THE ANALYSIS OF TWO DIFFERENT TYPES OF TAPERS ON EXERCISE PERFORMANCE

By

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TAPERS ON EXERCISE PERFORMANCE

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

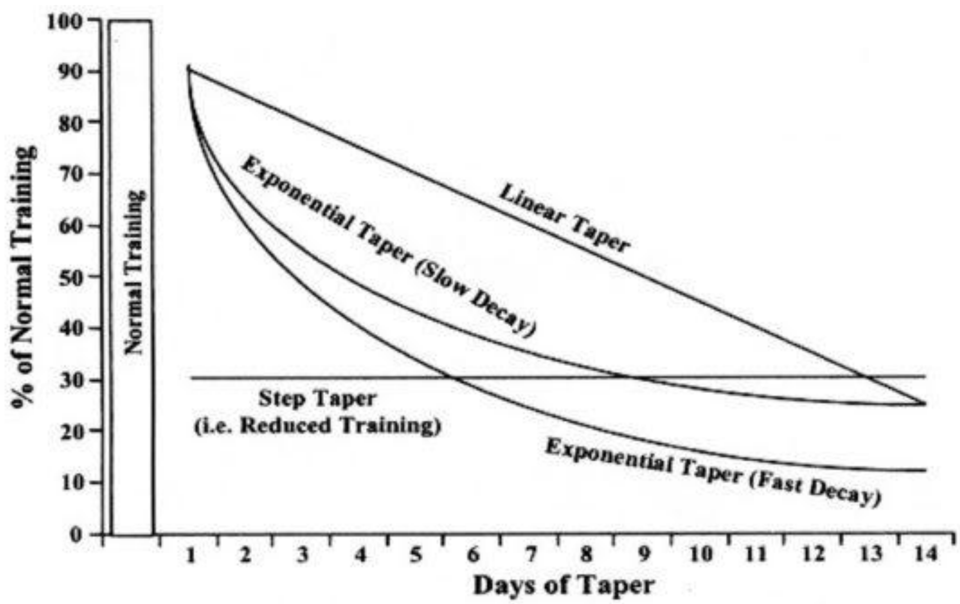
There are many aspects of an athlete's training that will determine the quality of an individual's performance. One of the main influences on performance is the change in frequency, intensity, and duration of the taper period. A taper is the decrease in duration, intensity, and frequency of training prior to a competitive event. There is much debate on how a taper should be implemented and which method is the most beneficial on performance levels. Such tapers include the step taper, the exponential decay taper, and the linear taper. The step taper is as a sudden standardized reduction in training. An exponential decay taper is a gradual decay in training load proportional to its current load while a linear taper is a decrease in training in a linear fashion proportional to the original load. There are two ways to compare the effects of a taper, physiologically and scientifically. Research has expressed an idea of an exponential decay taper being more beneficial. However, Rate of Perceived Exertion (RPE) and submax Heart Rate (HR) values have not been extensively studied. Due to the lack of physiologically based evidence in previous research, there is a need to compare the step taper and exponential decay taper methods using a scientific approach.

The comprehensive definition of a taper is: 'a progressive non-linear reduction in the training load during a variable period of time, in an attempt to reduce the physical and physiological stress of daily training and optimize sports performance' (Mujika, 2000). During a taper, many variables can be affected such as the frequency, intensity, and duration of training sessions (Bishop & Edge, 2005). Frequency of the taper is defined by the total number of training sessions during a time period (Wilson & Wilson, 2008). Reducing frequency by 20-50% for an aerobic event can enhance performance in minimally to moderately trained individuals (Wilson & Wilson).

Intensity of training is determined to be a percentage of a maximal performance. Wilson & Wilson (2008) state "research indicates that reducing intensity results in a decrease in performance for aerobic and anaerobic activities independent of training experience." Even though this suggests that intensity reduction is a hamper on performance, one study has found that a 20% increase in training intensity during the taper resulted in a 22% increase in running time (Wilson & Wilson). The last variable, duration of a taper, is determined to be the length of the decrease in intensity and frequency, and has been suggested to last from 7-21 days depending upon the type and length of the event. However, some studies have found that a taper less than 7 days in duration has been shown to produce significant improvements as well as tapers lasting more than 28 days (Bosquet, Montpetit, Arivasis, & Mujika, 2007).

According to Pyne, Mujika, & Reilly (2009), a step taper involves a sudden, standardized reduction of training load for the duration of the taper, by comparison to progressive tapers where a more gradual change is observed (Figure 1). Research has shown the benefits of grouping exponential tapers and linear tapers under the umbrella of progressive tapers. It has been suggested that an exponential decay taper is better than a step-reduction taper and that a fast exponential decay taper is superior to a slow exponential decay taper (Bishop). This study will focus on the differences and influences of the step taper and the exponential decay taper.

Figure 1



Statement of the problem

The problem of this study is that there is not a definite taper, which is considered more beneficial on exercise performance. Specifically between the step taper and the exponential decay taper.

Purpose

1. The purpose of this study is to determine the differences on endurance performance between the step taper and the exponential decay taper in middle distance recreational runners.

Hypotheses

The hypotheses will focus on significant differences in Rate of Perceived Exertion (RPE), submax Heart Rate (HR), and VO_2 max. Rate of perceived exertion is considered a qualitative value of the amount of energy being used. Submax HR is the maximum value of an individual's heart rate when working out at a certain period. VO_2 max is the maximal rate of oxygen that can be consumed by the body. VO_2 is the body's ability to deliver and extract oxygen.

Ho_1 – There is no difference between the step taper group and the exponential decay taper group within Rate of Perceived Exertion (RPE) during the pre-test.

Ho_2 – There is no difference between the step taper group and the exponential decay taper group within RPE during the post-test.

Ho_3 – There is no difference in submax Heart Rate (HR) between the step taper group and the exponential decay taper group during the pre-test.

Ho_4 – There is no difference in submax HR between the step taper group and the exponential decay taper group during the post-test.

Ho_5 – There is no difference in VO_2 max between the step taper group and the exponential decay taper group across time from baseline to post-test.

Ho_6 – There is no difference in VO_2 max between the step taper group and the exponential decay taper group across time from pre-test to post-test.

Delimitations

The study was conducted within the following parameters:

1. Participants were recruited from Oklahoma State University classes and by posted flyers throughout campus.
2. All familiarization and testing sessions were completed in the Applied Musculoskeletal & Human Physiology Research Laboratory (AMHP) in the Department of Health and Human Performance at Oklahoma State University.
3. 40 healthy, active individuals (18+ years) participated in the study. The participants consisted of 17 males and 23 females.

Limitations

1. Participants were responsible for following the exercise regimen and proper exercise guidelines.
2. Weather
3. Allergies
4. Sickenss
5. Injuries
6. Outside stress
7. Lack of comfort with the mask, treadmill, and/or familiarity with the exercise protocol.

Definition of Terms

BMI – a measurement of body overweight or obesity determined by dividing weight (Kg) by height (m) squared. (Kg/m^2).

Duration (of a taper) – how long the taper lasts.

Exponential Decay Taper – a gradual decay in training load proportional to its current load.

Frequency – total number of training sessions performed.

HR – Heart Rate

Heart Rate Reserve – maximal heart rate minus resting heart rate multiplied by intensity and then by adding resting heart rate. ([HRmax – HRrest] * intensity) + HRrest.

Intensity – a percentage of maximal performance.

Linear Taper – a decrease in training in a linear fashion proportional to the original load.

Max Heart Rate – the highest heart rate value attainable during all out effort to the point of exhaustion.

RER – Respiratory Exchange Ratio.

RPE – Rate of Perceived Exertion.

Step Taper – a sudden standardized reduction in training.

Submax Heart Rate – the maximum value of an individual's heart rate when working out at a certain period.

VCO_2 – the volume of CO_2 produced per minute.

VE – the volume of air expired.

VO_2 max – maximal rate at which oxygen can be consumed by the body. VO_2 is the body's ability to deliver and extract oxygen.

Volume – total work done.

CHAPTER II

LITERATURE REVIEW

Athletes train for hours in the hopes of improving their performance and competing to the best of their ability. For athletes to be able to train at peak performance, their training regimen must be created to allow for optimal training and rest. According to Mujika & Padilla (2003), a period of reduced training just prior to competition with the aim of achieving peak performance at the right moment of the season is termed a “taper”. The taper can also be conceptualized as the final period in a sequence of meso-cyclic patterns in the course of the training year or season (Pyne, Mujika, & Reilly, 2009).

The aim of the taper is to reduce the negative physiological and psychological impacts of daily training rather than achieve further improvements in the positive consequences of training (Mujika & Padilla, 2003). Impacts of daily training can include accumulated fatigue while consequences of training can include fitness gains. The taper involves many complex variables of which can be varied for optimal performance by the specific athlete. The variables that can be manipulated include training intensity, volume, duration, frequency, and the type of taper performed. Types of tapers include step tapers and progression tapers. The reduction and adaptation to these variables can elicit improvements in physiological, psychological, and performance gains (McNeely & Sandler, 2007). Not only are these variables considered in the taper period but also in overall training dynamics.

Tapering Dynamics

Intensity of training is considered to be a percentage of maximal performance. Current research has focused on the effects of intensity on performance and some common trends exist, primarily in high-intensity training groups (McNeely & Sandler, 2007). Shipley et al. (1992) found that a 20% increase in training intensity, while lowering running from 8 to 10 km during a 1-week taper, resulted in a 22% increase in running time and a 15% increase in muscle glycogen concentrations in trained middle-distance runners (Wilson & Wilson, 2008). Trinity, Pahnke, Sterkel, & Coyle (2008) also reported favorable data on higher intensity training during a taper. In the study conducted by Trinity et al. (2008), the high intensity taper proved to be more effective at maintaining maximal power and swim performance at the national championships when compared to the low intensity taper.

Wilson & Wilson (2008) define volume as the total work done and in weight training, it is estimated by the product of sets and reps. However, when dealing with endurance athletes, volume is considered the distance covered or the duration of the activity. Previous research has shown that optimal volume reductions during the taper depend on the previous training load, the duration of the taper, and the experience of the athlete (Wilson & Wilson). For minor and moderate tapers, McNeely & Sandler (2007) state that a step taper may be better where the taper duration is shorter than 10 days. This is due to the effects of detraining when the volume is decreased rapidly over a longer duration. According to Wilson & Wilson, Mujika & Padilla (2003), there are benefits of lowering volume 50-70% for anaerobic events and 50-90% for aerobic events. Shepley et al. (1992) also supports Mujika's findings that better physiological and performance results with a low-volume taper than with a moderate-volume taper (Mujika & Padilla).

Duration of a taper is considered to be how long the taper lasts. The duration of a taper should be dependent upon the activity and the amount of training involved. If taper duration is too long, the athlete may experience detraining. The majority of research supports a taper lasting 7-21 days on average. Duration is also dependent upon volume reduction and previous training loads. Wilson & Wilson (2008) state that with tapers 1-2 weeks in duration, volume can be reduced by 70-90% for inexperienced and experienced endurance athletes, respectively. Wilson & Wilson suggest the following guidelines for optimal tapering duration. For inexperienced athletes, training volume should be reduced 30% while experienced athletes should reduce volume by 50-75% depending upon the duration. Thomas & Busso (2005) examined the factors that could influence the characteristics of an optimal taper. From their research, it was concluded that greater training volume and/or intensity before the taper would allow high performance gains, but would demand a greater reduction of the training load over a longer period.

Frequency is the final variable in overall training dynamics. According to Wilson & Wilson (2008), frequency is defined as the total number of training sessions performed for a given skill, task, or body part in a given period. For aerobic events, their research suggests that training frequency can enhance performance when lowered from 20-50% in minimally to moderately trained individuals. Not only can training frequency reduction enhance performance but the benefits are derived through volume reduction. McNeely & Sandler (2007) support these findings in their study that found "in less than technical endurance sports like running and cycling, frequency can be decreased by up to 50%, partially in the final week before a competition."

Types of Tapers

The last variable in designing a taper is the type of taper, which can be generalized two ways: the step taper and the progression tapers. A step taper is the sudden drop in training load that is then maintained through to competition with a progressive reduction in work load (Whyte, 2006). Progressive tapers include two formats. Wilson & Wilson (2008) state that the final two formats are progressive in nature and include linear and exponential decreases in volume. A linear taper involves decreasing volume in a progressive, linear fashion (i.e. by 5% of initial values every workout) (Wilson & Wilson). The other format is the exponential taper, which involves a decrease in volume at a rate proportional to its current value in a nonlinear fashion (Wilson & Wilson). There are two forms of the exponential taper. The slow exponential taper involves the slow rate of decay whereas the fast exponential taper involves a faster decay of volume. It is hypothesized that an exponential decay taper is the most beneficial and can be easily incorporated into a relatively fast or slow decay rate (Wilson & Wilson, 2008).

Bosquet, et al. (2007) conducted a meta-analysis to assess the effects of alterations in taper components on performance in competitive athletes. From Bosque et al.'s research, the optimal strategy to optimize performance is a tapering intervention of 2-week duration, where the training volume is exponentially decreased by 40-60%, without any modification of either training intensity or frequency. Within this meta-analysis Bosque et al. also grouped all progression tapers into just one category. However, researchers feel that the fast exponential taper and the slow exponential taper should be considered separate tapers (Pyne et al., 2009). Their research found that a fast decay taper is more likely to enhance subsequent competitive performance than a slow decay taper. Therefore, one could benefit from the early reduction in training to reduce fatigue earlier in the taper (Pyne et al). Through mathematical modeling, their research reveals that an early reduction in training load followed by a subsequent increase in the lead up to competition could optimize performance (Pyne et. al.). Thomas, Mujika, & Busso (2008) supports this strategy in that the athlete would take advantage of reduced fatigue to enhance training tolerance and respond effectively to the training undertaken by the taper.

Thomas et al. (2008) is one of the only studies that was completed in a real setting rather than a laboratory setting.

> The study estimated model parameters for competitive swimmers in real training conditions. The results of the study showed that pre-taper training influences the characteristics and effectiveness of the optimal taper. A greater overload before the taper leads to higher performances but requires a longer taper. A progressive training reduction is preferred over a step reduction to enhance performance. The gain in performance was essentially explained by the dissipation of the negative influences of training. The taper can also be of benefit through a small gain in the positive influence only in the case of an overload before a reduction in training. (p 649)

Mujika & Padilla (2003) supports this theory that slow progressive reductions are more effective than sudden standardized reductions in improving the athlete's performance level. The following study focuses on the sprint performance rather than endurance performance. Bishop & Edge (2005) conducted the first study on the effects of a taper on repeated-sprint performance. While not significant, the 10-day taper did result in a 3-4% improvement in performance using an exponential taper. Overall, the research suggests that a worthwhile improvement in top-ranked athletes is in the order of 0.5-3.0% from sprint to endurance events in individual sports like running, swimming, and cycling (Hopkins, Hawley, & Burke, 1999; Pyne, Trewin, & Hopkins, 2004). “On this basis an effective taper on the order of 1-2% can make a substantial difference to the outcome of competition performance in many sports” (Pyne et al. 2009).

Physiological Changes

The ultimate goal of the taper is to maximize performance and numerous underlying variables that affect performance (Wilson & Wilson, 2008). Based on Wilson & Wilson’s research, an athlete can expect the following physiological changes and performance gains (Table 1)

The study by Mujika & Padilla (2003) concludes that there is a significant correlation between the percentage change in the testosterone/cortisol ratio and the percentage performance improvement during a 4 week taper. From this data, it has been suggested that the plasma concentrations of androgens and cortisol represent anabolic and catabolic tissue activities. Therefore the increased testosterone/cortisol ratio depicts enhanced recovery and elimination of accumulated fatigue (Mujika & Padilla). Other research has shown increments in red cell volume, hemoglobin levels and hematocrit as a result of the taper, and these hematological indices have been shown to be related to taper induced performance improvements (Mujika & Padilla).

Table 1

Physiological and Performance Gains
• 5-6% improvements in criterion competition performance gains • Up to 20% increases in power, neuromuscular function, and strength • 10-25% increases in cross-sectional area of muscle tissue • 1-9% improvements in VO_2 max • Up to an 8% increase in running economy • Changes in resting, sub maximal, and maximal heart rate and blood pressure are unclear after a taper, but generally remain unchanged. • Up to a 15% increase in erythrocyte volume. • Up to a 70% decrease in muscle damage after a workout, as indicated by creatine kinase concentrations. • Serum testosterone, an indicator of anabolism, may increase by 5%, with a corresponding 5% decrease in catabolic hormone cortisol. • Catecholamine, a marker of stress and overtraining, may be reduced by 20%. • A 10% increase in anti-inflammatory immune cells, with a concomitant decrease in inflammatory cytokines. • Tapering also facilitates positive affective mood states. Results indicate that tapering can reduce the rate of perceived exertion, depression, anger, anxiety, and increased vigor. • Tapering appears to lower sleep disturbances, as indicated by a 40% decrease in movements during sleep after a taper. • Tapering has also been shown to affect muscle glycogen and body fat stores but depends on diet.

Mujika et al. (2000) studied performance gains as a result of a reduction in training volume. The study compared the effects of progressive 50% and 75% training volume reductions during a 6-day taper in middle-distance runners and concluded that 75% reduction was a more appropriate strategy to optimize adaptations. The study also concluded that a negative correlation existed between the distance of low-intensity continuous training and the percentage change in circulating testosterone during the taper (Mujika & Padilla, 2003). Another similar study was conducted by Shepley et al. (1992) with a similar research group and found the same results. The study revealed better physiological and performance results with a low-volume taper than with a moderate-volume taper (Mujika & Padilla).

McNeely & Sandler's study found that various physiological adaptations are responsible for the 3-11% improvement in performance reported during a taper in endurance athletes (2007). These adaptations include responses to VO_2 max, peak blood lactate, and sport-specific muscle-power increases. VO_2 max improvements were only found in tapers lasting less than 14 days, most likely due to the duration impairments on maintenance (Mujika, Padilla, & Busso, 2004). Research also shows that peak blood lactate is increased during tapering with a correlation (r=0.87) between performance and changes in post race peak lactate concentration (Mujika et al., 2000). Another physiological benefit from the taper is the sport-specific muscle-power increase during a taper. Research suggests that these increases in muscle power are often greater than the improvements in aerobic fitness and may account for most of the performance gains in endurance athletes (McNeely & Sandler, 2007). The improvements post-taper include increases in strength, speed of contraction, and the power of both fast twitch and slow twitch muscle fibers.

Adaptations to Exercise

There are many factors which are affected by exercise. Which include Heart Rate, VO_2, and Rate of Perceived Exertion. According to Smith (2003), "one of the most pronounced cardio respiratory adaptations to endurance exercise is a lowered resting heart rate." From the research on Ratings of Perceived Exertion, there were notions of inconsistency to the effects of RPE across training stages. Buckworth, Fink, Rozorea, Jansen, & Mattern (2004) focused on the affects of RPE on exercise and found no significant differences among the different stages of change. VO_2, however, had a response comparable to Heart Rate. According to Casaburi, Storer, Ben-Dov, & Wasserman (1987) “the anaerobic threshold increased by 0.45 l/min (38%) and the VO_2 max increased by 0.36 l/min (15%)” during an 8 week endurance training. Not only was the data proof of the changes but the participants also stated that the four constant work rates subjectively less stressful in the post-training period (Casaburi et al., 1987).

Summary

Tapering is a specialized exercise training technique designed to reverse training induced fatigue without a loss of the training adaptations (Whyte, 2006). According to Wilson & Wilson (2008) the optimal taper is not clearly defined but should be based upon absolute volume reductions relative to total taper duration. Due to the lack of research in this area there is a need to compare the step taper and the exponential decay taper through RPE, submax HR, and VO_2 max values within this study. The purpose of this study is to determine the differences on endurance performance between the step taper and the exponential decay taper in middle distance recreational runners. In conclusion, athletes will be able to apply these principles to their performance in competition.

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CHAPTER III

METHODOLOGY

Methods

The purpose of this study was to determine the differences on endurance performance between the step taper and the exponential decay taper in middle distance recreational runners.

Participants

The participants in this study included 10 men and 9 women who qualified for and volunteered for this study (age: 28 ± 11.04 years). The mean height (68.39 ± 3.62 inches) and weight (159.42 ± 28.12 lbs.) calculated to a mean BMI of 24 ± 4.35. Two groups, the step taper and the exponential decay taper, of participants were evaluated. Participants were not allowed to participate if they currently worked out more than 3 days a week, were elite athletes, did not pass a participant readiness questionnaire, and had any pre-existing medical conditions that excluded them from participating in the study. If a question existed whether or not they were capable of completing the study or not, physicians consent was required.

Study Site

All testing assessments were conducted in the Applied Musculoskeletal & Human Physiology Research Laboratory in the Department of Health and Human Performance at Oklahoma State University.

Exercise Site

The exercise site was located on the first floor in the Colvin Recreation Center at Oklahoma State University. All equipment necessary for exercise was available in the Colvin Recreation Center. Participants worked out on treadmills and a running track. All exercise, heart rate, and VO_2 testing adaptations and assessments were conducted in the Applied Musculoskeletal & Human Physiology Research Laboratory.

Entry and Medical Screening Session

Participants were recruited by visitation to classrooms and bulletin board advertisements. The ads described the study in brief terms as well as listing any participant qualifications. If interested, the participants were asked to contact the researchers. They were then asked further questions regarding eligibility and to attend a familiarization session. If the participant did not pass entry criteria regarding medical concerns, physicians consent was required if there was not a potential injury at hand.

Study Design

After participants were selected, they participated in baseline testing to determine VO_2 Max (VO_2), resting Heart Rate (HR), and Rate of Perceived Exertion (RPE). Participants were then randomly assigned to a taper group. The first taper group was the step taper (ST) and the second taper group was the exponential decay taper (EDT). Participants then followed an exercise regimen of cardiovascular exercise for four weeks. The regimen increased in duration and intensity until the fifth week of training. On the fifth week, participants followed their designated taper assignment. Before and after the taper, the participants were tested on the Bruce Treadmill Protocol test according to the American College of Sports Science – IV Guidelines for Exercise Testing and Prescription (ACSM IV, pg. 101). Table 2 lists the study timeline. The participants were assessed to find any differences in max VO_2, HR, and RPE before and after the taper period. The independent variable in this study was the taper and the dependent variable was max VO_2, HR, and RPE.

Table 2 - Study Timeline

Step	Portion of the Study
1	Recruitment of participants through flyers and class meetings
2	Participants contact researchers
3	Participants sign up for and attend familiarization screenings
4	Participants schedule and complete baseline testing
5	Participants complete required workouts during weeks 1-4
6	Participants schedule and complete pre-test session
7	Participants complete required taper during week 5
8	Participants schedule and complete post-test session

Familiarization Session

Interested participants were then asked to come to a familiarization session. At this time they were to fill out a medical history form and a signed consent form. After completion of these forms, a trained researcher went over the forms to further evaluate the subjects' eligibility in the study. They were also informed in detail about the study and what it would entail.

Medical Monitoring

At least two trained non-physicians in CPR and First Aid were at the site during all testing and evaluation sessions. In the case of an emergency, researchers followed OSU protocol. Participants were to notify the researcher if any questions or unexpected actions occurred during the study.

Baseline Testing

The first baseline testing was used to determine the groups' overall max VO_2. Participants were to report to the Applied Musculoskeletal and Human Physiology Research Laboratory and complete a VO_2 max treadmill test. Participants performed a maximum cardiopulmonary exercise stress test to determine aerobic capacity and anaerobic threshold. The baseline testing followed the protocol for the Bruce Treadmill maximal exercise test (ACSM IV, pg 101). Figure 2 describes the protocol test. During the test, HR and RPE was recorded every 3 minutes while VO_2 max was recorded every 15 seconds. RPE was recorded using Borg's Rate of Perceived Exertion Scale (ACSM IV). Borg's RPE scale is shown in Figure 3.

Figure 2 – Bruce Protocol Test

Stage	Duration (min.)	Speed (mph)	Grade (%)
I	3	1.7	10
II	3	2.5	12
III	3	3.4	14
IV	3	4.2	16
V	3	5.0	18
VI	3	5.5	20
VII	3	6.0	22

ACSM IV

Figure 3 – Borg's Rate of Perceived Exertion Scale

6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
20	

ACSM IV

Participants were asked to exercise to their maximum potential unless they experienced or exhibited any clinical signs that would terminate the test. The clinical signs followed ACSM's Guidelines for Testing and Exercise Prescription (ACSM IV, pg 78). After the test, the participant was observed during a recovery period. During the recovery period they walked on a treadmill for about 5 minutes then rested for another 5 minutes. The researcher used anaerobic threshold and maximum aerobic capacity to determine the effects of exercise training.

HR Monitor Testing

The participant's heart rate data was collected using a Timex Personal Heart Rate Monitor (Timex Group USA, Inc.). The heart rate monitor functioned through the use of a telemetry strap that was placed against the skin at the base of the pectoral muscles and attached by an elastic strap. The individual's heartbeat was detected through electrodes that were against the skin. The data was sent to a wristwatch by a low frequency electromagnetic field. Data was recorded every three minutes in the middle of each stage.

When the participants arrived for each testing session they were given a telemetry strap and heart rate monitor to put on before their workout. Once the participant was ready to workout, the researcher ensured the functioning of the heart rate monitor. Once the equipment was determined to be working, the testing began and ran for the duration of the workout.

VO_2 Testing

VO_2 data during the exercise testing session was collected using the Parvo Medics True Max 2400 program (ParvoMedics). The program was comprised of a unit which contained O_2 and CO_2 analyzers, sampling pump, UHF transmitter, barometric sensors, electronics, and was connected to a Full Vision treadmill (Full Vision, Inc.). The unit was calibrated to room air and reference gas before each workout. The participants' demographic data was entered into the software.

When the participants arrived for their testing session the headpiece and facemask were placed on the participant and were secured using four Velcro straps. One final room air calibration was completed. The sampling line was placed in the optical gas reader, and the data began transmission to the telemetry unit and recorded in the software program. Once the participant was ready to workout, the researcher verified proper functioning of the VO_2 equipment. Once the equipment was deemed suitable and the data collection began, the participant began their workout. The unit ran for the duration of the workout and was stopped only by the researcher at the conclusion of the workout. The participant performed the workout as described in the familiarization session.

Assessment and Workout Schedule

The study included baseline testing for the participants followed by four weeks of training and pre-testing. It was then followed by one week of the designated taper and post-testing. The participants were asked to follow a workout regimen that ranged from working out 3 days a week for 30-60 minutes each day. Participants were asked to log their time and distance.

Table 3

Sample Workout Regimen for an Exponential Decay Taper

Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					Baseline Testing	
1	2.5 m run		3 m run		3 m	
2	3.5 m run		3.5 m run		4 m run	
3	4.5 m run		4.5 m run		5 m run	
4	5.5 m run		6 m run		6.2m run	Pre-Test
5	6 m run		3 m run		1.5 m run	Post-Test

Table 4

Sample Workout Regimen for a Step Taper

Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					Baseline Testing	
1	2.5 m run		3 m run		3 m run	
2	3.5 m run		3.5 m run		4 m run	
3	4.5 m run		4.5 m run		5 m run	
4	5.5 m run		6 m run		6.2m run	Pre-Test
5	2 m run		2 m run		2 m run	Post-Test

Data Analysis

The data collected using the Timex heart rate testing monitors (Timex Group USA, Inc.), Borg's Rate of Perceived Exertion (ACSM IV, pg 101), and the Parvo Medics True Max 2400 was analyzed for statistical analysis on SPSS 17.1 for Windows (SPSS, Inc.). Data that was out of the acceptable ranges may have been caused by electrical interference.

Descriptive statistics were determined for all participants in the study. Descriptive statistics that were reported were age, height, weight, and BMI. Other data that was collected for the variables were heart rate, percentage VO_2, and Rate of Perceived Exertion. Paired t-tests were used to compare the pre-test and post-test results for each individual variable. VO_2 measurements were compared using repeated measures analysis of variance (ANOVA). All hypotheses were tested at the probability of $p \leq .05$.

CHAPTER IV

RESULTS

Introduction

The purpose of this study was to determine if there were any significant differences between the exponential decay taper and the step taper to determine the benefits to an athletes' performance. The null hypothesis of this study was there is no difference between the exponential decay taper group and the step taper group in reference to Heart Rate, Rate of Perceived Exertion, and VO_2 max across time.

Participants Demographics

Participants who qualified for the study were randomly assigned to the exponential decay taper group or the step taper group. At the beginning of the study forty (40) active recreational middle-distance runners (ages 18-60) participated in the study. Ten (10) men and 9 women completed the study (ages 28 ±11.04 years). All subjects that completed the study had no adverse affects. Table 5 contains the descriptive data for all 19 participants in the study. The mean BMI (24, ± 4.35) classifies the average individual in the study as Normal, by ACSM guidelines. The mean height was 68.39 ± 3.62 inches and the mean weight was 159.42 ± 28.12 pounds.

Table 5

Participant Demographics (n = 19)

Variable	M	SD
Age	28	± 11.04
Height (inches)	68.39	± 3.62
Weight (pounds)	159.42	± 28.12
BMI	24	± 4.35

Exponential Taper Group

There were 11 subjects participated in this group. Out of the 11 subjects in the exponential taper group, 4 individuals trained for a 5k while 7 individuals trained for a 10k. All subjects completed the testing at baseline, pre-test, and post-test sessions. Therefore, because this study was to compare the two groups on exercise performance over the taper, those 11 participants who completed the testing were used in the analysis of the exponential decay taper group.

Step Taper Group

There were 8 subjects participated in this group. Out of the 8 subjects in the exponential taper group, 6 individuals trained for a 5k while 2 individuals trained for a 10k. All subjects completed the testing at baseline, pre-test, and post-test sessions. Therefore, because this study was to compare the two groups on exercise performance over the taper, those 8 participants who completed the testing were used in the analysis of the step taper group.

Data Results for RPE

The information in Table 6 describes the RPE data from the treadmill tests conducted during the pre-test. The RPE was gathered using Borg's Rate of Perceived Exertion Scale ranging from 6-20. The mean values of the RPE were not significantly different during each of the first three stages of the Bruce Protocol Test (Figure 2) using $p \leq .05$. The fourth stage showed a significant difference between the exponential decay taper group and the step taper group.

<u>Table 6</u>

*Pre- Test, t-Test: RPE (Stages 1-4**)*

Taper		N	Mean	Std. Dev.	t	p
Stage 1	Exp	11	8.73	0.91	-0.048	0.632
	Step	8	8.75	1.17		
Stage 2	Exp	11	10.64	1.21	-0.680	0.394
	Step	8	11.00	1.07		
Stage 3	Exp	11	13.27	0.91	-1.648	0.141
	Step	8	14.25	1.67		
Stage 4	Exp	9	15.56	1.33	-0.610	.025*
	Step	5	16.20	2.68		

* Indicates significance at P ≤ .05
** According to the Borg Scale

<u>Table 7</u>

*Post- Test, t-Test: RPE (Stages 1-4**)*

Taper		N	Mean	Std. Dev.	t	p
Stage 1	Exp	11	8.64	1.21	1.087	0.107
	Step	8	8.13	0.64		
Stage 2	Exp	11	10.64	1.21	-1.039	0.032*
	Step	8	11.13	0.64		
Stage 3	Exp	11	13.27	0.79	-0.501	0.312
	Step	8	13.50	1.20		
Stage 4	Exp	9	15.67	1.32	-1.674	0.239
	Step	7	17.14	2.20		

* Indicates significance at P ≤ .05
** According to the Borg Scale

The information in Table 7 describes the RPE data from the treadmill tests gathered during the post-test time period. The mean values for all stages 1, 3, and 4 were not significantly different. Stage 2 was significantly different between the step taper group and the exponential taper group. The significance was predetermined at $p \leq .05$.

Data Results for Heart Rate

The data in table 8 describes the differences in heart rate during the pre-test period. There were no significant differences between the exponential decay taper group and the step taper group in stages 3 and 4. There was a significant difference in stages 1 and 2 between the exponential decay taper group and the step taper group. Significance was predetermined at $p \leq .05$.

Table 8

*Pre- Test, t-Test: HR bpm (Stages 1-4**)*

Taper		N	Mean	Std. Dev.	t	p
Stage 1	Exp	9	107.22	15.06	0.563	0.034*
	Step	7	103.71	7.41		
Stage 2	Exp	9	127.33	22.25	0.229	0.043*
	Step	7	125.14	13.50		
Stage 3	Exp	9	155.67	19.77	-0.349	0.231
	Step	7	158.86	15.72		
Stage 4	Exp	8	176.50	12.82	-0.598	0.105
	Step	5	180.60	10.50		
* Indicates significance at P ≤ .05 ** According to the Borg Scale						

The data in Table 9 depicts the differences in heart rate during the post-test period during the four stages. The significance was $p \leq .05$. From this data, there were not any significant differences between the exponential decay taper group and the step taper group.

Table 9

*Post- Test, t-Test: HR bpm (Stages 1-4**)*

Taper		N	Mean	Std. Dev.	t	p
Stage 1	Exp	8	107.75	15.80	-0.019	0.134
	Step	8	107.88	9.55		
Stage 2	Exp	9	127.67	18.65	-0.842	0.656
	Step	8	135.38	19.07		
Stage 3	Exp	9	158.11	18.87	-0.217	0.448
	Step	8	160.00	16.78		
Stage 4	Exp	8	175.75	10.44	-0.676	0.958
	Step	7	179.71	12.07		

* Indicates significance at P ≤ .05
** According to the Borg Scale

VO_2 Max

Figure 4 depicts the marginal means of VO_2 between the exponential decay taper group and the step taper group across time. Table 10 describes the differences in VO_2 max values over time. The data was derived using repeated measures analysis of variance (ANOVA). There were not any significant differences between the exponential decay taper group and the step taper group across time. The significance was predetermined at $p \leq .05$.

Figure 4 – Estimated Marginal Means of VO_2 max

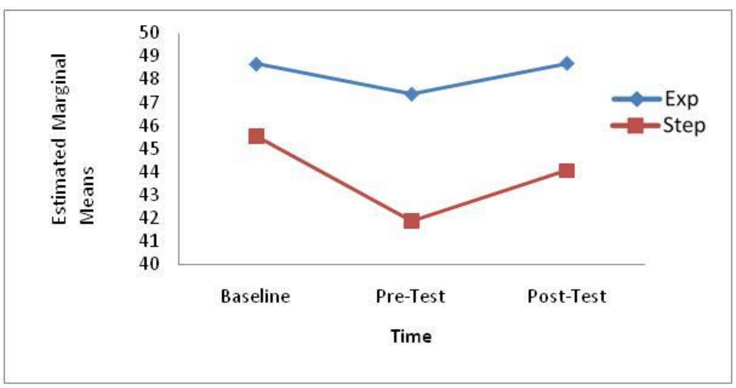

Table 10

Repeated Measures ANOVA: VO2 max (ml/kg/min)

		Time		
		Base	Pre-Test	Post-Test
Taper	Exponential	48.673	47.373	48.709
	Step	45.550	41.875	44.050

	SS	df	ms	F
Taper	272.2	1	272.2	1.21
error	3803.4	17	223.7	
Time	60.5	2	30.2	2.15
Time x Taper	13.4	2	6.7	0.48
error	478.3	34	14.1	
Total	4627.8	56		

.

Summary

Participation in either taper group indicated no benefit to the other. For the hypotheses proposed, this study confirms the null hypothesis in that there would be no difference between the groups in RPE, HR, and VO_2 across time.

CHAPTER V

DISCUSSION

The focus of this study was to determine if there were any differences in the type of taper performed prior to competition to reap the most benefits. The null hypotheses stated that there is no difference in RPE, HR, and VO_2 max across time between the exponential decay taper group and the step taper group.

The importance of taper research studies such as the current study is to improve the way athletes train prior to competition. The variables of frequency, volume, duration, intensity, and the type of taper performed all have an impact on the body and its responses to training. Banister et al. first examined the optimal taper for aerobic and anaerobic events and the results indicated that an exponential taper resulted in greater power than a step taper (Wilson & Wilson, 2008). Even though this result was common, there are many ways to manipulate the variables to get another result. For example, Thomas et al. also examined tapering formats for inexperienced athletes and found no difference with normal training but a 1% greater performance gain when the participants had overreached (Wilson & Wilson).

Summary of Study

This study involved participants who were randomly assigned to either the exponential decay taper group or the step taper group. Each participant was asked to workout 3 days a week for 30-45 minutes each day. They were then required to complete a one week designated taper. Participants (n = 40) who qualified for the study were assigned to either the exponential decay taper group or the step taper group. This study was conducted using the Statistical Package for the Social Sciences 17.1 (SPSS) with a pre-determined alpha set at ($p \leq .05$). The specific data analysis technique that was utilized was Levene's Test for equality of Variances (t-test) and Repeated Measures of Analysis of Variance (ANOVA).

The exponential taper group had 11 participants complete the Bruce Protocol Treadmill Test at the three designated testing periods (baseline, pre-test, and post-test) which were used in data analysis. The step taper group had 8 participants complete the Bruce Protocol Treadmill Test at the three designated testing periods which were used in the data analysis.

RPE Comparison

A visual inspection of the data outcomes shows that there was only one significant difference in RPE between the step taper and the exponential taper groups in the 4^{th} stage of the pre-test and stage 2 of the post-test (Table 6). This data neither supports nor rejects previous research on ratings of perceived exertion across time. Bukworth et al. (2004) found no significant differences among the different stages of change and RPE on exercise. Variables that may have an effect on RPE could include the stress placed on the participants outside of the study and sickness.

Heart Rate Comparison

The data depicts significant differences in heart rate between the step taper and the exponential taper group in stages 1 and 2 in the pre-test. There were not any significant differences in the post-test. This refutes current research in that heart rate will decrease over time with exercise. Smith (2003), states that one of the most pronounced cardio respiratory adaptations to exercise is a reduced heart rate. The lack of support for the current research findings could be due to a couple variables. While these athletes are already recreational runners their heart rate values may already have been adjusted to exercise. Not only could the participants’ level of exercise play a role but the length of the study: If the study was longer, a more significant difference in heart rate values might have shown up.

VO_2 Comparison

The previous data from the exponential decay taper group and the step taper group found insignificant differences in VO_2 max. While, this may have been a contrast to previous studies, it depicts that short-term training and tapers are not effective in nature. Mujika et al. (2004) suggests that an optimal taper will be produced with a prior training duration of over 10 weeks.

In comparison of the step taper and exponential taper group across time, the data suggests that there was not any significance in the recovery (Figure 2). This data does not support previous research in that a consensus among studies with tapers find the exponential or progressive tapers more beneficial to the athlete.

Lack of Significant Findings

During the course of the study many variables that affected the outcome became noticeable. The number of variables that may have taken place in the participant could deduce the lack of significant findings. Such variables include weather, allergies, sickness, injuries, stress upon the individual, and the length of training. Not only were the outside parameters an effect but indoor parameters were also significant. Indoor parameters involved the lack of comfort wearing the mask, lack of comfort on the treadmill, and the familiarity with the testing protocol.

Conclusion

Even though the study provided insignificant results it can still be used for further research. This study only resembled one other study in past research which was on middle distance recreational runners in a 6 day taper period (Mujika et al., 2000). Much research should be analyzed in a non-clinical setting to attract more reliable results.

Recommendations

1. It is recommended that the study be conducted over a longer period of time and with multiple trials.
2. It is recommended that the study be conducted in an actual setting that can include more than one sport, i.e. swimming, cycling, and running.

3. By testing physiological factors the research can be used to find underlying factors that are not normally presented in the taper variables.
4. By using more participants the data will be less construed and produce a better reliability of the athletic population.

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APPPENDICES

Appendix A

Institutional Review Board Approval

Oklahoma State University Institutional Review Board

Date: Wednesday, November 04, 2009

IRB Application No ED09128

Proposal Title: Analysis on Two Different Tapers on Exercise Performance

Reviewed and Processed as: Expedited

Status Recommended by Reviewer(s): Approved Protocol Expires: 11/3/2010

Principal Investigator(s):

Christina Rial
P.O. Box 2596
Stillwater, OK 74076

Douglas Smith
197 Colvin Center
Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

X The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia Kennison, Chair
Institutional Review Board

Appendix B

Informed Consent

Written Copy of Informed Consent to be provided to all Subjects

RESEARCH PARTICIPANT CONSENT FORM

"Analysis of Two Different Tapers on Exercise Performance"

Principal Investigators
Christina Rial and Douglas B. Smith, PhD.

Oklahoma State University
Department of Health, Leisure, and Human Performance

The present investigation will determine which taper is better suited for gains in exercise performance in recreational runners. Research has suggested that the exponential decay taper results in better performance gains than the step taper. Our purpose is to determine if this research is coherent with our study. The participant will be asked to train and taper according to either a step or exponential decay taper. The participant will be observed by observation and measurement. The participant will have a baseline, pre-test, and post-test to determine the differences in measurements by a Bruce Treadmill Test. The participant will be required to run 3 days a week for 5 weeks with two additional weeks of testing. Running shoes will be necessary.

Purpose of Research

The participant understands that the purpose of this research is to determine the differences on endurance performance between the step taper and exponential decay taper for recreational runners. The participant is participating in the study with the understanding that for the research to be concluded, analysis of their performance will be calculated. Information that will be collected includes their baseline, pre-test, and post-test values for maximum oxygen consumption, heart rate, respiratory exchange ratio, rate of perceived exertion, and blood pressure.

Procedures

- The participant understands the tasks required are as follows:
- Complete physical activity readiness questionnaire and informed consent forms.
- Allow examination of cardiovascular capabilities on a Bruce Treadmill Protocol test.
    - A Bruce Treadmill Protocol test is a protocol developed to analyze maximum oxygen consumption. The test has 5 stages in which percent grade and speed will increase at each stage. She/he will be asked to work at maximum potential.

- Perform a baseline, pre-test, and post-test.
    - All testing assessments will be completed in the Applied Musculoskeletal & Human Physiology Research Laboratory in the Department of Health and Human Performance at Oklahoma State University.
- Train 3 days a week for 30-45 minutes each day for 4 weeks with a 1 week taper.
- The total time involvement for the study will be 7 weeks.
- Have 3 individual interactions with the investigators during the study.
- Discomforts that may be experienced include soreness.

Risk of Participation

The participants will be required to participate in an exercise regimen. There is a moderate risk of physical injury and soreness with training. The risk will be alleviated with the monitoring of exercise intensity and adaptation to exercise regimen. All investigators are certified in CPR/First Aid.

The participant understands the risk associated with this study and voluntarily chooses to participate. The participant certifies to the best of their knowledge they are in good physical condition and are able to participate in this study. The participant understands that in case of injury or illness resulting from this study, emergency medical care is available through community health care providers by dialing 911. In addition, Oklahoma State University Health Services Center is available for all OSU students. The participant understands that no funds have been set aside by Oklahoma State University to compensate them in event of illness or injury.

Benefits to the Individual

Subjects will gain knowledge regarding a cardiovascular training program as well as the effects of the taper on the body. Potential benefits include improved cardiovascular function, decreased resting heart rate, increased bone mineral density, improved oxygen consumption, and improvements in body composition.

Confidentiality

To protect confidentiality, each participant's files will be coded with a number and filed in a locked cabinet in CRC 117. The data will only be available to researchers and individuals responsible for research oversight. After completion of the study, all paperwork detailed with names and ID numbers will be shredded. The names of the participants will not be used in any way in the presentation of the material. All data will be reported as means and standard errors. For added protection, the OSU IRB has the authority to inspect consent records and data files to assure compliance with approved procedures.

Compensation

No compensation will be offered for this study.

Voluntary Nature of Participants

The participant understands that participation in this research project is voluntary and they can withdraw their involvement in the study at any time without penalty.

Contact Statement

If the participant should have any questions about their rights as a research volunteer, they may contact Dr. Sheila Kennison, IRB Chair, 219 Cordell North, Oklahoma State University, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu. If they need any additional information concerning the study contact: Doug Smith, 197 CRC, Oklahoma State University, Stillwater, OK 74078, 405-744-5500, or Christina Rial, P.O. Box 2596, Stillwater, OK 74076, 405-264-3890.

Signatures

The participant has read and fully understands the consent form. The participant signs it freely and voluntarily. A copy of this form has been given to them.

______________________________ ____________________ _____________

Signature of Participant Date Date of Birth

As the researcher, I certify that I have personally explained this document requesting that the participant sign it.

_____________________________ ____________________

Signature of Researcher Date

Appendix C

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE

Regular physical activity is fun and healthy, and increasingly more people are becoming more active every day. Being more active is very safe for most people. However, some people should check with their doctor before becoming much more physically active.

If you are planning to become more physically active than you are now, start by answering the following seven questions below. If you are between the ages of 15 and 69, these questions will tell you if you should check with your doctor before you start.

COMMON SENSE IS YOUR BEST GUIDE WHEN ANSWERING THESE QUESTIONS. PLEASE READ EACH CAREFULLY AND CIRCLE YES OR NO.

YES NO 1. Has your doctor ever said that you have a heart condition and that you should only do physical activity as recommended by a doctor?
YES NO 2. Do you feel pain in your chest when doing physical activity?
YES NO 3. In the past month, have you had chest pain when not doing physical activity?
YES NO 4. Do you lose your balance because of dizziness or do you ever lose conscienseness?
YES NO 5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?
YES NO 6. Is your doctor currently prescribing drugs (for ex., water pills) for your blood pressure or heart condition?
YES NO 7. Do you know of any other reason why you should not do physical activity?

IF YOU ANSWERED YES TO ONE OR MORE QUESTIONS
Talk to your doctor by phone or in person BEFORE start becoming more physically active. Tell your doctor about this questionnaire and about which questions you answered yes. You may be able to do any activity you want as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are deemed safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.

IF YOU HONESTLY ANSWERED NO TO ALL QUESTIONS
You can be sure that you can start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.

I have read, understood, and completed this questionnaire. Any question I had was answered to my full satisfaction.

Name:______________________________ Date:______________________________

Signature:__________________________ Witness:____________________________

Appendix D

Script

Analysis of Two Different Tapers on Exercise Performance

Hi, my name is Christina Rial and I'm here to present an opportunity for you. I am a Masters student in Exercise Science completing a study on middle distance recreational runners. So, I'm here to ask for volunteers for my study.

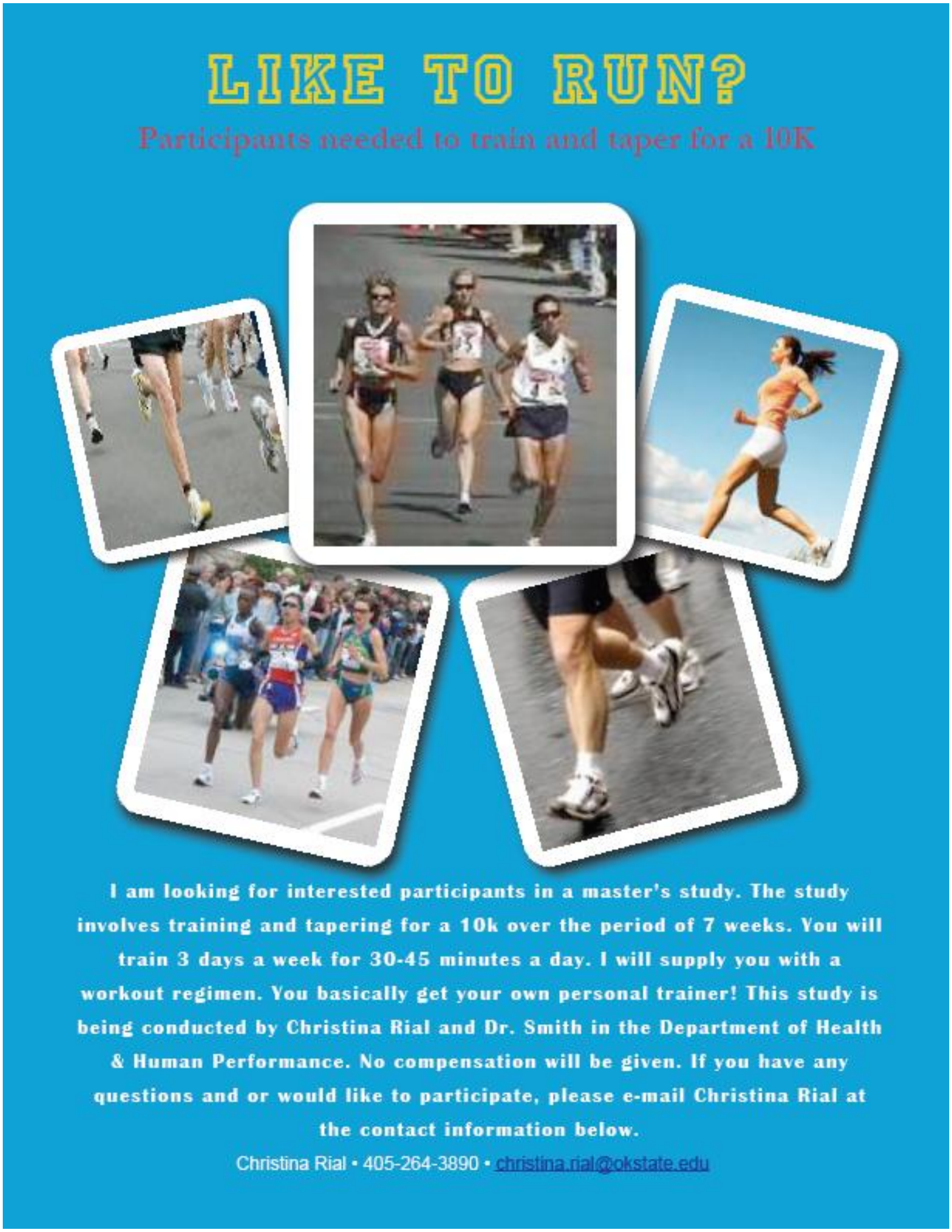
The purpose of this study is to determine the differences in the step taper and exponential decay taper in middle distance runners on exercise performance. I am looking for volunteers that currently run recreationally. However, athletes and novices will not be able to participate in this study.

During the study you will baseline test on a treadmill. You will then train 3 days a week for 30-45 minutes each day for 4 weeks. Following this, you will pre-test again and then be divided into one of two groups. Within the selected group you will complete a specific 1-week taper and then post-test. The total time of involvement will be 7 weeks.

I will provide the workouts for you to follow each week. You do not need to change your current diet or resistance-training regimen. There will not be any compensation. However, benefits of the study include reduced resting heart rate, improved VO2 max, increased bone density, and improvements in body composition. If you are interested please let me know. I will have sign-up sheets outside of my office at CRC 117 and in CRC 180 (see Sherri Longan). Are there any questions?

Appendix E

Flyer



VITA

Christian Virginia Rial

Candidate for the Degree of

Master of Science

Thesis: THE ANALYSIS OF TWO DIFFERENT TYPES OF TAPERS ON EXERCISE PERFORMANCE

Major Field: Health and Human Performance: Option in Applied Exercise Science

Biographical:

Education:

Completed the requirements for the Master of Science at Oklahoma State University, Stillwater, Oklahoma in May, 2010.

Completed the requirements for the Bachelor of Science in Exercise Science at Oklahoma City University, Oklahoma City, OK in 2007.

Experience:

Graduate Assistant, Oklahoma State University, Department of Leisure, Aug 2008-Present.
Center Staff, Seretean Wellness Center O-Zone Fitness Center, Stillwater, OK, Jan 2009 – Present.
Intern for Cardiac Rehab, Total Health, Stillwater, OK, May 2008 - July 2008.
Stillwater Parks and Recreation, Stillwater, OK, May 2009-Aug 2009.
Oklahoma City Parks and Recreation, OKC, OK, May 2004-Nov 2007.
Lifeguard & Swim Instructor, Program Specialist (OKC only) May 2007-Nov 2007, Supervisor (OKC only) May 2005- Aug 2005.

Professional Memberships:

American College of Sports Medicine
Oklahoma Applied Health, Physical Education, Recreation, and Dance
American Society of Exercise Physiologists.

Name: Christina Rial Date of Degree: May, 2010

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: THE ANALYSIS OF TWO DIFFERENT TAPERS ON EXERCISE PERFORMANCE

Pages in Study: 45 Candidate for the Degree of Master of Science

Major Field: Health and Human Performance

Scope and Method of Study: Athletes depend on tapers to allow repair and rest for the individual prior to competition. Many variables affect the performance of a taper. These variables include volume, intensity, duration, frequency, and the type of taper. The type of taper may include a step taper, progressive taper, or exponential decay taper. Manipulation of these variables may be the best accommodation for the athlete. The purpose of this study is to compare the differences in a step taper and an exponential decay taper across time. The variables that are statistically studied are heart rate, rate of perceived exertion, and VO_2 max at the pre-test and post-test periods. Nineteen subjects volunteered and participated in the study (age 24 ±11.04 years). The subjects were divided into two groups; the step taper group (n=8) and the exponential decay taper group (n=11). The participant's baseline tested, trained for a middle-distance run for 4 weeks, and pre-tested. The participants were then randomly assigned to one of the groups and performed the one week designated taper. Following the taper was a post-test period.

Findings and Conclusions: There was a significant difference in stage 4 (Brue Protocol Test) in the pre-test and stage2 in the post-test periods for RPE comparisons($p \leq .05$). There was also a significant difference in stages 1 and 2 of the pre-test in regards to submax HR values. VO_2 max values did not show any statistical significance across time. According to this study, the statistics show there is no significant benefit to either taper. In previous research, there has been evidence that an exponential decay taper is more beneficial to a step taper. More research should be analyzed to compare the variables. It is recommended that the study be conducted over a longer period with multiple trials. The study should be conducted in a real setting rather than a clinical one. The taper should also compare more than one endurance event such as swimming, running , and cycling. An increase in participant numbers would produce a better reliability of the athletic population.

ADVISER'S APPROVAL: Dr. Doug B. Smith