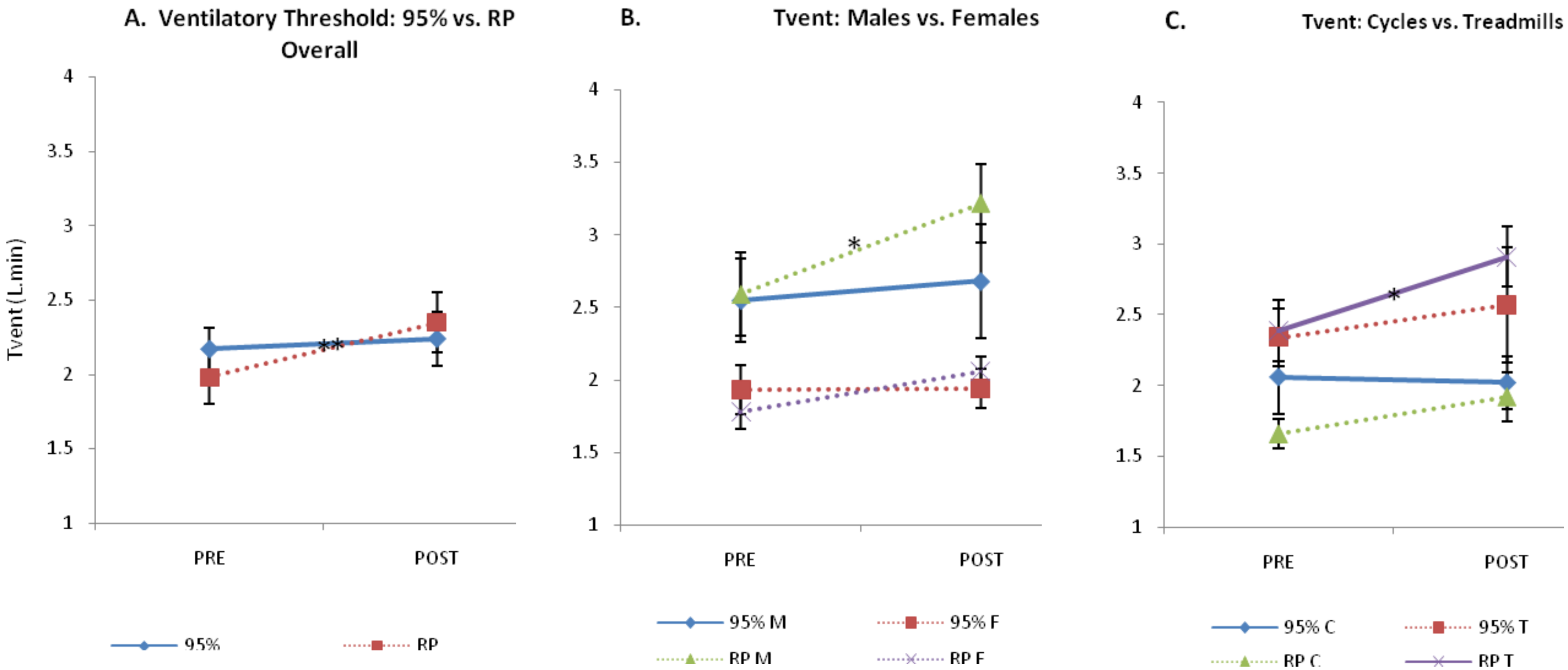

Figure 2: Mean values for ventilatory threshold pre- and post-training. A: Mean Tvent for all subjects separated by interval mode. B: Mean Tvent for all subjects grouped by interval mode (95% or RP) and gender (M or F). C: Tvent grouped by interval mode (95% or RP) and exercise mode (cycle or treadmill). Error bars show baseline and post-training standard error of each group. * Significant change across time within group.

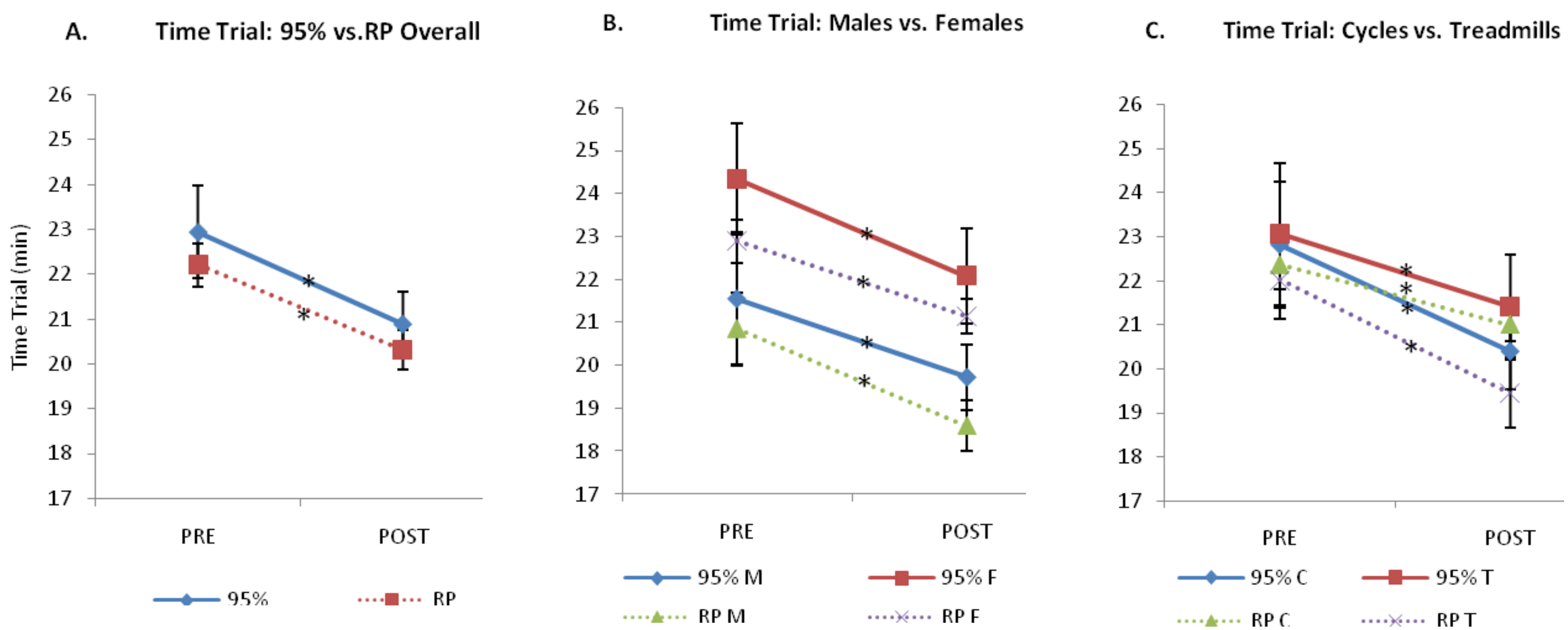

Figure 3: Mean values for time trial time pre- and post-training. A: Mean time trial time for all subjects separated by interval mode. B: Mean time trial time for all subjects grouped by interval mode (95% or RP) and gender (M or F). C: Time trial time grouped by interval mode (95% or RP) and exercise mode (cycle or treadmill). Error bars show baseline and post-training standard error of each group. * Significant change across time within group.

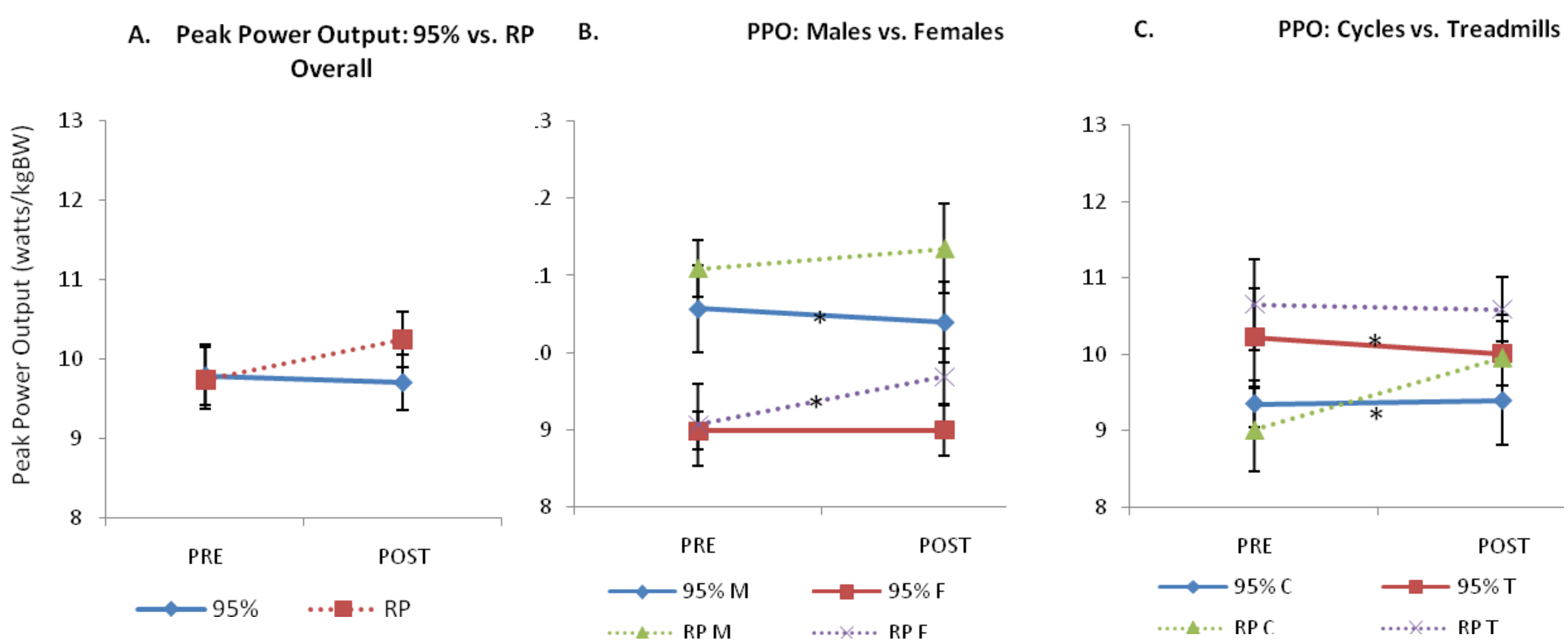

Figure 4: Mean values for peak power output pre- and post-training. A: Mean PPO for all subjects separated by interval mode. B: Mean PPO for all subjects grouped by interval mode (95% or RP) and gender (M or F). C: PPO grouped by interval mode (95% or RP) and exercise mode (cycle or treadmill). Error bars show baseline and post-training standard error of each group. * Significant change across time within group.

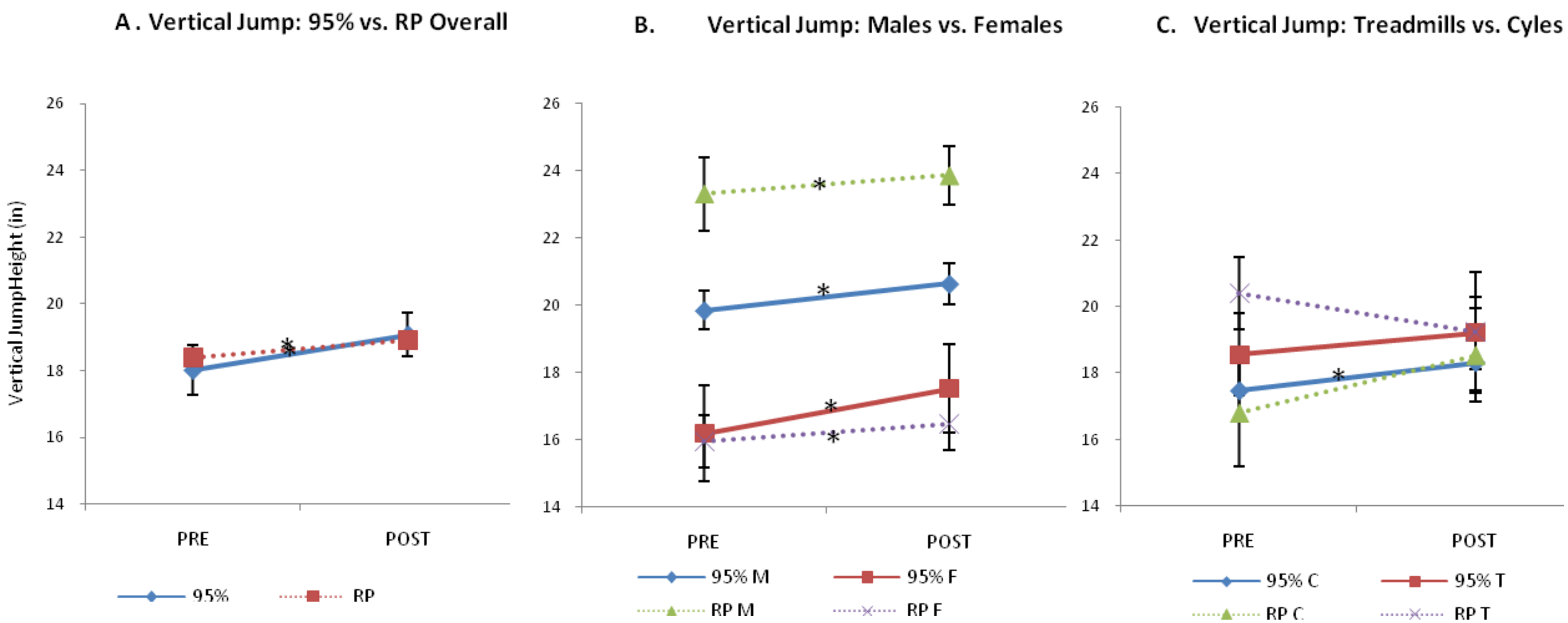

Figure 5: Mean values for vertical jump height pre- and post-training. A: Mean vertical jump height for all subjects separated by interval mode. B: Mean vertical jump height for all subjects grouped by interval mode (95% or RP) and gender (M or F). C: Vertical jump height grouped by interval mode (95% or RP) and exercise mode (cycle or treadmill). Error bars show baseline and post-training standard error of each group. * Significant change across time within group.

SUBJECT INFORMATION AND CONSENT FORM

TITLE: Comparison of Interval Training Techniques

PROJECT DIRECTOR(S): Steven Gaskill, Ph.D., 406/243-4268
steven.gaskill@umontana.edu
Laura Young, BS, 503/8813454
laura2.young@umontana.edu
Charles Palmer, Ph.D., 406/243-4826
charles.palmer@mso.umt.edu
Carla Cox, Ph.D. 406/243-4291
carla.cox@mso.umt.edu
General Address for Correspondence for all investigators:
101 McGill Hall, Health and Human Performance Dept
The University of Montana
Missoula, MT 59812

This consent form may contain words that are new to you. If you read any words that are not clear to you, please ask the person who gave you this form to explain them to you.

Purpose:
You are being asked to take part in a project to evaluate two types of interval training programs over an eight week period. Additionally, this project will look at differences between interval training completed on treadmills vs. stationary bikes, males vs. females, and with or without added aerobic training.

Procedures:
In general, if you agree to take part in this research study you will be asked to do a maximal exercise test, an anaerobic power test, and a time trial before and after eight weeks of training three to four days a week.

Specifics:
You will be asked to:

- Sign this informed consent.
- Complete a health risk screening form.
- Complete a descriptive data sheet.
  - Reading and completing these forms requires about 20 minutes.

Pre-Training (baseline) Testing
You are asked to come to the testing and training sessions well rested, hydrated, and non-fasted, but not having eaten a main meal for at least two hours.

First Testing Visit to the Human Performance Lab (McGill 131):

- This visit will take about 70 minutes.
- Your height, weight and blood pressure will be measured.
- You will complete a 30 second, maximal power Wingate Test. This test requires a 5 minute warm-up on a stationary bike and then a 30 second maximal effort “ride” followed by 5 minutes of cool-down.
- During a rest period, before the next exercise test you will be weighed underwater to determine body composition so that we can evaluate changes over the course of the training program. This requires wearing a swimsuit and submerging yourself in our heated underwater weighing tank while breathing out all of the air in your lungs and

holding your breath for about 5 seconds.

- After 15 minutes of rest required for the underwater weighing you will then complete an exercise tests for the determination of maximum endurance capacity, heart rate maximum, peak lactate concentration, ventilatory threshold, and respiratory exchange ratio. This exercise test will be done randomly on either a treadmill or a stationary bike. You be given time to familiarize yourself with the exercise equipment. This test will require you to wear head gear holding a mouthpiece which you will breathe through during the test to collect expired gases. After an easy 5 minute warm up the test will start at an easy intensity and increasingly become more difficult until you are unable to continue. The test will take about 10-14 minutes with the final 3-5 minutes being quite difficult. Following the test you will be given about 5 minutes of light walking to cool-down.

Second Testing Visit to the Human Performance Lab (McGill 131):

- This visit will take about 45 minutes.
- Within the same week, but separated by at least 48 hours from the first lab visit, you will be asked to again come to the lab to perform about a 20 minute time trial on either a stationary bike (8 miles) or a treadmill (2.5 miles) in the shortest amount of time possible. Time and distance covered will be given to you throughout the trial.

<u>Training Sessions</u>

- You will be asked to come to each training session well rested, hydrated, and non-fasted. All training will be monitored and completed in McGill 131.
- You will train using the same exercise mode that you used for testing (treadmill or cycle).
- You will be randomly placed into 1 of 2 types of interval training or a control group who will do no training for 8 weeks.
- Interval group A will do four - 4 minutes intervals at 95% of VO_2max (very hard intervals) with 2 minute rest periods. The first few initial sessions will be fewer and/or shorter intervals to allow you to adapt to the intensity and duration.
- Interval group B will do five to seven - 4 minute intervals at a speed slightly faster than your average time-trial speed with slight increases each week. The first few initial sessions will be fewer and/or shorter intervals to allow you to adapt to the intensity and duration.
- Each interval training group will train intervals 3 days a week.
- Each interval training session will take about 45-60 minutes to complete. 10 minutes of warm-up, about 30-40 minutes for the intervals (and rest periods) and 5 minutes to cool-down.
- You will also be randomized to a group that either does intervals only or adds one 70 minute easy aerobic training session each week.
- Thus you will be asked to train either 3 or 4 days a week.
- The training period will last for 8 weeks.
- During the training period you are requested to not do additional aerobic or anaerobic training other than resistance training if you were already doing resistance training prior to the start of this project.

Post –Training Exercise Testing

- Following the 8 weeks of training intervention, you will perform a second set of experimental tests that were identical in all respects to the baseline tests. Your first lab visit (power and endurance tests) will be performed after 3 days of rest following your final training session. Your time trial will be performed within the same week, but separated by at least 48 hours from your maximal endurance test.

Risks/Discomforts: You are being asked to do high intensity exercise testing and training. While only healthy, young adults will be invited to participate there are risks and discomforts associated with higher intensity exercise. These risks/discomforts include primarily fatigue and possible muscle soreness, especially early during the exercise training. You will experience shortness of breath and leg fatigue, especially during the maximal exercise test, the time trial and also during some of the interval training. While the danger of cardiovascular complications are minimal, there is an emergency plan in place, an automated electronic defibrillator in the testing room and trained emergency personnel on site. Subjects who experience any problems or have concerns should contact one of the researchers: Steven Gaskill at home (829-8978) or work (243-4289), Carla Cox at home (626-5314) or work (243-4291), Charles Palmer at work (243-4826), or Laura Young (503/881-3454).

Benefits:
Your help with this study may help us to better evaluate different methods for interval training. It is likely that you will improve your aerobic fitness as a participant in this study, based on the results of prior research, but those results cannot be guaranteed. Each participant will be given a copy of their individual data including: Aerobic Fitness (both maximal and submaximal), both before and after the training program and information explaining the meaning of the results. Other than these benefits, there are no additional benefits to participants. The results of this study should benefit coaches and athletes training for endurance events and further the understanding of interval training.

Confidentiality:

- Records will be kept private and will not be released without the subject’s consent except as required by law.
- Only the researchers will have access to subject files.
- Identities will be kept confidential on all forms, using only subject numbers which the researchers will assign.
- Informed consents including subject numbers will be kept in a locked cabinet in a locked room separate from all subject data files.
- Subject data files will be kept in a locked cabinet in a separate room from consent forms.
- Results of this study, when reported in any form, will not name any individual. Only group data will be presented.
    - The only exception to this is individual subject activity information which will be returned to each participant.

Compensation for Injury
Although we do not foresee any risk in taking part in this study, the following liability statement is required in all University of Montana consent forms.

In the event that you are injured as a result of this research you should individually seek appropriate medical treatment. If the injury is caused by the negligence of the University or any of its employees, you may be entitled to reimbursement or compensation pursuant to the Comprehensive State Insurance Plan established by the Department of Administration under the authority of M.C.A., Title2, Chapter 9. In the event of a claim for such injury, further information may be obtained from the University's Claims Representative or University Legal Counsel. (Reviewed by University Legal Counsel, July 6, 1993)

Voluntary Participation/Withdrawal:

- Your decision to take part in this research study is entirely voluntary.
- You may refuse to take part in or you may withdraw from the study at any time without penalty or loss of benefits to which you are normally entitled.
- You may leave the study for any reason.
- Your participation or non-participation, or your choice to leave the study without completing the entire training and all testing will have no effect on you status as a student or otherwise with the University of Montana.
- You may be asked to leave the study for any of the following reasons:

1. Failure to follow the Project Director's instructions;
2. Missing more than 4 training sessions that are not made up. You may make up 3 sessions by adding one additional week to your training, and you must complete at least 20 training sessions total to be included in the study.
2. Acute injury which limits your ability to do physical activity;
3. The Project Director thinks it is in the best interest of your health and welfare; or
4. The study is terminated.

Questions:
You may wish to discuss this with others before you agree to take part in this study.
If you have any questions about the research now or during the study contact: Carla Cox (243-4291), Steven Gaskill (243-4289), Charles Palmer (243-4826), or Laura Young (503/881-3454). If you have any questions regarding your rights as a research subject, you may contact the Chair of the IRB through The University of Montana Research Office at 243-6670.

Subject's Statement of Consent:
I have read the above description of this research study. I have been informed of the risks and benefits involved, and all my questions have been answered to my satisfaction. Furthermore, I have been assured that any future questions I may have will also be answered by a member of the research team. I voluntarily agree to take part in this study. I understand I will receive a copy of this consent form.

____
Printed (Typed) Name of Subject

____________________________________ ______________________
Subject's Signature Date

____
ID Number for subject (Assigned by Research Staff)

PRE-PARTICIPATION SCREENING QUESTIONNAIRE
Comparison of Interval Training Techniques

Subject ID:___________________________(researchers assign #)
Date__________

Gender_________ Age_________..Weight_______lbs Height_________inches

Assess your health needs by marking all true statements.

HISTORY

You have had:
__ A heart attack
__ Heart surgery
__ Cardiac catheterization
__ Coronary angioplasty (PTCA)
__ Pacemaker/implantable cardiac defibrillator/rhythm disturbance
__ Heart valve disease
__ Heart failure
__ Heart transplantation
__ Congenital heart disease

SYMPTOMS

__ you experience chest discomfort with exertion.
__ you experience unreasonable breathlessness
__ you experience dizziness, fainting, blackouts
__ you take heart medications

Other Health Issues

__ you have musculoskeletal problems.
__ you have concerns about the safety of exercise.
__ you take prescription medication(s).
__ you are pregnant

CARDIOVASCULAR RISK FACTORS

__ you are a woman older than 55 years or you have had a hysterectomy or you are postmenopausal.
__ you are a male older than 45 years.
__ you smoke.
__ your blood pressure is >130/85 or you have been told that you have hypertension.
__ you don't know your blood pressure.
__ you take blood pressure medication.
__ your blood cholesterol level is >240 mg/dL.
__ you don't know your cholesterol level.
__ you take medications for high cholesterol levels.

__ you have a close blood relative who had a heart attack before age 55 (father or brother) or age 65 (mother or sister).
__ you are diabetic or take medicine to control your blood sugar.
__ you are physically inactive (i.e., you get less than 30 minutes of physical activity on most days of the week).
__ you are >20 pounds overweight.

AHA/ACSM indicates American Heart Association/American College of Sports Medicine

DATA RECORDING SHEET
FOR TREADMILL MAX

Subject ID #: _______

(without shoes)
Height (CM): ________

Weight (KG): ________

Age: ________

Gender: (M or F)

Vertical Jump Test

(Circle one) Pre or Post

Date:________________

Use measure on right of screen

Trial #1_________________

Trial #2 _________________

Trial #3_________________

Trail #4_________________

VO_2 Max test:

(circle one) Pre or Post

Date:_______________

Time:_______________

Metabolic Cart #: **2**

During Test Record at end of each stage (after warm –up)

Minute	Heart Rate	RPE
0 (0:50)		
1 (1:50)		
2 (2:50)		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		

At end of VO_2max test record:

Peak/max Relative VO_2 (ml/kg/min):______________________

Peak/max Absolute VO2 (L/min):_________________________

Heart Rate Max: ____

DATA RECORDING SHEET
FOR TREADMILL TIME TRIAL

Subject ID #: ________

Gender: (M or F)

(without shoes)
Height (CM): ________

Weight (KG): ________

Age: ________

Skin Folds:

(Circle one) Pre or Post

Use right side of body

Male	Chest	Abdomen	Thigh
trial 1	______	_______	______
trial 2	______	_______	______
trial 3	______	_______	______

Female	Thigh	Triceps	Super Iliac
trial 1	______	_______	______
trial 1	______	_______	______
trial 1	______	_______	______

Time Trial:

(Circle one) Pre or Post

Date: _______________

Distance when time trial started:___________ @ 1% GRADE + 2.5

Total Distance Traveled = ______________

During time trial record

At end of minute	Heart Rate	RPE
4		
9		
14		
19		
24		
29		
34		
39		

At end of time trial

Elapsed time for 2.5 miles:__________________

Wingate Test

(Circle one) Pre or Post

Date:_______________

Time of Day:______________

Subject Weight (Kg):____________

Seat Height:_____________

Resistance Weight (kg): _____________ (after rounding)

Peak Watts (W):_________________

Peak Watts (W/KG): _____________

Ave/Mean Watts (W):__________________

Mean Watts (w/kg):______________________

<u>**DATA RECORDING SHEET**</u>

FOR CYCLE MAX

Subject ID #: ________

Height (CM): ________ (without shoes)

Weight (KG): ________ (without shoes)

Age: ________

Gender: (M or F)

<u>Vertical Jump Test</u>

(circle one) Pre or Post

Date:________________

Use measure on right of screen

Trial #1_________________

Trial #2 _________________

Trial #3_________________

Trail #4_________________

<u>VO_2 Max test:</u>

(Circle one) Pre or Post

Date:_______________

Time of day:_______________

Metabolic Cart #: **<u>1</u>**

Protocol Used: 50 or 75 (circle one)

Seat Height:________________

During Test Record at end of each stage after INCLUDING Warm-up

Minute	Heart Rate	RPE
0 (4:00)		
1 (3:00)		
2 (2:00)		
3 (1:00)		
4 (0:10)		
5 (0:10)		
6 (0:10)		
7 (0:10)		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		

At end of VO_2max test record:

Peak/max Relative VO_2 (ml/kg*min):_____________________

Peak/max Absolute VO2 (L/min):________________________

Heart Rate Max: _______________________

Max Watts: ___________________________

DATA RECORDING SHEET
FOR CYCLE TIME TRIAL

Subject ID #: ________

Height (CM): ________ (without shoes)

Weight (KG): ________ (without shoes)

Gender: (M or F)

Age: ________

Skin Folds:

(Circle one) Pre or Post Use right side of body

Male	Chest	Abdomen	Thigh
trial 1	______	_______	______
trial 2	______	_______	______
trial 3	______	_______	______

Female	Thigh	Triceps	Super Iliac
trial 1	______	_______	______
trial 1	______	_______	______
trial 1	______	_______	______

Time Trial:

(Circle one) Pre or Post

Date:______________

Time of Day:______________

Seat Height:____________

During time trial record after warm -up

At end of minute	Heart Rate	RPM/ Cadence	RPE	Watts
4				
9				
14				
19				
24				
29				
34				
39				

At end of time trial

Elapsed time for 12km:__________________

Average speed (Kph):____________________

Average Heart Rate:_____________________

Average Watts:_________________________

Average Cadence: ______________________

Wingate Test

(circle one) Pre or Post

Date:_____________________________

Time of Day:_____________________________

Seat Height:______________________

Subject Weight (Kg):_______________

Resistance Weight (KG):____________ (after rounding)

Peak Watts (W):___________________

Peak Watts (W/KG): _______________

Mean Watts (W/KG):_______________

Cycle Subject #: 8 95% Max Intervals

	Resitance Options								
	Option 1		Option 2		Option 3		Option 4		
	Cadence (RPM)	Resistance (kg)	Cadence (RPM)	Resistance (kg)	Cadence (RPM)	Resistance (kg)	Cadence (RPM)	Resistance (kg)	Expected HR
All Weeks	96	2.25	87	2.50	79	2.75	72	3.00	192

Assigned to: 95% VO2max Intervals

95% Max Intervals			Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes
Week	Intensity	Watts	Interval 1	Recovery	Interval 2	Recovery	Interval 3	Recovery	Interval 4
Week 1-1	95% MAX	228	2	2	2				
Week 1-2	95% MAX	228	2	2	2	2	2		
Week 1-3	95% MAX	228	3	2	3	2	3		
Week 2-1	95% MAX	228	4	2	4	2			
Week 2-2	95% MAX	228	4	2	4	2	4		
Week 2-3	95% MAX	228	4	2	4	2	4	2	4
Week 3	95% MAX	228	4	2	4	2	4	2	4
Week 4	95% MAX	228	4	2	4	2	4	2	4
Week 5	95% MAX	228	4	2	4	2	4	2	4
Week 6	95% MAX	228	4	2	4	2	4	2	4
Week 7	95% MAX	228	4	2	4	2	4	2	4
Week 8	95% MAX	228	4	2	4	2	4	2	4