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An Analysis of Resistance Training History in Ultramarathon Runners and Implications on Performance

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AN ANALYSIS OF RESISTANCE TRAINING HISTORY IN ULTRAMARATHON RUNNERS AND IMPLICATIONS ON PERFORMANCE

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PURPOSE: Identify current resistance training practices in ultramarathon runners participating in Eastern States 100 and determine the relationship between resistance training practices and pace. METHODS: A resistance training history survey was completed by 44 registered runners and time of arrival was collected at each aid station. RESULTS: Of the 24 finishers, 11 participants resistance trained, and 13 participants did not resistance train. Of the 20 non-finishers, 13 participants resistance trained, and 7 participants did not resistance train. A T-Test demonstrated that within the group of 21 finishers who had complete data, there was no significant difference ($p = 0.191$) in overall pace or in the last five splits between participants who resistance trained and who did not resistance train. CONCLUSION**:** This investigation offers insight to resistance training practices of ultramarathon runners and illustrates no significant difference in ultramarathon performance between those who resistance train and those who do not.

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CHAPTER I

INTRODUCTION

Background

An ultramarathon is a running event that exceeds a distance of 26.2 miles. There were over 304 ultramarathon events in the United States in 2016 at distances ranging from 28.4 miles to 200 miles. Hoffman et al. (2010) reported an increase in ultramarathon participation nationwide and worldwide. With this increase, questions are presented regarding the physiological demands that pertain to running economy and the adaptations needed to meet these demands. Running economy is a broad term that encompasses four components of physiology; biomechanics, metabolism, neuromuscular activation, and the cardiorespiratory system. Many physiological mechanisms contribute to each component. Thus, it is necessary for ultramarathon runners to maximize specific physiological adaptations that contribute to running economy in order to benefit performance.

Sheppard et al. (2016) of the National Strength and Conditioning Association (NSCA) classifies the performance of 12 repetitions or greater as muscular endurance, 6-12 repetitions as hypertrophy, 1-6 repetitions as strength, and 1-5 repetitions as power. When performing resistance training exercises within a specific repetition range to volitional fatigue, distinct cardiovascular, metabolic, and neuromuscular adaptations occur that can affect performance. A lower intensity training program, such as training for muscular endurance, may aid in maintaining consistent muscular contraction, lessening fatigue throughout the event, and improving vascular function. However, a higher intensity program, such as a strength program that is closer to maximal effort, may produce the ability to produce a greater muscular force to maintain stride length, a greater ability to sprint at the end of an event to improve pace, and increased left ventricular cardiac contraction.

Nevertheless, a lack of understanding still exists pertaining to resistance training habits and tendencies of runners in preparation for ultramarathons. For example, a study conducted by Hoffman et al. (2013) examined aerobic training history in current and previous ultramarathon runners but acquired minimal information about resistance training history. With little current research regarding the prevalence of resistance training in this population, it is necessary to gain fundamental understanding of current training techniques and methods.

The purpose of this investigation was to identify current resistance training practices in ultramarathon runners participating in the Eastern States 100, an annual ultramarathon that takes place through the Appalachian trails of Pine Creek State Park in Waterville, Pennsylvania. Secondly, this study explored the relationship between resistance training practices and pace throughout an ultramarathon.

Problem Statement

Numerous studies have demonstrated the importance of physiological adaptations made through aerobic training in ultramarathon athletes and implications on performance. However, no investigations have looked at the effects of resistance training programs on race performance in ultramarathon runners. Lastly, there are no existing scholarly guidelines addressing an effective resistance training periodization for ultramarathon runners.

Significance of Study

Ultramarathon participation is increasing nationwide and worldwide, and it is important to address the lack of understanding in resistance training periodization for ultramarathon runners. This study is a fundamental analysis of current resistance training practice in ultramarathon runners and implications on ultramarathon performance.

Research Questions

1. What is the difference in prevalence of resistance training in those who complete ES100 and those who do not complete ES100?
2. Is there a difference in pace of the last three splits of an ultramarathon in runners who resistance train and runners who do not resistance train?

Hypotheses

1. There will be a greater prevalence of resistance training in those who complete ES100 as compared to those who do not complete ES100.
2. Ultramarathon runners who resistance train as part of their overall training program will present a faster pace in the last five splits of an ultramarathon.

Limitations

1. A cohort was used rather than a simple random sample.
2. There was an underrepresentation of females, thus results were not generalizable.
3. It was not well established how many ultramarathon runners at ES100 resistance train.
4. Of 230 registered runners, 44 volunteered to participate in this study; a small sample size may have misrepresented the entire population and is not generalizable.

Assumptions

1. Participants were honest when completing the survey.
2. The inclusion criteria of completion of two ultramarathons prior to study participation was appropriate in assuring running experience was equivalent.

Definition of Terms

Metabolism – all chemical processes within the body that are required to maintain life.

Neuromuscular activation – the nervous and musculoskeletal systems working together to create muscle contraction.

Cardiorespiratory system – the cardiovascular and respiratory systems working together to uptake, transport, and deliver oxygen to the working muscles.

Muscular endurance – the ability of a muscle to exert a force repeatedly without the accumulation of fatigue.

Strength – the ability of a muscle to exert a maximal force.

Aerobic exercise – exercise that uses oxygen to supply the oxidative metabolic pathway.

Arterial vasoconstriction – the reduction in arterial diameter in response to vascular contraction.

Nitric Oxide – a chemical compound that causes vasodilation.

Systolic blood pressure – the force exerted on an artery by the blood when the heart contracts.

Diastolic blood pressure – the force exerted on an artery by the blood when the heart relaxes.

End-diastolic volume – the volume of blood in the left ventricle at the end of the resting phase between contractions.

Anaerobic training – exercise that requires the use of metabolic pathways without the presence of oxygen.

Intensity – percentage of maximal effort.

Respiratory exchange ratio (RER) – the ratio between the volume of carbon dioxide being produced and oxygen being consumed.

Mitochondrial density – the size and number of mitochondria within a cell.

Mitochondrial biogenesis – the increase in mitochondrial size and the number of mitochondria within a cell.

Fat oxidation – lipid metabolism in the presence of oxygen.

Cardiac stroke volume – the volume of blood pumped from the left ventricle of the heart per beat.

Cardiac output – the volume of blood that travels through the heart within one minute.

VO_{2max} – maximum amount of oxygen utilized by the body during exercise.

Anaerobic speed – absolute maximal speed that uses the glycolytic energy system.

CHAPTER II

REVIEW OF LITERATURE

General and Performance Implications of Aerobic Training

The cardiorespiratory system consists of the lungs, heart, and blood vessels; this system is responsible for the oxygenation of blood, transportation of blood to muscles and organs, and oxygen diffusion. Oxygen is diffused passively from the alveoli to the blood stream and is transported within the blood via hemoglobin down a pressure gradient where facilitated diffusion occurs at the capillary to the working muscle. Also at the capillary site, carbon dioxide diffuses from the muscle to the blood stream where it is transported through the blood to the alveoli to be exhaled. Vasoconstriction and vasodilation are mechanisms that can enhance or impede blood flow to the working muscle. For example, sympathetic vasoconstriction is necessary to shunt blood away from non-working muscles so that it can be used elsewhere that more blood and oxygen are required, whereas vasodilation is necessary to increase blood flow to the working muscle. However, increased sympathetic activity causes vasoconstriction within the arteries transporting blood to the working muscles. Metabolic factors at the local site of an artery combat the sympathetic vasoconstriction and cause vasodilation. This mechanism is known as functional sympatholysis. At the onset of exercise, arterial vasoconstriction in the periphery occurs to maintain arterial blood pressure.

Aerobic training has been associated with an increase in arterial dilation capacity and vascular health in general. Tinken et al. (2008) demonstrated a significant change in arterial dilation capacity in the popliteal artery for the last six of eight weeks in an aerobic training intervention in 20 recreationally active young men. Change in vessel dilation that is dependent on the volume of blood flow, also known as flow mediated dilation, significantly increased in the second through sixth week of the intervention. Improvements have been demonstrated in recreationally active men; however, changes in arterial properties pertaining to arterial compliance through hypervolemia have not been examined in ultramarathon participants.

Many physiological adaptations resulting from aerobic training enhance blood flow. One adaptation to aerobic training is hypervolemia, an increase in blood volume. According to Green et al. (1990), cycling at an intensity of 65% VO_{2max} for two hours on three consecutive days has been shown to increase blood plasma levels, decrease heart rate, and increase stroke volume in seven college aged males. Implications from this study are that hypervolemia is associated with improved cardiorespiratory function and thus may enhance aerobic performance. Lee et al. (2016) conducted a study to determine the differences in cardiac structure and function between a healthy sedentary control group and a group of recreational swimmers who performed swimming exercises for at least one hour, four days per week, for the past five years. Results found that internal ventricular dimensions and end-diastolic volume were greater in the swimming group than the sedentary group. A greater end-diastolic volume demonstrates a greater venous return, a more effective alignment of cardiac muscle fibers due to a greater pre-load. End-systolic volume was shown to be lesser in the swimming group than the control group, demonstrating a higher ejection of blood from the left ventricle and more blood transportation to the working muscles. According to the Frank-Starling law, a greater end-diastolic volume and lesser end systolic volume will result in a greater stroke volume and cardiac output. Thus, long term aerobic training is beneficial in eliciting cardiovascular adaptations that enhance oxygen delivery and heart health. Although it has been established that aerobic training increases left ventricular volume and improves diastolic and systolic function, acute left ventricular dysfunction has been identified in ultramarathon runners immediately upon completion of an event. Shave et al. (2002) examined left ventricular systolic and diastolic function of 11 male ultramarathon participants via echocardiography prior to competition and immediately following completion. Characteristics of cardiac dysfunction were observed in 10 of the 11 participants immediately following the ultramarathon event. Systolic blood pressure, diastolic blood pressure, stroke volume, and ejection fraction were all significantly lower than baseline values collected prior to running. Heart rate was significantly higher than baseline value prior to racing. The results of this study suggest that even though aerobic training may enhance cardiorespiratory function, ultra-endurance modes of competition may acutely decrease cardiorespiratory function. However, it is unknown how participation in ultramarathons effect chronic cardiorespiratory function.

In addition to cardiovascular adaptations, musculoskeletal and metabolic adaptations also occur with aerobic training. Hawley et al. (1996) demonstrated that a 7-week high intensity interval training (HIIT) intervention of six to nine 5:1 work/rest ratio bouts on a cycle ergometer improved cycling performance. First, power output was significantly increased by 15-20 Watts within 3 weeks of implementation. However, following the initial 3 weeks of implementation, there were no further improvements in power output. Secondly, absolute and relative work rate were both significantly improved, meaning a higher rate of work was sustained for a greater duration. Third, there was a shift in metabolic substrate dependence at the same absolute cycling workloads. Fat utilization increased whereas carbohydrate utilization decreased. Therefore, glycogen depletion may be deferred for a greater period of time and fatigue may be delayed. Lastly, metabolic enzyme activity was heightened as a result of this study. Specifically, hexokinase and phosphofructokinase; two enzymes that aid in the primary stages of glycolysis. The physiological adaptations acquired through HIIT may be advantageous to ultramarathon athletes to enhance performance through improvements in increased power output, increased work rate, decreased reliance on carbohydrates, and improvements in glucose usage to preserve glycogen.

Despite many beneficial physiological adaptations acquired through aerobic training, the lack of resistance training within a program may ultimately result in decreased ability to reach performance potential.

Running Economy

Running economy is a concept that encompasses all biomechanical, neuromuscular, cardiorespiratory, and metabolic properties utilized in submaximal running. According to Saunders et al. (2004), running economy is determined by assessing the energy needs at a given velocity of submaximal running through measurement of volume of consumed oxygen (VO_2) and respiratory exchange ratio (RER). Running economy is comprehensive and can be affected by numerous genetic characteristics and physiological adaptations. A 100-mile ultramarathon requires all economic factors to work efficiently together to maximize performance. Without efficiency within each component of running economy, it may be difficult to maintain performance for the duration of the event. Each component of running economy can be altered by adaptations made through resistance training, which may aid or hinder running abilities depending on methods utilized.

Neuromuscular factors include neural signaling, muscle force production, and power production. A study by Kyröläinen et al. (2001) concluded that increased electromyography activity in skeletal muscle and power production may account for part of the increased energy expenditure with increasing running velocity. Thus, increased strength may decrease exertion to produce the same force against the ground to propel forward. Strength may be increased via resistance training and has additional implications on running economy. A study by Millet et al. (2002) demonstrated no significant difference in triathletes in strength, hopping power, VO_2, or running economy prior to implementation of intervention. After 14 weeks, there was a significant difference in strength, hopping power, and running economy between triathletes who resistance trained at a frequency of two sessions per week for 14 weeks in addition to endurance training as compared to their counterparts who solely endurance trained. In addition, there was no significant difference found in VO_2. Hopping power was moderately correlated to running economy. Resistance training has been shown to be beneficial in improving running economy when supplemented to an aerobic training program. Mikkola et al. (2011) recruited 27 male recreational runners. All participants performed the same marathon training program, but were separated into a heavy resistance training group (n=11), an explosive resistance training group (n=10), and a muscular endurance resistance training group (n=6). Prior to intervention, maximal strength, muscle activation, jump height, maximal anaerobic speed, and maximal endurance running were assessed. 8 weeks of heavy resistance training supplementation significantly increased maximal strength, muscle activation, jump height, and maximal speed in anaerobic running, and maximal endurance running. Explosive resistance training contributed to significant increases in maximal strength, muscle activation, and maximal endurance running. Muscular endurance resistance training significantly improved maximal running endurance, but did not significantly affect other performance markers. Heavy and explosive resistance training were shown to improve neuromuscular characteristics, and physiological adaptations were made in response to heavy resistance training that improve high-intensity running. Anaerobic speed is known as absolute maximal speed that uses the glycolytic energy system. This differs from maximal aerobic speed which is the speed at which the oxidative system is the primary energy pathway being used. Anaerobic speed can be utilized in sprinting to the finish line at the end of an endurance event and may be enhanced through heavy resistance training.

Metabolic factors include mitochondrial density, substrate usage, lactate threshold, and muscle fiber type. According to Lundby et al. (2015), mitochondrial density increases with muscle contraction through aerobic training. A higher mitochondrial density has been shown to increase fat oxidation and decrease reliance on glycogen to produce ATP. A study conducted by Gollnick et al. (1972) demonstrated that an increase in mitochondrial density only appears in the muscle fibers recruited during exercise. Supporting this concept, Dudley et al. (1982) established that mitochondrial density will increase in type II fibers if interval training is implemented and type II fibers are recruited. In addition to interval training, resistance training can also play a role in increasing mitochondrial density. A study conducted by Wang et al. (2011) evaluated mitochondrial biogenesis after two separate exercise sessions. The first session included aerobic exercise, and the second session separated by 2 to 4 weeks consisted of aerobic training followed by six sets of leg press at 70 to 80% maximum effort. Results demonstrated that resistance training will heighten molecular signaling of mitochondrial biogenesis that is stimulated by endurance training. This concept is important because fat oxidation takes place within the mitochondria. An increase in mitochondrial density implies that fat oxidation will be more efficient, and this could prolong the use of muscle and liver glycogen.

General Implications of Resistance Training

Anaerobic training, including resistance training, also elicits cardiovascular adaptations that are advantageous for ultramarathon runners. Resistance training may enhance blood flow in competition and ultimately improve running economy and performance. A study conducted by Davis et al. (2008) investigated 30 female and 20 male collegiate athletes. Females underwent intervention 3 times per week for a duration of 11 weeks, and males underwent intervention 3 times per week for a duration of 9 weeks. 50% of the females and 50% of the males were randomly assigned into a serial concurrent exercise group, and the remainder of participants were randomly assigned into an integrated concurrent exercise group. The serial concurrent group performed resistance training exercise and then aerobic exercise, whereas the integrated concurrent exercise group performed aerobic exercise between sets of resistance training exercises. Prior to program implementation, one-repetition maximum (1RM) tests and number of correct repetition at 50% max tests were performed to program resistance accordingly. Resting heart rate and blood pressure were collected in addition to average active heart rate of the first ten sessions in the aerobic training portion. For the duration of implementation, the serial training group performed resistance training (3 sets of 9 exercises), followed by aerobic training at a steady state heartrate, and then static stretching. The integrated group performed one resistance training exercise and then completed a few minutes of steady-state aerobic training. This was repeated until the same volume was achieved as the serial group. Similarly, the integrated group stretched at the end of the session. Post-testing measured the same variables collected in pre-testing, and demonstrated greater cardiovascular adaptations in terms of decreased active heart rate in men and women in the integrated group in comparison to the serial group. Additionally, participants in the integrated training group had a greater reduction in systolic blood pressure than the serial training group, although serial training also produced significantly lower systolic blood pressures as well. Diastolic pressure was significantly lowered in both groups. Both groups showed significant differences in active heartrate and blood pressure, but the integrated concurrent exercise group demonstrated significantly better results. This study demonstrates that concurrent training and aerobic training has positive effects on the cardiovascular system. Furthermore, it demonstrates the need to take sequence of exercise into consideration when programming for an endurance athlete to maximize physiological adaptations to the cardiovascular system.

On the contrary, Miyachi et al. (2004) demonstrated that high intensity resistance training had negative effects on the cardiovascular system. Implementation consisted of resistance training three times per week for four months at 80% one-repetition maximum with a two-minute rest period between each set. After the four months of training, detraining for an additional four months took place. Strength and vascular function was measured every two months of the study. Results determined resistance training was associated with increased thickness in left ventricular cardiac muscle, but arterial compliance was decreased at the end of the resistance training period. A decreased arterial compliance is associated with a higher blood pressure and lower due to a lack of elasticity in the arteries. However, after the four-month detraining period, arterial compliance increased to baseline levels. This compliance decrease during high intensity training and increase in the detraining phase is applicable in periodization to meet physiological needs of ultramarathon runners. For example, it may be beneficial to complete high intensity resistance training in the off-season to improve biomechanical and neuromuscular factors, and decrease intensity in the pre-season. Supporting this periodization model is a study conducted by Okamoto et al. (2011), pertaining to the effects of low intensity resistance training on arterial compliance.

Prior to intervention, arterial compliance was measured. Implementation consisted of resistance training at a frequency of two days per week for ten weeks at an intensity of 50% 1RM. Immediately following the ten weeks, arterial compliance was re-evaluated and results showed improvements in vascular endothelial function and reductions in arterial stiffness. A change in resistance training intensity shifts demands placed on the anaerobic and aerobic metabolic pathways. Thus, as periodization changes in preparation for an ultramarathon, resistance training must also change to make appropriate physiological adaptations to strengthen the heart and improve ability of blood transportation.

Performance Implications of Resistance Training

Resistance training performed at a high intensity elicits anaerobic adaptations that may aid in running performance at the end of an ultramarathon event. A study conducted by Mikkola et al. (2007) examined the neuromuscular and anaerobic effects of concurrent endurance and explosive training in young distance runners. 25 runners were split into either the control group who performed aerobic training or the intervention group, in which 19% of aerobic training was replaced with explosive anaerobic training 3 days per week for 8 weeks. Explosive training consisted of sprinting, jump training, and strength based resistance training. Results of this study demonstrate no change in maximal aerobic running speed, VO_{2max}, or running economy in either group. There were no negative effects from explosive anaerobic training; and even though positive changes were not observed in the previously mentioned variables, there were improvements observed within others. First, the trained group had increased leg extension force production and neural activation of muscles was significantly more rapid. Secondly, anaerobic abilities such as lactate production was lesser at higher running velocities. Lastly, 30-meter sprint time significantly improved in the explosively trained group. Implications suggest that anaerobic training such as strength based resistance training, sprint training, and jump training may improve an ultramarathon runner's ability to utilize the anaerobic metabolic pathway at the end of a race and improve pace within the last split of an event which aligns with hypothesis 2 in the current investigation.

Paton et al. (2005) used a similar approach to investigate the performance effects of explosive and high intensity training. Cyclists were divided into a training intervention group and a control group. The intervention group underwent jump training and cycling sprints; however, resistance training was not implemented within this design. Despite the omission of resistance training, anaerobic metabolic pathways were still utilized rather than aerobic metabolic pathways due to the high intensity and short duration of exercise. Results demonstrated a significant increase in power production in cyclists who underwent explosive and high intensity training. Thus, training the muscles anaerobically without formal resistance training may improve running economy due to increased power production. Nevertheless, the study aforementioned by Mikkola et al. presents implications that an explosive high intensity intervention including resistance training may further enhance anaerobic performance at the end of an ultra-endurance event.

Esteve-Lanao et al. (2008) also looked at the performance effects of a resistance training intervention. This study aimed to examine the effects of a periodized strength-based resistance training program on middle distance runners' ability to maintain stride length at competitive velocities. 18 sub-elite participants were split into the following groups: periodized strength, non-periodized strength, and non-strength as the control. The 16 week periodized resistance training program resulted in no change of stride length throughout the interval training session. The non-periodized and control group had significant reductions in stride length as fatigue increased throughout the interval session. A periodized resistance training program specifically designed for ultra-endurance runners may enhance the ability to maintain force production and stride length throughout the event and may increase ability to increase stride length in the last split of the race. Overall, an effective resistance training periodization may improve force output, power output, and anaerobic properties that improve performance near the end of an ultramarathon event.

Current Ultramarathon Training Practices

Resistance training has been demonstrated to elicit anatomical adaptations to improve running economy and may have implications to improve performance. Despite the importance of this variable in training for an ultramarathon, many studies that collect training history of ultramarathon runners omit resistance training inquiries or do not ask for specific resistance training methods. For example, Hoffman et al. (2013) had collected data regarding aerobic training volume within the last year for current ultramarathon runners. Ultramarathon runners identified participating in other modes of aerobic training aside from running. 63% of study participants self-reported biking to contribute to aerobic exercise. 39% of participants self-reported backpacking, 14.6% self-reported swimming, 8.7% self-reported cross-country or roller skiing, 11.6% self-reported snowshoeing, 7.1% self-reported kayaking, and 19% self-reported participation in other types of aerobic exercise in the last year that they have prepared for an ultramarathon. This study also demonstrated that active ultramarathon runners' annual running volume does not lessen with an increase in age. The median age of study participants was 42.8 years with an interquartile range of 35 – 51 years. This descriptive statistic demonstrates the possibility that a high percentage of ultramarathon participants may be at risk of sarcopenia, the loss of muscle mass associated with aging. Thus, resistance training may be a method for muscle mass preservation. This study determined that 46.2% of study participants self-reported participating in consistent resistance training for a minimum of three consecutive months within the last year. However, this study does not provide a clear definition of consistent resistance training and does not provide details about resistance training methods. Resistance training may aid in preserving muscle mass of aging ultramarathon runners and maintain a healthier training condition.

Knechtle et al. (2010) collected anthropometric measurements and the training history of 66 male ultramarathon runners competing in a 100km race. The average age of study participants was 46.7 years. Training history in preparation for this race was collected via survey and asked for years of active running, average weekly training volume in running in kilometers, average weekly training volume in hours, average speed when training, personal best in a marathon, and personal best in an ultramarathon of 100 kilometers. The average number of years of active running was 11.2 years. The average weekly training volume when preparing for the last ultramarathon event was 75.4 km/week or 7.5 hours/week. Average running speed while training was 10.6 km/hr. Concluded from this study was that average weekly running volume in kilometers and personal best in a marathon were both associated with ultramarathon race performance in terms of time to completion. Resistance training history was not included in this study, and may have been a beneficial addition. This survey lacks the ability to identify current resistance training methodology or the absence of resistance training within the ultramarathon community. With lack of information pertaining to current resistance training programs, it is challenging to analyze true differences in performance associated with physiological characteristics without consideration of adaptations made through resistance training.

Another important piece of information is where ultramarathon participants receive training information. A study conducted by Krouse et al. (2011) surveyed 344 female ultramarathon runners regarding coach utilization. It was found that 20.4% of runners utilize a coach and 79.6% of runners do not use a coach to prepare for ultramarathons. The primary source of training information was personal experience and personal knowledge. The most common explanation for not using a coach was due to finances. This study did not survey men and did not ask about exercise programming aside from running volume. In addition, this study did not isolate participants of a single race or distance. Thus, training volume ranged from 3 hours per week to 37 hours per week.

Attempts have been made to grasp the training tendencies of ultramarathon runners, but there are many unanswered questions regarding resistance training practices within this population. Multiple studies have identified running volume and alternative methods of aerobic training, but none have determined the resistance training methods that are utilized when preparing for an ultramarathon. It is important to investigate current resistance training tendencies within this population as well as a variety of resistance training program implementations to determine the most effective method of training for an ultramarathon.

CHAPTER III

METHODOLOGY

Subjects

Of the 230 runners registered to participate in Eastern States 100-mile ultramarathon located in Pine Creek, Pennsylvania, on August 12, 2017, 44 volunteered to participate in this study. To be included in this study, participants were required to be at least 18 years of age and to have completed a minimum of two ultramarathons of at least 50 miles in their lifetime prior to investigation.

A cohort of 44 consenting ultramarathon runners were surveyed and monitored for pace. Participants were identified during data collection by the bib number assigned at the ultramarathon event. Immediately following data collection, participants were assigned a new number that had no association to name or bib number.

Recruitment

Race competitors received an email (Appendix A) from the race director with a link to voluntarily complete an electronic survey via Qualtrics two weeks prior to the ultramarathon. By clicking the external link, consent was provided to collect and use data via survey and monitor pace for the duration of the ultramarathon. If participants did not complete the survey after the initial email, a follow-up email was sent one week prior to the ultramarathon. These initial emails containing the survey link were sent by the race director of Eastern States 100. If race participants did not complete the survey electronically, participants completed a hard copy survey at registration and prior to commencement of the event, in which consent was written (Appendix D).

Procedures

Subjects were recruited electronically to complete a preliminary survey regarding demographics, race history, and resistance training history. Preceding the survey (Appendix F), electronic consent via link (Appendix A) was required to use survey information and monitor pace throughout the ultramarathon on August 12, 2017. If race participants did not complete the survey electronically, participants completed a hard copy survey at registration and prior to commencement of the event, in which consent was written (Appendix D). Of the 44 study participants, 18 runners completed the survey electronically and the remaining 26 participants completed the survey using a hard copy on the day of the event.

There were 17 aid stations at Eastern States 100. At the event, time of arrival was recorded (Appendix G) at 16 aid stations and the finish line for each participant. Time of arrival was not collected at aid station 10 due to inaccessibility. The 16 aid stations (AS) were set up at the following accumulative mileage points: **AS1**: 5.8, **AS2**: 11.3, **AS3**: 17.8, **AS4**: 25.8, **AS5**: 31.6, **AS6**: 38.5, **AS7**: 43.2, **AS8**: 51.1, **AS9**: 54.7, **AS10**: 59.4, **AS11**: 63.8, **AS12**: 69.1, **AS13**: 75.6, **AS14**: 80.3, **AS15**: 84.8, **AS16**: 92.8, **AS17**: 99.1, **Finish:** 102.9.

Statistical Analysis

All data was evaluated for normality using a Shapiro-Wilk test. Data was determined as normal ($p > 0.05$). In addition, there was no skewness or kurtosis in these data. Participant demographics and resistance training methods were analyzed via descriptive statistics. An Analysis of Variance (ANOVA) was utilized to determine if an interaction or main effect existed. An Independent T-test was utilized to determine if there was a significant difference in overall pace as well as the last five splits between finishers who resistance train and who do not resistance train. Lastly, a Bivariate Pearson Correlation was utilized to determine a relationship between age and pace. Significance was set at an alpha level of 0.05. All collected data were organized and analyzed in a statistical application, IBM SPSS Statistics 24.

CHAPTER IV

RESULTS

Participants

Inclusion criteria for this investigation required participants to have completed a minimum of two ultramarathons of at least 50 miles in their lifetime prior to investigation. 46 ultramarathon participants at Eastern States 100 provided written consent to participate in this study. However, one runner was excluded from this study due to insufficient number of responses on the training history survey. The second excluded runner unintentionally signed the consent form in an attempt to quickly confirm his registration at the registration table. Thus, 44 ultramarathon runners were included in this study for analysis.

Table 1 illustrates demographics of all study participants (N = 44). The average age of participants was 41.20 ± 8.32 years, with a minimum age of 24 years and a maximum age of 57 years. 86.6% of study participants were male and the remaining 11.4% were female. In addition, 90.9% of study participants identified as Caucasian, 6.8% identified as Asian, and 2.3% identified as Hispanic. Of the 44 study participants, 27.3% reported living in Pennsylvania and 72.7% reported living out of state.

Table 1

Demographics of All Study Participants (N = 44)

	Mean ± SD	
Age	41.20 ± 8.32	
	N	%
Gender		
Male	39	88.6%
Female	5	11.4%
Ethnicity		
Caucasian	40	90.9%
Asian	3	6.8%
Hispanic	1	2.3%
Residence		
Pennsylvania	12	27.3%
Out of State	32	72.7%

Note. Age is presented mean ± SD
Gender, ethnicity, and residency are
presented in frequencies and percentages.

Table 2 illustrates demographics of those who completed the ultramarathon (N = 24) and those who did not complete the ultramarathon (N = 20). Within the group of finishers, the average age was 39.42 ± 7.28 years, with a minimum age of 25 years and a maximum age of 57 years. Of the 24 finishers, 87.5% were male and 12.5% were female. Twenty-one of 24 finishers identified as Caucasian, two identified as Asian, and one identified as Hispanic. Of the 24 finishers, 41.7% identified living in Pennsylvania, and 58.3% of finishers identified living out of state. Within the group of non-finishers, the average age was 43.35 ± 9.14 years, with a minimum age of 24 years and a maximum age of 56 years. Of the 20 non-finishers, 90% were male and 10% were female. Nineteen non-finishers identified as Caucasian and one identified as Asian. Ten percent of non-finishers identified living in Pennsylvania, and the other 90% identified living out of state.

Table 2

Demographics of Finishers (N = 24) and Non-Finishers (N = 20)

	All Participants (N = 44)			
	Finishers (N = 24)		Non-Finishers (N = 20)	
Age	39.42 ± 7.28		43.35 ± 9.14	
	N	%	N	%
Gender				
Male	21	87.5%	18	90.0%
Female	3	12.5%	2	10.0%
Ethnicity				
Caucasian	21	87.5%	19	95.0%
Asian	2	8.3%	1	5.0%
Hispanic	1	4.2%	---	---
Residency				
Pennsylvania	10	41.7%	2	10%
Out of State	14	58.3%	18	90%

Note. Age is presented as mean ± SD.
Gender, ethnicity, and residency are presented in frequencies and percentages.

Table 3 breaks down finishers and non-finishers into those who resistance train and those who do not resistance train. Of the 24 participants who completed the ultramarathon, 11 (45.8%) reported resistance training. Of the 20 participants who did not complete the ultramarathon, 13 (65%) reported resistance training. Within finishers who resistance train, the average age was 37.09 ± 6.75 years. Of the 11 who finished and resistance train, 90.9% were male and the other 9.1% were female. In addition, 81.8% identified as Caucasian, 9.1% identified as Asian, and 9.1% identified as Hispanic. Lastly, 45.5% reported living in Pennsylvania and 54.5% reported living out of state. Within finishers who do not resistance train, the average age was 41.38 ± 7.38 years. Of the 13 who finished and resistance train, 84.6% were male and the other 15.4% were female. In addition, 92.3% identified as Caucasian and 7.7% identified as Asian. Lastly, 38.5% reported living in Pennsylvania and 61.5% reported living out of state. Within non-finishers who resistance train, the average age was 42.54 ± 8.34 years. Of the 13 who did not finish and resistance train, 84.6% were male and the other 15.4% were female. In addition, 92.3% identified as Caucasian and 7.7% identified as Asian. Lastly, 7.7% reported living in Pennsylvania and 92.3% reported living out of state. Within non-finishers who do not resistance train, the average age was 44.86 ± 11.02 years. Of the 7 who did not finish and do not resistance train, 100% were male and identified as Caucasian. Lastly, 14.3% reported living in Pennsylvania and 85.7% reported living out of state.

Table 3

Demographics of Finishers and Non-Finishers Who RT and Do Not RT

	Finishers (N = 24)				Non-Finishers (N = 20)			
	RT (N = 11)		Non-RT (N = 13)		RT (N = 13)		Non-RT (N = 7)	
Age (years)	37.09 ± 6.75		41.38 ± 7.38		42.54 ± 8.34		44.86 ± 11.02	
	N	%	N	%	N	%	N	%
Gender								
Male	10	90.9%	11	84.6%	11	84.6%	7	100%
Female	1	9.1%	2	15.4%	2	15.4%	---	---
Ethnicity								
Caucasian	9	81.8%	12	92.3%	12	92.3%	7	100%
Asian	1	9.1%	1	7.7%	1	7.7%	---	---
Hispanic	1	9.1%	---	---	---	---	---	---
Residency								
Pennsylvania	5	45.5%	5	38.5%	1	7.7%	1	14.3%
Out of State	6	54.5%	8	61.5%	12	92.3%	6	85.7%

Note. Age is presented as mean ± SD. Gender, ethnicity, and residency are presented in frequencies and percentages.

Resistance Training

Hypothesis 1 stated that there would be a greater prevalence of resistance training in those who complete ES100 as compared to those who did not complete ES100. Table 4 demonstrates no significant difference in participation rates in resistance training between those who finished and those who did not finish the ultramarathon (*p* = 0.204). Of the 24 finishers, 45.8% reported resistance training. Of the 20 non-finishers, 65.0% reported resistance training.

Table 4

RT Participation in Finishers (N = 24) and Non-Finishers (N = 20)

RT Participation	Finishers (N = 24)		Non-Finishers (N = 20)		Chi-Square	df	P
	N	%	N	%	1.616	1	0.204
Yes	11	45.8%	13	65.0%			
No	13	54.2%	7	35.0%			

Note. Participation is presented in frequencies and percentages.
Differences are presented by Chi-Square values.

Table 5 illustrates months of resistance training experience among finishers and non-finishers. One finisher and on non-finisher did not report experience in the survey, thus finisher N = 10 and non-finisher = 12 for this analysis. The majority of finishers (80%) and non-finishers (66.67%) reported having greater than 2 years of resistance training experience.

Table 5

RT Experience of Finishers and Non-Finishers Who RT

Variable	Finishers (N = 11)		Non-Finishers (N = 13)	
Experience (months)	N = 10	%	N = 12	%
< 6	1	10%	1	8.3%
6-11	1	10%	1	8.3%
12-24	---	---	2	16.7%
>24	8	80%	8	66.67%

Note. Participation is presented in frequencies and percentages.

Table 6 illustrates frequency of resistance training in terms of days/week. One runner who completed the ultramarathon and resistance trained did not provide a frequency of training. Of the 10 finishers who provided a response, 50% resistance train 1-2 days per week and 50% resistance train 3-4 days per week. Of the 13 non-finishers who resistance train, one did not provide a response for frequency of resistance training. Of the 12 non-finishers who provided a response, the majority of non-finishers (58.3%) resistance train 1-2 days per week. None of the finishers who resistance train reported resistance training more than 4 days. None of the non-finishers reported resistance training greater than 6 days.

Table 6

RT Frequency of Finishers and Non-Finishers Who RT

Variable	Finishers (N = 11)		Non-Finishers (N = 13)	
Frequency (days/week)	N = 10	%	N = 12	%
1-2 days	5	50%	7	58.3%
3-4 days	5	50%	4	33.3%
5-6 days	---	---	1	8.3%
7 days	---	---	---	---

Note. Participation is presented in frequencies and percentages.

Table 7 illustrates typical repetitions per set performed by those who completed ES100 and those who did not complete ES100. Of the 13 non-finishers who resistance train, 12 provided a response for this question on the survey. The majority of finishers (63.6%) reported completing at least 13 repetitions per set when resistance training. The majority of non-finishers (58.3%) reported resistance training within a repetition range of 6 to 12. No study participants reported resistance training within the repetition range of 1 to 5.

Table 7

Repetitions Performed Per Set in Finishers and Non-Finishers Who RT

Variable	Finishers (N = 11)		Non-Finishers (N = 13)	
Repetitions (reps/set)	N = 11	%	N = 12	%
1-5	---	---	---	---
6-12	4	36.4%	7	58.3%
13-20	6	54.5%	1	8.3%
>20	1	9.1%	4	33.3%

Note. Participation is presented in frequencies and percentages.

Table 8 illustrates the resistance training split used by those who finished ES100 and those who did not finish ES100. There was no majority found in either group, both groups resistance train using a variety of splits.

Table 8

RT Splits Used in Finishers and Non-Finishers Who RT

Variable	Finishers (N = 11)		Non-Finishers (N = 13)	
Split	N = 11	%	N = 13	%
Full Body	5	45.5%	4	30.8%
Muscle Group	3	27.3%	2	15.4%
Push/Pull	1	9.1%	1	7.7%
Upper/Lower	1	9.1%	4	30.8%
Other	1	9.1%	2	15.4%

Note. Participation is presented in frequencies and percentages.

Table 9 illustrates the type of equipment finishers and non-finishers use to resistance train. It was found that 72.8% of finishers use either free weights alone or in combination with other equipment to resistance train. It was also determined that 69.2% of non-finishers utilize free weights either alone or in combination with other equipment to resistance train. Of the 24 study participants that resistance train, 17 reported using free weights when resistance training.

Table 9

RT Equipment Used by Finishers and Non-Finishers Who RT

Variable	Finishers (N = 11)		Non-Finishers (N = 13)	
Equipment Used	N = 11	%	N = 13	%
Free weights	1	9.1%	2	15.38%
Bodyweight/Bands	3	27.3%	3	23.1%
Free weights, Bodyweight/Bands	5	45.5%	6	46.2%
Free weights, RT Machines	1	9.1%	---	---
All 3 above modes	1	9.1%	1	7.7%
Other	---	---	1	7.7%

Note. Participation is presented in frequencies and percentages.

Table 10 illustrates the person who created the resistance training program. Using a Fisher's Exact Test, a significant difference was demonstrated between finishers and non-finishers who resistance train ($p = 0.005$). 90.9% of finishers designed their resistance training program by themselves, and 9.1% of finishers utilized a coach/trainer. Of non-finishers who resistance train, 30.8% created their program by themselves, 23.1% utilized a coach/trainer, 7.7% utilized a family member or friend, 15.4% utilized workouts provided on workout videos, and 23.1% utilized a combination of at least 2 methods.

Table 10

RT Program Creator of Finishers and Non-Finishers Who RT

Variable	Finishers (N = 11)		Non-Finishers (N = 13)		P
RT Program Creator	N = 11	%	N = 13	%	0.005
Self	10	90.9%	4	30.8%	
Trainer/Coach	1	9.1%	3	23.1%	
Family/Friend	---	---	1	7.7%	
Workout Video	---	---	2	15.4%	
Combination of 2 or more	---	---	3	23.1%	

Note. Participation is presented in frequencies and percentages.
Differences were assessed by Fisher's Exact Test.

Pace

Hypothesis 2 states that pace among finishers in the last five splits of the ultramarathon would be significantly faster in those who resistance train than those who do not resistance train. Within finishers, a two group (resistance train; non-resistance train) by 5 time-point (14^{th}, 15^{th}, 16^{th}, 17^{th}, and 18^{th} splits) analysis of variance was used to evaluate the interaction and main effect between groups. Table 11 demonstrates no interaction (F = 0.009, *p* = 0.925) between resistance training and pace no main effect of group (F = 0.943, *p* = 0.444).

Table 11

Interaction and Main Effect of Resistance Training and Pace

	Df	MS	F	P
RT_Non-RT*Pace	1	0.246	0.009	0.925
Pace	4	4.316	0.943	0.444

An Independent Sample T-Test was utilized to analyze the difference in pace of the last five splits of the ultramarathon between the two groups of finishers. 3 of 24 study participants who completed the ultramarathon were excluded from this analysis due to lack of data regarding the last five splits of the ultramarathon. As demonstrated in Table 7, it has been shown that there is no significant difference in the pace within the 14^{th} split (*p* = 0.286), 15^{th} split (*p* = 0.382), 16^{th} split (*p* = 0.935), 17^{th} split (p = 0.888), and 18^{th} split (*p* = 0.775) of the ultramarathon between those who resistance train and those who do not resistance. In addition, Table 12 demonstrates no significant difference (*p* = 0.191) in overall pace between those who completed ES 100 and resistance train and those completed ES100 and do not resistance train.

Table 12

Difference in Pace Between Finishers Who RT (N=11) and Those Who Do Not RT (N=10)

Split	Cumulative Mileage (mi)	Split Mileage (mi)	Group	Pace (min/mi)	*Df*	p
14	80.3	4.7	RT No RT	21.68 ± 3.09 20.42 ± 2.09	19	0.286
15	84.8	4.5	RT No RT	26.29 ± 2.74 27.49 ± 3.36	19	0.382
16	92.8	8.0	RT No RT	19.47 ± 2.18 19.40 ± 1.74	19	0.935
17	99.1	6.3	RT No RT	19.17 ± 3.44 19.34 ± 1.88	19	0.888
18	102.9	3.8	RT No RT	22.51 ± 5.65 21.98 ± 2.29	19	0.775
Overall	102.9	102.9	RT No RT	31.37 ± .92 32.81 ± .60	22	0.191

Note. Pace is presented as Mean ± SD.

Table 13 illustrates the relationship between age and pace in the last five splits of the ultramarathon for the 21 finishers who did not have missing data points for any of the last five splits in the ultramarathon. Age was inversely associated with a significance of $p = 0.006$ with pace in split 15, from mile 80.3 to 84.8.

Table 13

Pearson Correlation Between Age and Pace of Finishers (N = 21)

Splits		14	15	16	17	18
Age	Correlation	-0.334	-0.579	-0.056	-0.110	0.152
	P	0.126	0.006	0.810	0.636	0.551

CHAPTER V

DISCUSSION

Discussion

The purpose of this investigation was to identify current resistance training practices in ultramarathon runners participating in the Eastern States 100 and determine if a significant difference existed in pace between finishers who resistance train and who do not resistance train. Previous studies have investigated aerobic training practices within the ultramarathon population, but resistance training history has not been collected within this population. Therefore, this study was a preliminary data collection of resistance training methods of ultramarathon runners.

This current investigation found that the average age of ultramarathon study participants was 41.20 ± 8.32 years. This demographic was similar in studies conducted by Hoffman et al. (2013), who presented an average age of 42.8 years and Knectle et al. (2010), who presented an average age of 46.7 years. Future research is necessary to determine the musculoskeletal risks associated with age and ultra-endurance running.

Previous studies have neglected resistance training history when asking for training history. This present study found that 24 of 44 (54.5%) of study participants participate in some variety of resistance training in-season. Hoffman et al. (2013) reported 46.2% of ultramarathon runners in that specific study resistance trained for 3 consecutive months within the last year of training for an ultramarathon. Additional research is needed to determine the effectiveness of resistance training within a training program for this population.

The study aforementioned in the section Current Ultramarathon Training Practices by Krouse et al. (2011) presented information regarding coach utilization. Of 344 female study participants, 80% did not use a coach/trainer. In this present study, 83.3% of participants who resistance train did not utilize a coach/trainer to aid in training. Of the four participants who utilized a coach/trainer, three runners did not complete ES100 and one runner completed ES100. In addition, it was found that 90.9% finishers design their resistance training program by themselves whereas 30.8% of non-finishers design their resistance training program by themselves. The other 69.2% of non-finishers rely on others to design their resistance training program. Finishers may have more understanding of current resistance training methodology that is applicable to their own program as opposed to the non-finishers and those who assist in designing their program. The majority of both groups reported having experience with resistance training for greater than two years, but it appears that the finishers have more confidence in designing their own program than non-finishers who rely on other people. In addition, the finishers may be more invested into the adaptations made through training than the non-finishers who rely on others to program.

The majority of finishers (63.6%) resistance train in the muscular endurance zone as described by Sheppard et al. (2016) in the NSCA guidelines previously mentioned. Of the 13 non-finishers who resistance train, 41.6% reported resistance training in the muscular endurance zone. The other 58.4% of non-finishers reported resistance training in the hypertrophic zone. Specific repetition ranges elicit separate physiological adaptations, and can be used methodically throughout the year to effectively prepare for an ultra-endurance event. However, it may be recommended to resistance train within a repetition range that elicits muscular endurance adaptations when nearing competition. It has been found that ultramarathon runners who create their own resistance training program are more likely to resistance train in the muscular endurance zone as opposed to those who rely on others to create their program. Thus, those who finished ES100 and resistance train may have a greater understanding of resistance training programming than the individuals who designed the resistance training programs of those who did not finish ES100. Further investigation is needed to determine the rationale utilized in designing these resistance training programs.

It was found in this current investigation that finishers who resistance train did not present a faster overall pace or faster pace in any of the last five splits of the ultramarathon than finishers who did not resistance train. This investigation has shown that resistance training does not inhibit or improve performance near the end of an ultramarathon. Thus, results of the present study suggest that resistance training has minimal effect on ultramarathon running performance.

Even though resistance training variables were collected, it has not been determined that these runners are resistance training within a properly structured program or periodization to achieve maximal physiological adaptations. It is necessary to examine resistance training periodization if it exists within this population. The current resistance training practices may not be producing appropriate physiological adaptations to enhance performance and further research needs to be done.

Summary

In conclusion, this study was a preliminary investigation to gain understanding of what ultramarathon runners are currently doing in terms of resistance training in preparation for a 100-mile event located in Central Pennsylvania. Results have demonstrated that there was no significant difference in pace between finishers who resistance train and those who do not resistance train near the end or overall pace (p = 0.191) of an ultramarathon event. Hypothesis 1 and 2 have been rejected due to lack of a significant difference between groups.

Limitations

Ultramarathons involve many factors that aid or harm completion rate such as weather, macronutrient intake, dehydration, injury, timing, a plethora of factors that induce fatigue, and other factors that are specific to the situation. This study did not isolate resistance training to investigate the impact on performance or completion rate without confounding factors such as the variables previously listed. Secondly, there were missing data points for three finishers in the last five splits of the ultramarathon. If the data existed and was included in analyses, results may have differed. Lastly, these results cannot be generalized to a wider population due to the small sample size, inadequacy of female representation, and the wide range of ultramarathon distances run nationwide and worldwide that require different preparation methods and techniques than an event such as ES100. Of 230 registered runners, 44 volunteered to participate in this study. This

Future Research

Future research is needed to investigate the physiological and performance benefits or lack thereof when implementing a specific periodized resistance training program within the ultramarathon population. This present study was a step in understanding the present resistance training practices of ultramarathon runners, but a more in-depth survey with a larger population should be conducted as well as a resistance training implementation. A longitudinal study over the course of one year of preparation for an ultramarathon would be ideal in assessing cardiovascular changes, musculoskeletal, and performance changes that are associated with specific training practices.

In addition, it is necessary to collect resistance training history of more ultramarathon runners competing in 100-mile ultramarathons as well as other distances. Lastly, the inclusion of more females is important to determine if differences exist between men and women in terms of resistance training practices and physiological responses to resistance training that impact performance in an ultra-endurance event.

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APPENDIX A

ELECTRONIC CONSENT

Hi, my name is Kathryn Jones and I am a graduate student at Indiana University of Pennsylvania. I am conducting a thesis and asking for volunteers to participate in my study. This study has two parts; part 1 is an online survey, and part 2 involves passive laboratory testing. The purpose of this investigation is to identify current resistance training history and periodization in ultramarathon runners. This study will also explore the differences in resting velocity of arterial blood flow in between ultramarathon runners who resistance train and do not resistance train. In addition, this study will define implications on ultramarathon performance in terms of intra-race pace. Lastly, this study will determine if there is a trend in resistance training methods in athletes who compete in the Eastern States 100.

- The first portion is a survey about race history and resistance training history. **By clicking the link and completing the survey, you are consenting** to use of survey data and having your pace monitored at each aid station throughout the Eastern States 100 ultramarathon event on August 12, 2017. Race and Resistance Training History Survey

- The second portion will take place in Indiana, Pennsylvania on your choice of August 26, 2017 or September 9, 2017 at 8am and will last a maximum of two hours. Locations will be Indiana Regional Medical Center (IRMC). At IRMC, blood velocity on your lower leg will be measured via ultrasound.
    - Guidelines for participation in laboratory testing:
        - You must not be hyper/hypotensive
        - You must not smoke tobacco products
        - You must refrain from supplementation that changes arterial properties within 48 hours of testing. Including but not limited to: Caffeine, sexual enhancement supplementation, L-arginine, nicotinic acid, niacin, etc.
        - You must maintain current exercise regimen identified in the survey.

There are no risks associated with this study.

If you have any questions, concerns, or would like to participate in the second portion, contact me by August 1, 2017.

Kathryn E. Jones
Graduate Student
Kinesiology, Health & Spt Science
k.e.jones4@iup.edu

Hayden D. Gerhart, Ph.D.
Assistant Professor
Kinesiology, Health & Spt Science
724-357-7730
hgerhart@iup.edu

APPENDIX B

RECRUITMENT EMAIL

Hello (insert name),

My name is Kathryn Jones. Thank you for voluntarily completing the first portion of my study. Details of the second portion of this study are as follows:

- The second portion will take place in Indiana, Pennsylvania on your choice of August 26, 2017 or September 9, 2017 at 8am and will last a maximum of two hours. Location will be Indiana Regional Medical Center (IRMC). At IRMC, blood velocity on your lower leg will be measured via ultrasound.
    - Guidelines for participation in laboratory testing:
        - You must not be hyper/hypotensive
        - You must not smoke tobacco products
        - You must refrain from supplementation that changes arterial properties within 48 hours of testing. Including but not limited to: Caffeine, sexual enhancement supplementation, L-arginine, nicotinic acid, niacin, etc.
        - You must maintain current exercise regimen identified in the survey.

There are no risks associated with this study.

If you would like to participate or have any questions please contact me by September 7, 2017.

Kathryn E. Jones
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724-599-9896
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Assistant Professor
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APPENDIX C

VERBAL COMMUNICATION RECRUITMENT

Good evening, my name is Kathryn Jones and I am conducting a study for my thesis at Indiana University of Pennsylvania. The study involves two portions; the first portion is a survey pertaining to resistance training history and collecting your pace at each aid station throughout the event. The second portion is measuring blood flow velocity via ultrasound in the lower leg on a separate date at Indiana Regional Medical Center. Details regarding the second portion of my study will be given upon request. Today I am asking for volunteers for the first portion of my study. The survey will take approximately 8 minutes and the collection of pace will involve no additional participation on your end. Please see me at the end of the meeting if you are interested in being a subject in this study. Thank you very much.

APPENDIX D

INFORMED CONSENT

Approval: ___________

Informed Consent to Participate in a Research Study

AN OBSERVATION OF RESTING BLOOD FLOW VELOCITY AND ANALYSIS OF RESISTANCE TRAINING HISTORY IN ULTRAMARATHON RUNNERS

Contact Information

Principal Investigator:
Kathryn E. Jones
Graduate Student
Kinesiology, Health & Spt Science
k.e.jones4@iup.edu

Co-Investigator:
Hayden D. Gerhart, Ph.D.
Assistant Professor
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The purpose of this investigation is to identify the relationship between resting blood flow velocity and pace throughout an ultramarathon. This study will also explore the differences in resting velocity of arterial blood flow between ultramarathon runners who resistance train and do not resistance train. This study will identify current resistance training practices in-season and off-season in ultramarathon runners participating in the Eastern States 100. This study will determine if there is a relationship between resistance training practices and blood flow velocity. Lastly, this study will determine if there is a relationship between resistance training practices and pace throughout an ultramarathon. You are invited to participate in this research study on a voluntary basis. If you have any questions, we ask you to contact us via the contact information located at the top of this page.
You are invited to participate in this study because you are an ultramarathon runner of at least 18 years of age participating in the Eastern States 100. You may not qualify to be a participant in this research if you have certain health conditions or identify with certain behaviors (cardiovascular disease, hypertension, hypotension, and smoking)

If you volunteer as a research subject for the second portion of this project, you will be asked to come to Indiana Regional Medical Center in Indiana, Pennsylvania on your preference of August 26 or September 9, 2017.

Portion one of this study will include completion of a training history survey and observation of your pace throughout the race. The survey includes 13 questions and will take approximately 8 minutes to complete. If you choose to complete the survey, you also give consent for monitoring of pace throughout the ultramarathon. Data collectors will be positioned at each aid station and when we see your bib number enter or pass the aid station, your bib number and time will be

written down. This is observational and will require no assistance or additional participation from you.
If you choose to participate in the second portion of the study, you will come to IRMC to have blood flow velocity measured via ultrasound. This process is non-invasive and will last approximately 5 to 10 minutes per participant. Data collection for this portion of the study will begin at 8:00am and will last for a maximum of 2 hours. You are free to leave at the end of your individual measurement. This process is described below:

1) Wear shorts or pants that expose the calf region of the leg.
2) Lay on the table in the position directed by the technician.
3) Relax and breathe naturally as blood flow velocity is measured on the lower leg.

Blood flow velocity will be measured non-invasively with a Philips CX50 vascular ultrasound system by a licensed ultrasound technician. This technique requires ultrasound gel to be placed on the lower leg at the level of the ankle in the region where the ultrasound will be conducted. You are responsible for disclosing your medical history on the health history form prior to your participation in the research. You are also expected to report all medications (including non-prescription) taken recently to the research staff prior to participating in each research session.

If you decide to participate in the first portion of this research, we will ask you to complete the following procedures:

Survey
If you complete the survey via a paper copy, this will serve as informed consent. The survey pertains to training history and ultramarathon completion history and is 13 questions in length, 2 of which are short answer, and the remaining 11 are multiple choice. You must answer all questions. The survey will take approximately 8 minutes for completion.

Pace Monitoring
Throughout the ultramarathon, time of arrival will be recorded at each of the 17 aid stations and at the finish line. This portion is observational and will require no additional assistance on your part.

If you decide to participate in the second portion of this research, we will ask you to complete the following procedures:

Blood Flow Velocity
You will come to the ultrasound laboratory at IRMC. Upon arrival, signed consent forms will be collected. Next, blood flow velocity will be measured in your lower leg using a Doppler ultrasound system. This is non-invasive, but will require you to wear shorts or capris for access to the specific site on the ankle. This will be measured in a resting state; thus you will be asked to not consume caffeine within 48 hours of measurement, exercise within 24 hours, or consume supplements with L-arginine, a pre-curser to nitric oxide, nicotinic acid, sexual enhancement aids, or any other ergogenic aids that impact vascular function or heartrate within 48 hours of laboratory testing. Supplements and medications will be assessed via health history. You must

also not smoke tobacco products, you must not be hyper/hypotensive, and you must maintain current exercise regimen identified in the survey.

Benefits

After ultramarathon participation, personal split times will be available to study participants. In addition, immediately after ultrasound measurement, participants will learn their resting arterial blood flow velocity.

Risks and Discomforts

It is possible, but not highly likely, that participants will experience an allergic reaction to the ultrasound gel being used in measuring blood flow velocity.
Every effort will be made to minimize this risk by evaluation of allergies in the health history questionnaire. Details regarding the safety and precautions of using Aquasonic ultrasound gel are available upon request. Physicians are available on site if allergic reaction occurs. Lastly, the subject may decide to stop participation at any time.

Privacy and Confidentiality

Your personal information will be kept confidential. Any identifying information will be kept in a secure location that only the researchers will have access to. Research participants will not be identified in any publication or presentation of research results; only aggregate data will be used.

Your research information may, in certain circumstances, be disclosed to the Institutional Review Board (IRB), which oversees research at the Indiana University of Pennsylvania, or to certain federal agencies. Confidentiality may not be maintained if you indicate that you may do harm to yourself or others.

Compensation

There will be no compensation for participation.

Voluntary Participation

Taking part in this research study is entirely up to you. You may choose not to participate or you may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. You will be informed of any new, relevant information that may affect your health, welfare, or willingness to continue your study participation.

I have read and understand the information that is provided in the informed consent form. I consent to voluntarily participate in this research study. I understand that there will not be compensation to be a participant. I understand the all data collected will be kept confidential and only seen by the principle investigator. I have the right to withdrawal at any point in the study without penalty. I have received an unsigned copy of the informed consent to keep in my possession. I understand and agree to the conditions of this study as described.

Level of Participation: (Circle all that apply)

a. Survey and Race Pace Monitoring
b. Blood Flow Velocity Measurement

Name (please print): ____

Signature: ____ Date: ___________________

Phone number or location you can be reaches: _____________________________________

Best days to reach you: ____

I certify that I have explained to the above participant the purpose of this study and potential risks and benefits that are associated with participating in this study. I have answered any questions that the participant has asked and have been a witness to the above signature.

Investigators Signature: ______________________________ Date: ____________________

THIS PROJECT HAS BEEN APPROVED BY THE INDIANA UNIVERSITY OF PENNSYLVANIA INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF HUMAN SUBJECTS (PHONE: 724-357-7730)

VOLUNTARY CONSENT FORM

APPENDIX E

RACE AND RESISTANCE TRAINING HISTORY SURVEY

Race and Training History Survey

Name

Email

Age

Gender

- Male
- Female

Race/Ethnicity

- White
- Black
- Hispanic
- Asian
- Other

Where do you live (City, State, Country)

Have you / will you run at least two (2) ultramarathons of at least fifty (50) miles prior to August 12, 2017. (Choose one)

- Yes

- No

How many ultramarathons of any distance have you completed prior to August 12, 2017? Please describe how many completions and the distances of each.

How many ultramarathons have you / will you run this summer including the Eastern States 100 and what are the distances?

Do you CURRENTLY resistance train? (Choose one)

- Yes
- No

How long have you been resistance training? (Choose one)

- N/A
- Less than 6 months
- 6 - 11 months
- 12 - 24 months
- Greater than 2 years

How often do you CURRENTLY resistance train? (Choose one)

- N/A
- 1-2 days per week
- 3-4 days per week
- 5-6 days per week
- 7 days per week

What is your typical mode of CURRENT resistance training? (Choose all that apply)

- ☐ N/A
- ☐ Bodyweight or bands
- ☐ Resistance Machines
- ☐ Free weights (Barbells, dumbbells, kettlebells)
- ☐ Other [ ]

How many repetitions do you typically complete per exercise in your CURRENT program? (Choose one)

- ○ N/A
- ○ 1-5 repetitions
- ○ 6-12 repetitons
- ○ 13-20 repetitions
- ○ Greater than 20 repetitions

What is your CURRENT resistance training split? (Choose one)

- ○ N/A
- ○ Muscle Group (Each day trains a separate muscle group)
- ○ Upper body / Lower body
- ○ Full Body
- ○ Push / Pull
- ○ Other [ ]

Do you typically perform compound (multi-joint) exercises? (ex. Squats, deadlifts, overhead press, bench press, cleans, snatches, jerks, etc.) (Choose one)

- ○ N/A
- ○ Yes
- ○ No

Does your resistance training program change throughout the year? (Choose one)

- N/A
- Yes
- No

If your resistance training program changes, what changes? (Choose all that apply)

- N/A
- Frequency (days per week)
- Mode (Type of equipment used)
- Set and repetition range
- Exercises
- Other

How did you design your resistance training periodization / program? (Choose one)

- N/A
- Myself
- Trainer / Coach
- Internet Program
- A friend / family member
- Other

Do you resistance train in the OFF-SEASON? (Choose one)

- Yes
- No

How often do you resistance train in the OFF-SEASON? (Choose one)

- N/A
- 1 - 2 days per week
- 3 - 4 days per week
- 5 - 6 days per week
- 7 days per week

How many repetitions do you typically complete per exercise in the OFF-SEASON? (Choose one)

- ○ N/A
- ○ 1 - 5 repetitions
- ○ 6 - 12 repetitions
- ○ 13-20 repetitions
- ○ Greater than 20 repetitions

APPENDIX F

EASTERN STATES PACE COLLECTION TIMESHEET

Bib #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	End

***Time: Time of day (military time)**

APPENDIX G

EASTERN STATES 100 SITE APPROVAL

Site Approval Form

Dear Mr. Walker,

I am writing this letter to ask permission to recruit race participants from the Eastern States 100. With your permission, I will be conducting research that will analyze the relationships between resistance training history, race performance via pace, and blood flow velocity. Pending IRB approval, I am asking your permission to attend Eastern States 100 to discuss my study, and recruit qualified participants for research. The first portion of this study will be conducted electronically and at Eastern States 100 and the second portion will be conducted at Indiana Regional Medical Center (IRMC) in Indiana, Pennsylvania.

The purpose of this study is to identify current resistance training periodization in ultramarathon runners. This study will also explore the relationship between in-season resistance training (categorized based on volume-load) and resting velocity of arterial blood flow. In addition, this study will define implications on ultramarathon performance in terms of intra-race pace. Lastly, this study will determine if there is a trend in resistance training periodization in athletes who compete in the Eastern States 100. This study will include a survey prior the event comprised of 13 questions pertaining to running and resistance training history. In addition, pace throughout the race will be collected by observation by myself and three to four co-investigators. Lastly, blood flow velocity in the lower leg will be measured non-invasively via Doppler ultrasound at IRMC.

As the race director of the event I am seeking participants, I am writing to specifically request approval to attend Eastern States 100 to recruit participants and conduct my research. I have attached a form to be completed and returned to myself at your earliest convenience. If there are any further questions, please feel free to contact me with any further questions you may have.

Thank you very much for your consideration and time.

Principle Investigator:
Kathryn E. Jones
Graduate Student
Kinesiology, Health and Sport Science
k.e.jones4@iup.edu
(724)-599-9896

Co-Investigator:
Dr. Hayden Gerhart, Ph.D
Assistant Professor
Kinesiology, Health, & Sport Science
hgerhart@iup.edu
(724)-357-2770

Site Approval Form:

Please Check One

___X____ YES, I give you permission to attend Eastern States 100 for recruitment and data collection purposes.

________ NO, I do not give you permission to attend Eastern States 100 for recruitment purposes and data collection purposes.

Name ______David Walker________________________________

Signature David Walker

Date _______5/19/17____________________________________

APPENDIX H

CITI TRAINING

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE

COMPLETION REPORT - COURSEWORK

* NOTE: Scores Requirements reflect quiz completions at the time all requirements for the course were met. See separate Transcript Report for more recent quiz scores, including those on optional

- **Nam** Kathryn Jones (ID:
- **Institution** Indiana University of Pennsylvania
- **Institution** Kinesiology Health & Sport

- **Curriculum** Human Subjects
- **Course Learner** Biomedical
- **Stag** Stage 1 - Basic

- **Record** 231112
- **Completion** 11Ma
- **Expiration** N/
- **Minimum** 8
- **Reported** 9

REQUIRED AND ELECTIVE	DAT COMPLET	SCO
Populations in Research Requiring Additional Considerations and/or	11Ma	5/5 (100
Belmont Report and CITI Course	11Ma	3/3 (100
History and Ethics of Human Subjects	11Ma	7/7 (100
Basic Institutional Review Board (IRB) Regulations and	11Ma	5/5 (100
Informed Consent	11Ma	5/5 (100
Social and Behavioral Research (SBR) for Biomedical	11Ma	4/4 (100
Records-Based Research	11Ma	3/3 (100
Genetic Research in Human	11Ma	5/5 (100
FDA-Regulated Research	11Ma	5/5 (100
Research and HIPAA Privacy	11Ma	5/5 (100
Conflicts of Interest in Research Involving Human	11Ma	5/5 (100
Recognizing and Reporting Unanticipated Problems Involving Risks to Subjects or Others (ID:	11Ma	5/5 (100
Students in Research (ID:	11Ma	5/5 (100
Vulnerable Subjects - Research Involving	11Ma	4/4 (100
Vulnerable Subjects - Research Involving	11Ma	1/3

For this Report to be valid, the learner identified above must have had a valid affiliation with the CITI identified above or have been a paid

Verify www.citiprogram.org/verify/?k348105c8-bb0f-40e2-a0c5-

Collaborative Institutional Training Initiative
Email support@citiprogra
Phone: 888-529-
Web https://www.citiprogr

COMPLETION REPORT - PART 2 OF COURSEWORK

** NOTE: Scores on this Transcript reflect the most current quiz completions, including quizzes on optional (supplemental) elements of course. See list below for details. See separate Requirements Report for the reported scores at the time all requirements for the course were

- **Name** Kathryn Jones (ID:
- **Institution** Indiana University of Pennsylvania (ID:
- **Institution** Kinesiology Health & Sport

- **Curriculum** Human Subjects
- **Course Learner** Biomedical
- **Stage** Stage 1 - Basic

- **Record** 2311122
- **Report** 17Ma-
- **Current** 9

REQUIRED, ELECTIVE, AND SUPPLEMENTAL	MOS RECEN	SCOR
History and Ethics of Human Subjects Research (ID:	11May-2017	7/7 (100%)
Students in Research (ID:	11May-2017	5/5 (100%)
Informed Consent (ID:	11May-2017	5/5 (100%)
Social and Behavioral Research (SBR) for Biomedical Researchers (ID:	11May-2017	4/4 (100%)
Belmont Report and CITI Course Introduction (ID:	11May-2017	3/3 (100%)
Records-Based Research (ID:	11May-2017	3/3 (100%)
Genetic Research in Human Populations (ID:	11May-2017	5/5 (100%)
Vulnerable Subjects - Research Involving Children (ID:	11May-2017	1/3 (33%)
FDA-Regulated Research (ID:	11May-2017	5/5 (100%)
Research and HIPAA Privacy Protections (ID:	11May-2017	5/5 (100%)
Vulnerable Subjects - Research Involving Workers/Employees (ID:	11May-2017	4/4 (100%)
Conflicts of Interest in Research Involving Human Subjects (ID:	11May-2017	5/5 (100%)
Basic Institutional Review Board (IRB) Regulations and Review Process (ID:	11May-2017	5/5 (100%)
Recognizing and Reporting Unanticipated Problems Involving Risks to Subjects or Others in Biomedical Research 14777	11May-2017	5/5 (100%)
Populations in Research Requiring Additional Considerations and/or Protections (ID:	11May-2017	5/5 (100%)

For this Report to be valid, the learner identified above must have had a valid affiliation with the CITI Program subscribing identified above or have been a paid Independent

Verify : www.citiprogram.org/verify/?k348105c8-bb0f-40e2-a0c5-4a36bacddf78-

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Email: support@citiprogram.or
Phone: 888-529-
Web: https://www.citiprogram.o