COMPARISON OF TWO DIFFERENT MODES OF ACTIVE RECOVERY ON BLOOD LACTATE CLEARANCE

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May 5th 2018

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A Thesis

Submitted to

The Graduate Faculty of

Auburn University Montgomery

In Partial Fulfillment of the

Requirements for the Degree of

Master of Education

Montgomery, Alabama

May 5th, 2018

ACKNOWLEDGEMENTS

I would like to thank all of the faculty and staff in the AUM departments of Kinesiology and Education. Each one of you has played a vital role in assisting and encouraging me throughout my master's program. I would not be where I am today if it weren't for each of you. I would like to extend a special thank you to Deanne Allegro, Dr. Henry Williford, Dr. Angela Russell, and Dr. George Schaefer for you have all served as amazing mentors. Thank you for all of your support, guidance, and encouragement. I am indebted to each one of you for challenging me to strive for excellence every step of the way. I would also like to acknowledge my fellow graduate assistants in the Human Performance Lab. This study would not have been possible without your assistance. It has truly been a pleasure to work with you. In addition, I would like to thank all the participants who took part in this study. The effort and time that you put into the data collection process is greatly appreciated. Finally, I must express my very profound gratitude to my family, and loving wife Haley for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. Your love and encouragement is irreplaceable and this accomplishment would not have been possible without you.

Journal format used: Journal of Strength and Conditioning Research

Computer software used: Microsoft Word, Microsoft Excel, IBM SPSS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACSM	American College of Sports Medicine
ADP	Air Displacement Plethysmography
ANOVA	Analysis of Variance
ATP	Adenosine Triphosphate
ATP- PC	Adenosine Triphosphate Phosphocreatine System
BF%	Body Fat Percentage
BLa	Blood Lactate
BPM	Beats Per Minute
Cm	Centimeters
ES	Effect Size
ERYT	Experienced Registered Yoga Teacher
GXT	Graded Exercise Test
HR	Heart Rate
HR_{max}	Heart Rate Max
HRR	Heart Rate Reserve
Ht	Height in Centimeters
HIE	High Intensity Exercise
Kcal	Kilocalories
Kph	Kilometers per hour
LT	Lactate Threshold
MATCH	walking at pace that matched HR of yoga session
METS	Metabolic Equivalents
MHR%	Maximal Heart Rate Percentage
MPH	Miles Per Hour
MSSLA	Maximal Steady State Lactate
$MSS\dot{V}O_2$	Maximal VO_2 Steady State

RPE	Rate of Perceived Exertion
SELF	self- selected treadmill walking
TM	Treadmill
TR	Treadmill Recovery
T1	Trial 1
T2	Trial 2
$\dot{V}O_2$	Maximal Volume of Oxygen Consumption
$\dot{V}O_2$ peak	Peak Volume of Oxygen Consumption
$\dot{V}O_2R$	Reserve Volume of Oxygen Consumption
VT	Ventilatory Threshold
Wt	Weight in kilograms
YR	Yoga Recovery

INTRODUCTION

Blood lactate (BLa) response to exercise has been researched by physiologists for many years (23). BLa, like heart rate (HR), has become a key variable to measure during exercise recovery. The popularity of BLa is due to its relevance to exercise, practical application, and ease of sampling related to with new technology (23). Additionally, several studies have suggested a strong relationship between BLa and performance (1, 4, 11, 14).

The American College of Sports Medicine (ACSM) defines moderate and high intensity exercise as 3.0 to 6.0 METS (3.5 to 7 kcal/min, 40-59% VO_2R/ HRR) and ≥6.0 METS (≥7 kcal/min, 60-85% VO_2R/ HRR), respectively (13). Exercise and physical activity that involves a shift from low to high intensity results in shifting of predominant energy systems. Oxidative phosphorylation is primarily utilized during low to moderate intensity exercise, while energy produced from glycolysis predominates during high intensity exercise (32). Glycolysis utilization during high intensity exercise yields accumulation of lactic acid. Once produced, lactic acid ionizes by releasing hydrogen ions and lactate. Hydrogen ions inside active muscles create an acidic environment (32). Research suggests that at high concentrations, hydrogen ions impair muscle function and energetics, consequently causing decreases in exercise performance (1, 4, 11, 14). To prevent this, methods have been evaluated to reduce BLa post exercise due to BLa's association with hydrogen.

BLa can be cleared by active and passive recovery (1, 4, 14). Strong evidence supports the need for dissipation of BLa following high intensity exercise to promote optimal subsequent performance (1, 4, 11, 14). Research suggests that the rate of BLa dissipation is greater during recovery with continuous aerobic physical activity (30%-70% Volume of maximal oxygen consumption (VO_2 max), 3-6 METS, or 50-80% max heart rate (HR_{max})) compared to passive recovery such as sitting in a chair for thirty minutes (3). A randomized crossover design study was conducted to investigate the effect of active recovery at several different intensities on subsequent performance of swimming trials (20). Participants were fourteen college-aged male swimmers from a university swim team. Participants had an average body mass of 84.4 $\pm$ 5.6 kilograms (kg). Each participant completed two 200-meter freestyle trials at maximum speed followed by a 15-minute recovery. The active recovery included swimming at lactate threshold (LT), 50% lactate threshold (LT.5), and 150% lactate threshold (LT 1.5). During passive recovery, the athletes remained lying down covered by a towel. The subjects who completed active recoveries recorded faster trials (seconds=s) in subsequent exercise bouts than those who completed passive recovery: passive = 0.64 +1.32 s, (LT.5) s= 0.53 +1.0 s, (LT) s= 0.26 -1.67 s, (LT1.5) s= 0.51 -0.07 s; $p < 0.0001$ for (LT).

Another study (1) examined power output and BLa clearance with active and passive exercise recoveries. Ten male participants completed repeated sprint bouts on a Monark cycle ergometer against increasing braking forces. These bouts were separated by five minutes of recovery. The active recovery included five minutes of cycling at 30% maximal anaerobic power. For passive recovery participants remained seated on the cycle for five minutes. Recovery intensity was calculated from an incremental aerobic exercise test that was performed during the initial visit. This study concluded that active recovery during repeated sprint bouts attenuates the plasma lactate concentration measured at high braking forces on cycle ergometer (active 5.66 $\pm$ 0.38 mmol l_{-1} vs passive 7.56 $\pm$ 0.51 mmol l_{-1}). Moreover, the decrease in BLa concentration with active recovery was accompanied by a parallel increase in the power output, active recovery vs passive recovery, 945 $\pm$ 56 watts vs 883 $\pm$ 58 watts, respectively.

The recovery process is of importance to athletes seeking to optimize performance during events involving repeated bouts of activity. Recovery methods such as swimming, running, walking, and cycling have been researched (1, 14, 20, 24); however, there is limited research on recoveries outside of these traditional modes of recovery. Exploration of non-traditional post-exercise recovery methods could lead to improvements in performance, greater decreases in muscular soreness, and quicker rates of BLa removal. A study by Monedero et. al (31), investigated the effects on massage therapy on post- exercise recovery. The authors sought to determine the effectiveness of BLa clearance after four different recoveries. Eighteen trained male cyclists age 25 ± 0.9 years, with body mass of 72 ± 1.6 kg reported for testing on six separate occasions over a three-week time frame. The initial test session involved a medical examination and a continuous graded exercise test (GXT). Average VO_2 max was 68 ± 1.7 ml/ kg/ min. The second test session consisted of a 5-minute warm-up, a 5 kilometer (km) maximal effort test, and a 10-minute cycling at a self-selected intensity. After this, subjects completed a 20-minute seated recovery and a subsequent performance of a second 5- km maximal effort test. This test session served to familiarize the subjects with the test protocol. On their third through sixth visits, subjects completed two 5- km cycle tests separated by one of four different recoveries.

The four 15-minute recovery interventions were passive, active, massage, and combined recovery; intervention sequences were randomized to eliminate bias. During passive recovery, following the initial 5- km time trial, the cyclist dismounted the bicycle and remained seated at rest on a chair for 15- minutes. Active recovery consisted of sub-maximal cycling at a load equivalent to 50% of individual $VO_{2\ max}$. Massage consisted of three basic manipulations (effleurage, stroking, and taponement) applied to the posterior part of the lower extremities in the supine position. The same certified masseur applied massage to all cyclists. Combined recovery consisted of pedaling at a sub-maximal load equivalent to 50% of $VO_{2\ max}$ for the initial 3.75 minutes of the intervention, followed by the massage application in the supine position for 7.5 minutes (3.75 minutes per leg), and finally cycling for the final 3.75 minutes at the same equivalent load. Performance capacities across recovery interventions were compared by computing the time difference ($t_2 - t_1$) of each 5- km cycling bout. The mean increase in time was significantly lower following combined recovery compared with the other interventions (Mean increases, Passive recovery= 9.9 ± 1.6 s; Active recovery =6.9 ± 1.3 s; Massage= 7.7 ± 1.5 s; Combined= 2.9 ± 1.5 s, $p < 0.05$). The findings from this study suggested the utilization of non-traditional recovery methods can be as effective in clearing BLa as traditional methods (28).

There are a variety of different forms of yoga. Traditionally, yoga has been described as a mind-body practice involving multiple integrated elements such as conscious control of breathing, postures, and meditation (29). However, yoga can also be viewed as an alternative mode of physical activity. Yoga research has produced positive effects on resting heart rate, blood pressure, flexibility, muscular strength, and power output (2, 18, 33). Hagins et. al (21) performed a study to determine if yoga met the physical activity guidelines of the ACSM. The study included 20 intermediate-to-advanced level yoga practitioners (18 females and 2 males). Average age, weight, height, and BMI for participants was 31.4 ± 8.3 years, 64.3 ± 9.0 kg, 165.2 ± 7.9 cm, and 23.58 ± 3.03, respectively. The yoga trial included a 30-minute resting period, during which subjects were seated and motionless. Following this, subjects began a 56-minute beginner Ashtanga yoga routine. The session began with 28 minutes of sun salutation poses (a standard series of moving poses found in Ashtanga and Vinyasa yoga), followed by 20 minutes of standing poses. Lastly, 8 minutes of siting and lying poses were performed. After completing the yoga session, subjects walked on a treadmill for 20 minutes. All exercise was performed in a human respiratory chamber (indirect calorimeter). Measurements for HR, energy expenditure (kcal), and METS were examined. Analyses of variance (ANOVAs) compared the mean rate of kcal, METs, and percentage of MHR% across all activities. Metabolic cost of yoga was low. Mean values were as follows: kcal/min= 3.2 $\pm$ 1.1; METs= 2.5 $\pm$ 0.8; and MHR% 49.4 $\pm$12.2, $p < 0.0001$. These values were not significantly different from walking on the treadmill at 2 mph. The METs for the entire yoga session were lower than the recommended ACSM physical activity guidelines. However, average METs for the 28 minutes of sun salutations were 3.2 $\pm$ 1.1 kcals/ minute, ($p < 0.0053$), suggesting that some forms of yoga can potentially be classified as moderate intensity exercise.

Vinyasa yoga is growing in popularity because of its ability to increase and sustain a relatively high HR, engage the musculoskeletal system for benefits in muscular strength, and incorporate elements from all schools of yoga, including sun salutations (2, 18, 33, 34). Vinyasa yoga, similar to Ashtanga yoga, links continuous sequences through breathing cues. Ashtanga uses a proscribed sequence of poses that are taught the same way in every class, whereas vinyasa is more flexible and includes several different poses and postures at a faster pace (35).

Research supports the effectiveness of post exercise recovery protocols on BLa clearance and subsequent exercise performance (1, 4, 11, 14). This research also suggests that the use of different modes of physical activity being beneficial for BLa (31). For optimal performance it is recommended that recoveries involve continuous aerobic activity at 30-70% VO_2 max (3, 31).

Vinyasa yoga employs controlled breathing through variations of static stretching and dynamic muscular contractions and has potential to be utilized as a post-exercise recovery protocol (34).

Purpose of Study

The aim of this study was to determine differences in BLa clearance following a high- intensity exercise between a yoga session and treadmill recovery.

Hypothesis

Treadmill walking and running have a positive relationship with removal of blood lactate. Recent works suggest that yoga can provide energy requirements similar to that of walking or running on a treadmill at a slow pace. The null hypothesis suggests that there would be no difference in blood lactate clearance during a yoga recovery as compared to a treadmill recovery.

CHAPTER 1

REVIEW OF THE LITERATURE

Blood Lactate and exercise

The blood lactate (BLa) response to exercise has interested physiologists for many years and has recently become a routine measurement in many exercise laboratories (23). In the past BLa was measured via arterial and venous sampling, which required trained clinical technicians performing a venipuncture (6). Due to new technology BLa is now measured with portable lactate analyzers. The portable analyzers have been found to be practical and produce essentially the same values for BLa compared to more sophisticated BLa analyzers (23).

During prolonged exercise at a constant intensity, rates of oxygen uptake and carbon dioxide output tend to be constant (32). Therefore, during long bouts of exercise, energy (adenosine triphosphate-ATP) requirements are constant. The energy required to perform long term exercise is produced primarily from aerobic metabolism, or more specifically, the use of the oxidative phosphorylation system. However, a shift in energy requirements from low to high-intensity requires a change in the predominant energy system. The systems primarily responsible for energy production during high- intensity exercise is the phosphagen system (ATP-PC) and glycolysis. Glycolysis results in the production of ATP and pyruvic acid or lactic acid (32). When a person transitions from low- intensity exercise to high- intensity exercise, the result is a sudden rise in lactic acid and an increased reliance on glycolysis compared to oxidative phosphorylation. In addition to this increased reliance on glycolysis, the rate of lactic acid removal is much slower than the rate of production (32).

Several studies have documented a positive relationship between BLa and HIE (1, 4, 14, 20, 24). Haverty et. al (22) compared $\dot{V}O_2$ max to the running velocity at which the lactate threshold (LT), ventilatory threshold (VT), maximal steady state $\dot{V}O_2$ (MSS$\dot{V}O_2$), and maximal steady state lactate (MSSLA) occurred in 11 trained male runners. For this study runners completed an incremental treadmill test to exhaustion. The subjects also completed a series of steady state treadmill runs for a duration of 20-minutes, as well as a 5-kilometer (km) time trial run. There was a significant correlation between MSS$\dot{V}O_2$ and MSSLA, MSSLA and MSS$\dot{V}O_2$ (r = 0.74) expressed as $\dot{V}O_2$; and between MSSLA and MSS$\dot{V}O_2$ (r = 0.90), MSS$\dot{V}O_2$ and VT (r = 0.70), and MSSLA and VT (r = 0.67) expressed as velocity. A stepwise regression analysis found MSSLA to be the best predictor of 5- km performance (r = 0.87). The researchers concluded that MSSLA and MSS$\dot{V}O_2$ are closely related.

The terms are BLa and lactic acid are often used interchangeably. However, they are not the same. Lactic acid is produced at the end of glycolysis, especially during HIE. Lactic acid cannot be utilized by the body; therefore, the muscle breaks it down to form lactate and hydrogen ions. These hydrogen ions can negatively affect muscle physical performance and exercise capacity (32). Because BLa formation results in production of hydrogen, BLa is associated with impaired muscle contractions and muscular discomfort (32). The impairments and discomforts caused by BLa can have a negative impact on physical performance and exercise capacity. Therefore, exercise scientists have investigated how to promote removal of BLa during post exercise (1, 14, 20, 24, 30).

Blood Lactate Recovery and Various Recovery Methods

Recovery is essential during any type of physical activity or exercise. An effectively executed recovery reduces BLa, reduces muscular soreness, and gradually helps HR and breathing return to normal levels (32). In an attempt to evaluate BLa clearance following exercise, a study was conducted with ten moderately trained adult males (30). Average age, height, weight, and $\dot{V}O_{2\ max}$ was 21.1 $\pm$ 0.4 years, 181 $\pm$ 2 cm, 75.3 $\pm$ 2.8 kg, and 56.6 $\pm$ 1.4 ml/kg/min. These moderately trained individuals completed two 30- second all-out runs at 90% of $\dot{V}O_{2\ max}$ which increased BLa concentration from 1.0 ± 0.1 mmol l_{-1} to 3.9 ± 0.3 mmol l_{-1}. Immediately after maximal exercise, subjects performed recovery bouts, each randomized to either of 100%, 80%, 60%, 40%, or 0% (complete rest for passive recovery) of the individual LT. LT was defined as the point at which lactate rose above resting levels (32). Capillary blood was sampled by finger pricks for analysis of BLa before and after the warm-up, at the end of the maximal exercise, every minute for the first five minutes of the recovery, and every four minutes thereafter during the active or passive recovery bouts until BLa returned to baseline. The repeated BLa measurements showed active recovery at 60% of LT cleared BLa at a faster rate than either active recovery at 40% of lactate threshold, or passive recovery. There was no difference between 40% of LT and passive recovery or faster clearance of BLa during active versus passive recovery. Recoveries at 100% and 80% LT were significantly different than 60% and 40% of LT ($P < 0.05$). Recoveries at 60% and 40% LT were significantly different from passive recovery (0% of lactate threshold; $P<0.01$), suggesting exercise recovery should be performed at at 40% LT or higher.

Running, cycling, and soccer represent athletic events that require high- intensity training (32). Swimming is another high- intensity performance sport. Swimmers perform strokes through water in a repetitive manner. These repetitive strokes have potential to cause elevated BLa levels. To examine the effects of active versus passive recovery on BLa clearance, a study with 14 swimmers from a college swim team was conducted (20). Each swimmer completed a lactate profile session during which swimming speed at LT was determined. Swimmers also completed four randomly assigned experimental sessions that consisted of a 200- yard maximal-effort swim (T1) followed by ten minutes of recovery and a subsequent 200- yard maximal effort swim (T2). Active recovery intensities were set at lactate threshold (LT), 50% lactate threshold (LT.5) and 150% lactate threshold (LT 1.5). The conclusion was that only active recovery modes increased performance during the second maximal swim trial (T2- T1): passive s = 0.64 +1.32, (LT.5) s= 0.53 +1.0 s, (LT) s= 0.26 -1.67s, (LT1.5) s= 0.51 -0.07s; $p < 0.0001$ for (LT).

A direct link between muscular function and lactate accumulation has not been made. However, strong correlations between the two are evident, and the ability to exercise at high-intensities is negatively impacted when exercising above LT (32). This serves as an indirect link between BLa and muscular function. Consequently, research has evaluated the intensity of recovery and removal of BLa, as well as investigated optimal methods of recovery.

Monedero et. al (31) set out to determine if there was a better method of post-exercise recovery compared to walking or running for BLa clearance. Instead of investigating traditional recovery methods Monedero et. al examined an active recovery of 50% $\dot{V}O_2$ max, combined active and massage, passive, and a massage only groups for BLa clearance. The study included 18 trained cyclists. Each cyclist completed an GXT to determine $\dot{V}O_2$ max, as well as two 5-kilometer maximal effort cycling tests separated by a 20-minute recovery. Active recovery was performed by cycling at 50% of individual $\dot{V}O_2$ max. Massage manipulations were performed on posterior lower extremities in the supine position following sub-maximal cycling at 50% $\dot{V}O_2$ max for combined recovery, and immediately after maximal effort cycling for massage only recovery. During passive recovery the cyclist dismounted bike and remained seated in a chair. Performance time for the cycling test, HR, and BLa were measured every 3 minutes during recovery. The study found active recovery with massage was most effective at clearing BLa. Mean increases in 5- km time trial were significantly lower following combined recovery (9.9s ± 1.6s, 7.7s ± 1.3s, 7.7s ± 1.5s, and 2.9s ±1.5s, $P < 0.05$ for passive, active, massage, and combined interventions, respectively). BLa removal was also more rapid for the combined intervention (0.37 ± 0.03, 0.38 ± 0.04,0.21 ± 0.04, and 0.16 ± 0.06 $mM \times min^{-1}$, $p < 0.01$ for active, combined, massage, and passive interventions, respectively). The authors concluded that the exact mechanism by which combined recovery induced the best maintenance of performance capacity was unclear. However, it was hypothesized the massage created an increased arterial flow and venous compliance. This study is important because it introduced non-traditional active recovery modes.

Yoga

Yoga originated in India more than 5,000 years ago (29). In its original form, yoga was a complex system of spiritual, moral, and physical directives. The purpose of yoga practice was attaining "spiritual self-realization" (29). Outside of the spiritual-mind body approach, yoga is also used for improving muscular strength, weight loss, flexibility and posture (2, 18, 33). It was around 1960 when the practice of yoga postures and breathing techniques began to grow in popularity in the United States (29). Since then, yoga has been made popular through entertainment, sports, and celebrities. A variety of populations participate in yoga, including senior citizens, pregnant women, and children. In 2015, a study reported that 21 million Americans used yoga as an exercise modality (10). With the emergence of research demonstrating the benefits to cardiovascular health, the number of practitioners continues to increase (10, 21).

Although millions of Americans participate in yoga, others question the effectiveness of it as an everyday exercise modality (21). In a recent attempt to clarify those questions a systematic review was conducted to analyze energy cost and metabolic intensity of yoga (27). The authors surveyed PubMed and cross checked with the Web of Science using the general terms ‘‘yoga’’ and ‘‘energy expenditure’’ with no date limitations. To be included, articles had to use indirect calorimetry to calculate kcals from measures of VO_2 and carbon dioxide production. Key variables of interest, including absolute and relative VO_2, kcals, MET values, HR, respiratory rate, and rate of perceived exertion, were evaluated and summarized from each identified article, and the references were scanned for additional manuscripts not identified in the initial literature search. Thirteen manuscripts were initially identified with an additional 4 located from the review of manuscript references. Out of the 17 studies, 10 evaluated the METs for a full yoga session. METs for yoga averaged 3.3±1.6 METs. This review suggested that yoga can typically be classified as a light-intensity physical activity. However, a few sequences/poses, including Surya Namaskar, met the criteria for moderate- to vigorous-intensity activity.

In 2012, a study was conducted to evaluate yoga and what effects it may have on cardiovascular functioning (10). The study included 50 healthy volunteers with no previous experience with yoga. Base values of cardiovascular, pulmonary, autonomic function tests, lipid profile, and thyroid function tests were recorded before yoga training and were reassessed for post-yoga changes after 41 days. The yoga course of 41 days included meditation, body awareness, controlled breathing exercises, and relaxation. The 75- minute daily yoga practice included 10 minutes of Savasana, 5 minutes of Pranayama (controlled breathing), 35- 45 minutes of Asana, 10 minutes of meditation (traditional audio-guided meditation), and 10 minutes of Savasana. After yoga practice there was a significant reduction in the mean arterial blood pressure (2.37% p< 0.05), resting HR (pre- 76.94 ± 10, post- 73.74 ±7.80, p< 0.001), systolic blood pressure (pre- 120 ± 10, post- 117 ± 10 p< 0.001), diastolic blood pressure (pre- 80.44 ± 6.73, post- 79.24 ± 5.71, p< 0.001), and mean blood pressure of the participants (pre- 93.67 ± 7.70, post- 91.75 ± 6.53, p< 0.001).

Sherman et. al compared kcals during a single bout of vinyasa yoga and two walking protocols (35). Twenty males and 18 females performed a 60-minute session of vinyasa yoga, treadmill walking at self-selected brisk pace (SELF), and treadmill walking at a pace that matched the HR of the yoga session (MATCH). The results revealed a significantly lower energy expenditure (kcal) with yoga as compared to HR matched and self-selected treadmill walking (difference = 79.5 ± 44.3 kcal; p < .001) and SELF (difference = 51.7 ± 62.6 kcal; p < .001). Although the kcals were significantly lower, the rate of perceived exertion for yoga was much higher than the walking interventions (SELF= 11.9 ± 1.4; MATCH= 12.6 ± 1.9; YOGA= 13.7 ± 1; p < .001). This study found that yoga did meet the criteria for moderate-intensity physical activity (yoga measured at approximately 4 METS, with moderate-intensity physical activity defined as 3.0 to < 6.0 METS).

Similar to the study by Sherman (35), Hagins et. al (21) investigated whether a yoga session using various postures met the current recommendations for levels of physical activity required to improve and maintain health and cardiovascular fitness. Another goal for this study was to compare the METs of yoga practice to that of treadmill walking. Hagins et. al (21) evaluated intermediate-to-advanced level yoga practitioners (<1year experience doing yoga). The mean demographic values for the 20 participants were: age 31.4 ± 8.3 years, height 165.2 ± 7.9 cm, weight 64.3 ± 9.0 kg, and BMI of 23.58 ± 3.03. Participants were instructed to perform 30-minutes of sitting, 56-minutes of beginner-level hatha yoga, and 10- minutes of treadmill walking. With the hatha yoga, practitioners performed 24 minutes of sun salutations. Sun salutations are signature sequences in vinyasa yoga (34). Measures for $\dot{V}O_2$, HR, percentage predicted maximal heart rate (MHR%), METS, and energy expenditure were taken. Average values across the entire yoga session for $\dot{V}O_2$, HR, MHR%, METs, and energy/min were 0.6 $\pm$ 0.2 L/kg; 93.2 $\pm$ 25.9 beats/min; 49.4 $\pm$ 12.2 %; 2.5; and 3.2 $\pm$ 1.1 kcal/min, respectively. The METs for yoga across the entire session represented a low intensity of physical activity, similar to walking on a treadmill at 3.2 kph (kilometers per hour). Average HR across the entire yoga session was 93.2 $\pm$ 25.9 beats per minute (bpm), whereas the sun salutation yielded HR of 103.5 $\pm$ 24.2 bpm. From these results the authors concluded that yoga does not meet the requirements for maintaining health or cardiovascular fitness. However, yoga along with the sun salutation postures was comparable to the recommended minimum values for moderate intensity exercise.

Current evidence suggests stretching causes a significant macro- and microcirculatory event that alters blood flow and the relationship between oxygen availability and oxygen utilization, reducing arterial stiffness (25). These acute vascular changes may result in reduced arterial blood vessel stiffness and increased blood flow (10). Monedero et. al (31) hypothesized that massage therapy may have increased the rate of BLa clearance by increasing arterial blood flow. Since vinyasa-like yoga incorporates high- and low-intensity bouts, as well as periods of static stretching, it can also be hypothesized that yoga enhances arterial blood flow and has the potential to clear BLa at a faster rate than a more traditional exercise recovery (27, 34).

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CHAPTER 2

COMPARISON OF TWO DIFFERENT MODES OF ACTIVE RECOVERY ON BLOOD LACTATE CLEARANCE

ABSTRACT

Research suggests using a combination of active cool down, at both high and low intensities (1, 9, 13, 20, 26). Vinyasa-like yoga incorporates high- and low-intensity bouts as well as periods of static stretching; however, no research has examined the effect of yoga on blood lactate (BLa) clearance and active recovery. This study investigated the differences in BLa clearance following a high- intensity exercise bout comparing a yoga session and a treadmill recovery (TR) using a random cross-over design. Fifteen physically active males and females aged 21.7 ± 1.2 years, with an average $\dot{V}O_2$ peak of 48.1± 9.2 ml/kg/min were recruited. Participants reported to the laboratory on three separate days. On day one, anthropometrics were measured and participants completed a graded exercise test (GXT) wearing the Cosmed K5 portable metabolic system and a Garmin heart rate (HR) monitor. On days two and three, participants completed two 4-minute bouts of treadmill exercise at 80%-90% heart rate max (HR_{max}) followed by either a TR or a modified vinyasa yoga recovery (YR) lasting twenty minutes at 35%-60% of heart rate reserve (HRR). BLa was collected from the ear via capillary blood samples pre-exercise, post-exercise, and every three minutes during recovery. Dependent t-tests revealed no significant difference in BLa clearance between TR and YR at any point during recovery 3-min. (t= -.540, df= 14`, p= 1.682), 6-min. (t= .168, df= 14, p= 1.466), 9-min. (t= .582, df= 14, p= 1.280), 12 min. (t= 1.014, df=14, p= 1.288), 15 min. (t= -.131, df= 14, p= .613), 18 min. (t= -718, df= 14, p= .411), 20 min. (t = -2.034, df = 14, p = .035). These findings suggest that performing yoga promotes similar BLa clearance to treadmill walking and is therefore a potential exercise mode for high-intensity exercise recovery.

KEY WORDS acidity, fatigue, subsequent performance, yoga

INTRODUCTION

It is well known that exercise of varying intensity involves the use of different bioenergetic pathways (28). During prolonged exercise at constant intensity, there is a steady rate of oxygen consumption ($\dot{V}O_2$) as well as carbon dioxide output (28). Therefore, during long bouts of exercise, energy (adenosine triphosphate-ATP) requirements are relatively balanced. The energy required to perform long duration exercise is produced primarily from aerobic metabolism, or more specifically, the use of the oxidative phosphorylation system. During higher intensity exercise, ATP production is needed at a much faster rate, and the predominant energy system shifts from oxidative phosphorylation to glycolysis. Glycolysis results in the production of ATP and pyruvic acid or lactic acid (28).

Glycolysis utilization with insufficient oxygen consumption during high- intensity exercise primarily results in production of lactic acid. The body breaks this lactic acid down into a usable substrate of energy, lactate and hydrogen ions. Both lactate and hydrogen ions have been related to impaired muscle contractions and muscular discomfort (28). The impairments and discomforts caused by blood lactate (BLa) can have a negative impact on physical performance and exercise capacity (1, 4, 9, 13). Consequently, exercise practitioners have explored several different recovery methods to clear BLa following exercise. A properly performed recovery clears BLa, reduces muscular soreness, and lowers heart rate (HR) to resting levels (9, 28).

Research suggests incorporating a light to moderate intensity cool down to aid in removal of BLa post exercise (1, 9, 13, 16, 20, 26). The American College of Sports Medicine (ACSM) defines light and moderate intensity exercise as ≤ 3.0 METS (≤3.5 kcal/min, 20-39% $\dot{V}O_2R$/HRR) and 3.0 to 6.0 METS (3.5 to 7 kcal/min, 40-59% $\dot{V}O_2R$/ HRR) respectively (12).

Several different recovery methods have been researched, including cycling, swimming, running, and walking (1, 13, 17, 20). It has been suggested that most effective recovery interventions for removing BLa include continuous aerobic activity at 30-70% $\dot{V}O_2$ max (3).

Yoga is an increasingly popular form of exercise. In fact, yoga participation in the United States reportedly increased from 20.4 million practitioners in 2012 to 30.6 million in 2016 (8). Despite the growth in popularity, research on yoga as a recovery method is limited. Existing research suggests yoga, more specifically vinyasa-like yoga, meets physical activity guidelines for light to moderate physical activity, yielding HR of 30%-60% heart rate max (HR_{max}) (18). With peak BLa removal occurring around 30-70% $VO_{2\ max}$, yoga is a potential recovery method as it involves variations of static stretching and poses as well as dynamic muscular contractions (30). The purpose of the present study was to investigate the difference in BLa clearance following a high intensity exercise bout comparing a yoga and a treadmill recovery.

METHODS

Experimental Approach to the Problem

This study was designed to examine the differences in two different recovery modes, yoga recovery (YR) and treadmill recovery (TR), on BLa clearance. This study had a cross-over design in which participants underwent both exercise recoveries in a randomized order. Each test session was separated by at least 48 hours. On day one, participants completed a graded exercise test (GXT) to determine maximal heart rate (HR_{max}). On days two and three, participants completed two 4-minute bouts of treadmill exercise at 80%-90% HR_{max} followed by either a TR or YR. Recovery lasted twenty minutes and intensity was between 35%-60% of heart rate reserve (HRR). BLa was measured pre-exercise, post-exercise, and every three minutes during each recovery and compared for statistical significance.

Subjects

Fifteen physically active participants (age 21.7 ± 1.2 years, height 172.5 ± 9.4 cm, weight 71.3 ± 11.3 kg) with average $\dot{V}O_2$ peak of 48.1± 9.2 ml/kg/min and body fat (BF%) of 16.6 ± 9.6% were recruited for this study from a local university. The following were criteria for acceptance: currently physically active, between ages of 18 and 45, and in general good health. General good health was defined as having no known cardiovascular disease and absence of all signs and symptoms suggestive of cardiovascular disease (12). Participants completed a screening questionnaire where self-reported exercise participation was recorded (Appendix B). Before any participation, experimental risk was explained, and informed consent documents were signed (Appendix C). Participants were asked to avoid exhaustive exercise 48 hours prior to participating, and to avoid foods and fluids except water within 2 hours of all laboratory visits. All procedures involved in this study were reviewed and approved by the university's Institutional Review Board.

Procedures

This study required completion of three laboratory sessions, each lasting 60-90 minutes separated by 48-72 hours. The following describes activities for each session:

Session 1. Metabolic and body composition evaluation. Height (using a wall-mounted Stadiometer Pro Doc Detecto scale, Missouri, US) was obtained and measured in centimeters (cm) to the nearest tenth. For height measurement subjects removed shoes and had their back against the wall, with hands on their sides. Weight was recorded in kilograms to the nearest tenth using a calibrated digital scale (Tanita BWB-800A, Tanita Corp., Tokyo, Japan). Body fat percent (BF%) was measured via BodPod (COSMED The Metabolic Company, Rome, Italy). The BodPod estimates BF% using air displacement plethysmography technology (ADP).

Each subject completed a graded exercise test (GXT) on a treadmill (Trackmaster, Full Vision, Inc., Carrollton, TX) to establish peak oxygen consumption ($\dot{V}O_2$ peak). The Bruce Protocol (12) was used in which the treadmill speed and grade increased every three minutes. $\dot{V}O_2$ peak was measured using a Cosmed K5 Portable Metabolic System (COSMED The Metabolic Company, Rome, Italy). A Garmin HR monitor was worn to measure and record HR at rest, during all exercise, and immediately post- exercise. Resting heart rate was used to calculate intensity ranges for all exercises. Rating of perceived exertion (RPE) was also recorded during the last thirty seconds of each stage using Borg RPE scale (7). $\dot{V}O_2$ peak was recorded as plateau in oxygen consumption during maximum physical effort. BLa measurements were taken pre-test, at the beginning of stages two and three of GXT, and immediately after GXT. BLa samples were collected aseptically via capillary blood sample using a valid and reliable analyzer, the Nova Biomedical lactate plus analyzer (5, 6, 22). BLa measurements were sampled from the ear to avoid any complications from the finger during yoga. Earlobe samples have potential to be as accurate as fingerstick measurements (14). The Lactate plus analyzer required 0.7 µl of blood. BLa was measured in 13 seconds and all waste was disposed of in biohazard containers.

Session 2 &3. Consisted of two four-minute HIE bouts on the Trackmaster treadmill. Exercise intensity was set at 90% $\dot{V}O_2$ peak as determined by the $\dot{V}O_2$ peak test. Oxygen and carbon-dioxide fractions were continuously sampled with a Cosmed K5 Portable Metabolic System during HIE bout and all recoveries. Following the HIE bout, subjects completed a recovery protocol. A cross-over design was used, and subjects performed either a YR or TR in a random sequence. Recovery bouts lasted approximately 20 minutes, with the intensity of recovery set at 30%-45% HRR for both recoveries (12). HRR was calculated using the Karvonen formula (12, 31). BLa measurements were recorded prior to exercise, immediately after the first and second HIE bout, and every three minutes during recovery for both yoga and treadmill recoveries.

During the yoga session, participants performed the yoga sequence while wearing the Cosmed K5. The yoga followed a vinyasa- like sequence and a recording of an Experienced Registered Yoga Teacher (ERYT) with 500-hours of specialized yoga training (> 2,000 teaching hours) was shown to demonstrate the sequence. During the recording the ERYT also gave verbal cues for breathing. Participants were advised to perform poses to the best of their ability, and modifications were suggested when appropriate to reduce the risk of injury. The vinyasa- like sequence for this study was created by an ERYT who specializes in training professional athletes. The sequence was developed to minimize injury, especially for those who had not previously practiced yoga. Along with this consideration, the yoga sequence utilized movements that could be completed while wearing the Cosmed K5 portable metabolic system. BLa measurements were taken at the earlobe because they were easily accessible. YR was also designed to keep heart rate within 30-45% HRR for moderately trained individuals. The yoga sequence is shown in Appendix A. Time duration of the yoga video consisted of 20 minutes of active recovery. The TR intervention consisted of jogging or walking on the treadmill at 30%-45% HRR. The Cosmed K5 portable metabolic system was also worn during the TR.

During the third and final visit, subjects completed the same HIE running protocol as in their second visit. For consistency, BLa was measured pre-exercise, immediately after the first and second HIE bout, and every three minutes during recovery. If subjects completed YR on their second visit, TR was completed on the final visit. Likewise, if TR recovery was completed on the second visit, YR was completed on the final visit.

Statistical Analyses

Statistical analyses were completed using SPSS for windows software (release 25.0; SPSS, Inc., Chicago, IL, USA). First, the required sample size of 15 was determined by prospective statistical power analysis using G*Power 3.1.9.2 (11). Second, because YR could have produced higher energy expenditure depending on level of yoga practitioner, mean $\dot{V}O_2$ and mean METS between the two recovery groups were compared using repeated measures analysis of variance (ANOVA). To test for the study's main hypothesis regarding the differences in BLa clearance between YR and TR following a HIE bout, dependent t-tests were used to compare the mean difference at each BLa collection point: pre-exercise, post-exercise, and every three minutes during recovery. Significance was set at $p < .05$. BLa between YR and TR at each collection point was compared with dependent t-tests, using the Bonferroni-adjusted alpha level of $p < .006$. After analyzing the dependent t-test, Cohen's *d* was calculated to determine the effect size (ES) of the mean differences in final BLa. The following values were used to determine the magnitude of the ES: trivial = ES < 0.2; small = 0.2-0.6; moderate = 0.6-1.2; large = 1.2-2.0; and very large > 2.0 (18).

RESULTS

The sample size for the current study was 15 participants. The study began with 17 total participants, however one participant dropped out after completing the first lab visit and a second dropped out due to an unrelated injury. All participants' descriptive characteristics are present in **Table 1**. Data is presented as means $\pm$ standard deviation (SD). There was no significant difference in anthropometrics (age, height, weight, and BF%) between males or females ($p < 0.05$). There was also no significant difference between $\dot{V}O_2$ peak or HR_{max} between males or females ($p < 0.05$). A paired sample t-test showed no significant difference in BLa pre (t=-1.693, df= 14, p= 0.317) or post (t= -0.841, df= 14, p= 0.961) HIE, demonstrating that HIE was consistent on both days of testing. After each participant completed all three experimental trials, paired sample t-tests were conducted to compare BLa clearance for TR and YR. These tests showed no significant difference in BLa post recovery (t= 2.855, df= .737, p= -.620). Furthermore, dependent t-tests revealed no significant difference in BLa clearance between TR and YR at any point during recovery: 3-min. (t= -.540, df= 14`, p= 1.682), 6-min. (t= .168, df= 14, p= 1.466), 9-min. (t= .582, df= 14, p= 1.280), 12 min. (t= 1.014, df=14, p= 1.288), 15 min. (t= -.131, df= 14, p= .613), 18 min. (t= -718, df= 14, p= .411), 20 min. (t = -2.034, df = 14, p = .035) **Figure 1**. However, further analysis revealed that TR plateaued at 18-minutes (TM BLa 18- min= 2.560± 1.512, TM BLa Final= 2.560± 1.550), while YR continued to decrease (yoga BLa 18-min= 2.353±1.194, yoga BLa Final= 1.960± .914). Statistically there was no difference in BLa between TR and YR at the final recovery point (t= -2.034, df=14, p= .354), but the results from the ES analysis revealed a moderate ES (Cohen's d= 0.79).

In attempts to understand why YR displayed a faster rate of BLa clearance, a one-way Analysis of Variance (ANOVA) was performed to compare mean $\dot{V}O_2$ for both recovery groups.

The ANOVA revealed that the TR $\dot{V}O_2$ was significantly higher (20.28 ± 2.41 ml/kg/min) than YR $\dot{V}O_2$ (14.58 ± 1.86 ml/kg/min) ($F(1, 28) = 50.524$, $p = .000$). Another ANOVA was performed to compare mean METS between the two recovery groups. This analysis also revealed a significant difference in METS between groups ($F(1, 28) = 54.85$, $p = .000$), with a mean value of 5.75 ± .73 METS for TR and a mean value of 4.13 ± .43 METS for YR. These findings suggest TR required a higher energy expenditure than YR.

DISCUSSION

Several theories have been proposed to explain the mechanisms behind how BLa negatively impacts exercise (1, 4, 9, 13). Although it is still being researched, it is evident that active recovery clears BLa more effectively than passive recovery and yields a greater performance in subsequent activity (1, 4, 9, 13). The aim of the current study was to examine the differences in BLa clearance following a HIE, comparing a YR and TR. Similar to previous studies (1, 3, 16, 17, 19, 20, 24, 26, 27) HIE was performed to elevate BLa levels. The results of this investigation support current research suggesting that active recovery clears BLa (1, 3, 16, 17, 19, 20, 24, 26, 27). The findings in this investigation also support Monedero et. al (27) theory for the exploration of non-traditional modes of exercise recovery post HIE. The observation that both recovery modes cleared BLa was hypothesized. However, if there were three groups, one of which a control group involving a passive recovery, it could have possibly provided a stronger relevance for YR rather than just comparing to TM since BLa can also be cleared with a passive recovery, or cessation of exercise (26, 27).

During HIE BLa was collected from the ear via capillary blood samples pre-exercise, post-exercise, and every three minutes during recovery. All participants experienced a significant increase in BLa concentration from the beginning of exercise (1.7 mmol l_{-1}) to post exercise (7.49 mmol l_{-1}). Other studies (9, 16, 20, 30) exhibited higher BLa increases with HIE. This is likely due to the difference in populations, as a highly trained individual will have a higher BLa increase compared to a moderately trained individual. Present research investigating recovery methods and BLa utilize participants who are endurance trained athletes (cyclists, swimmers, and distance runners) (1, 13, 16, 17, 20). Participants for the current study self-reported moderate level physical activity ≥ 3 d/wk. None of the participants reported high levels of endurance training, or any type of sport specific training. However, participants actively participated in walking/jogging, weightlifting, swimming or yoga **TABLE 2.** Participants also self-reported level of practitioner of yoga (beginner, intermediate, or advanced) and all prior yoga exercise (Appendix B). Only one participant identified herself as intermediately trained in yoga while others reported a beginner level. In addition to this, only four participants reported prior yoga training. Of those four, only two participants reported yoga training more than twice prior to this study. The majority of literature on yoga utilizes intermediate to advanced level yoga practitioners (2, 8, 18, 23, 29). To isolate the effects of yoga and BLa clearance, future research should investigate BLa clearance on participants who are aerobically trained and regularly engaged in yoga exercise.

Although the current study has limitations, the data supports yoga as a potential post-exercise recovery mode. As mentioned, TR plateaued at 18-minutes of recovery (TM BLa 18-min= 2.560± 1.512, TM BLa Final= 2.560± 1.550), while YR continued to decrease (yoga BLa 18-min= 2.353±1.194, yoga BLa Final= 1.960± .914). Statistically there was no difference in

BLa between TR and YR at the final recovery point ($t= -2.034$, $df=14$, $p= .354$), but the results from the ES analysis revealed a moderate ES (Cohen's $d= 0.79$) suggesting practical significance. A possible explanation for this could be that TR required a higher energy expenditure than YR. Another explanation could be the stretching utilized during yoga. Kruse et. al (21) performed a literature review on studies that examined blood flow during stretching and found that it causes acute increases in blood flow and reductions arterial stiffness. This literature review supports Elson et. al's (10) results that yoga actively contracts the muscles and increases blood flow and levels of hemoglobin and red blood cells which allows for more oxygen to reach the body cells, enhancing their function. While several theories can be made, a larger sample size may be necessary to further investigate these findings.

An active recovery promotes BLa clearance via increased use of lactate as a fuel by the heart and contracting skeletal muscle (9, 28). Because yoga increases blood flow, engages dynamic muscular contractions, and provides several other cardiometabolic and musculoskeletal benefits (8) it is proposed that yoga could be an impactful post exercise cool down. Yoga also yields potential benefits for blood pressure, muscular strength, resting heart rate, and power. In addition to this, yoga also increases flexibility (15).

During this study, a sit-and-reach test (32) was also performed to assess flexibility both before exercise and after each recovery on visits two and three. The sit-and-reach test is a valid and reliable test to measure hamstring flexibility (25, 32). During the test the subjects sat at the sit-and-reach box and fully extended one leg so that the sole of the foot was flat against the end of the box. The subjects bent the other leg so that the sole of the foot was flat on the floor with the knee and hip at 90° and 45°, respectively. They placed the right hand over the left, and slowly reached forward as far as they could by sliding their hands along the measuring board.

The sit-and-reach was administered with each leg extended in a counterbalanced order to ensure that asymmetry would not bias the test results (25).

The difference in reach length before exercise and after recovery was determined and compared between YR and TR. Participants had a significant improvement ($p < .0125$) in reach length from pre-exercise to post-recovery for both YR and TR, with participants reaching 1.77 cm (right leg) and 2.03 cm (left leg) farther after YR compared to pre-exercise, and 1.30 cm (right leg) and 1.05 cm (left leg) farther after TR compared to pre-exercise. Furthermore, participants improved by .470 cm more following YR than TR on the right leg and by .977 cm more following YR than TR on the left leg. However, the difference in improvement between recovery methods was not significant (right leg: $t = 1.256$, $df = 14$, $p = .230$; left leg: $t = 1.967$, $df = 14$, $p = .069$). Nevertheless, the finding of a nearly 0.5 cm to 1.0 cm greater improvement following YR compared to TR suggests that YR may have a practical difference in its effects on flexibility compared to TR. Future studies should examine the effects of YR compared to TR as the sample size in this study may have been too small to find statistical significance. Additionally, the present study did not measure sit-and-reach immediately post-exercise, so future studies could also examine the differences in flexibility improvements after HIE between YR and TR.

In conclusion, there was no significant difference in BLa clearance between twenty minutes of a modified vinyasa yoga session and twenty minutes of treadmill walking following two four-minute bouts of HIE ($t = -2.034$, $df = 14$, $p = .035$). This research finding suggests that vinyasa yoga promotes similar BLa clearance to treadmill walking and is therefore a potential exercise mode for HIE recovery.

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GRAPHS, TABLES, AND FIGURES

TABLE 1. Subject characteristics

Variable	Men	Women	Combined
Age (yrs)	21.8 ± 1.3	21.7 ± 1.3	21.7 ± 1.2
Weight (kg)	77.9 ± 9.0	63.8 ± 9.2	71.3 ± 11.4
Height (cm)	178.1 ± 8.9	166.9 ± 5.2	172.5 ± 9.4
BF%	10.5 ± 7.1	22.8 ± 7.3	16.6 ± 9.6
$\dot{V}O_2$ peak (ml·kg·min)	53.2 ± 7.7	43 ± 7.5	48.1 ± 9.2
HR_{max} (bpm)	186.5 ± 12.8	191.2 ± 6.9	188.6 ± 11.3

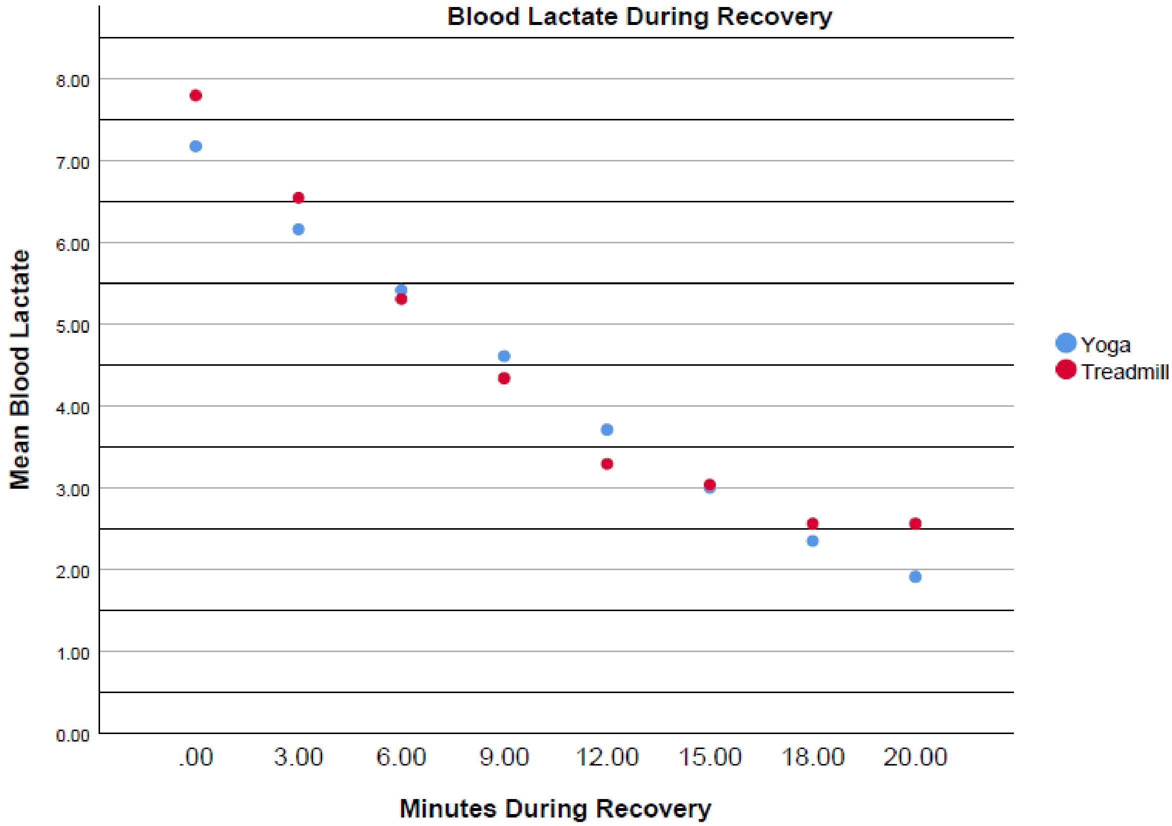
Values are means ± SD.

BF%= Percent body fat

TABLE 2. Physical activity participation

FORMS OF EXERCISE	Number of participants
Jogging/ Running	13
Weightlifting	13
Yoga	1
Walking Swimming	5
Swimming	1
Jogging/running and swimming	1
Jogging and weightlifting	11

Figure 1. Blood Lactate During Recovery



Appendix A.

Yoga Description

Intro
Mountain pose
Ragdoll
Chair Pose*
High Lunge*
Warrior 3*
Warrior 2*
Radiant Warrior*
Warrior 2*
High Lunge*
Chair Pose*
Diamond Pose (inhaling and exhaling rounding and extending spine
Forward fold
Mountain Pose
Standing Side Stretch
Downward Dog
High Plank
Camel Pose
Cat Pose
Seated Twist
Butterfly Pose
Forward Fold
Seated breathing

* Indicates poses that were repeated as part of the vinyasa- like sequence

Appendix B

Screening Questionnaire

Auburn University Montgomery

Human Performance Laboratory

This is your physical activity questionnaire to be completed prior to your exercise test at Auburn University Montgomery, Human Performance Lab. All information will be kept confidential. Please fill out the form carefully and thoroughly, and then review it to be certain you have not left anything out.

Name ____

Address ____

City ____________________________________ State _________________________

Age ______ Birthdate ____

Race (circle): Caucasian/White African American/Black Other

Contact phone number(s) ____

In case of an emergency who should we call? Name ____________________________

Relationship to you ____________________ Phone number(s)___________________

Address ____

City/State ____

1. Are you currently physically active? Y / N
2. If yes, what forms of exercise do you currently do?

   Jogging/ Running Cycling Weight lifting Yoga Aerobics/ Group exercise

   Tennis CrossFit Walking Swimming

   Please list any not provided above: ____

3. If yes, how many times a week to you exercise? Please think back on the past 30 days.

   < 1 1-2 3-4 >5

4. Have you ever practiced yoga? _____________________If yes, how many times?

   < 1 1-2 3-4 >5

5. If you practice yoga regularly, how many times a week do you currently practice yoga (within the past 30 days)?

   < 1 1-2 3-4 >5/?

6. What level of practitioner would you consider yourself?

7. Beginner Intermediate Advanced

Assess your health status by marking all *true* statements

History

You have had:

____ a heart attack

____ heart surgery

____ cardiac catheterization

____ coronary angioplasty (PTCA)

____ pacemaker/implantable cardiac

____ defibrillator/rhythm disturbance

____ heart valve disease

____ heart failure

____ heart transplantation

____ congenital heart disease

If you marked any of these statements in this section, consult your physician or other appropriate health care provider before engaging in exercise. You may need to use a facility with a ***medically qualified staff.***

Symptoms

____ You experience chest discomfort with exertion.

____ You experience unreasonable breathlessness.

____ You experience dizziness, fainting, or blackouts.

____ You take heart medications.

Other health issues

____ You have diabetes.

____ You have asthma or other lung disease.

____ You have burning or cramping sensation in your lower legs when walking short distances.

____ You have musculoskeletal problems that limit your physical activity.

____ You have concerns about the safety of exercise.

____ You take prescription medication(s).

____ You are pregnant.

Cardiovascular risk factors

____ You smoke, or quit smoking within the previous 6 months.

____ Your blood pressure is > 140/90 mm Hg.

____ You do not know your blood pressure.

____ You take blood pressure medication.

____ Your blood cholesterol level is > 200 mg/dL.

____ You do not know your cholesterol level.

____ You have a close blood relative who had a heart attack or heart surgery before age 55 (father or brother) or age 64 (mother or sister).

____ You are physically inactive (i.e., you get < 30 minutes of physical activity on at least 3 days per week).

If you marked two or more of the statements in this section you should consult your physician or other appropriate health care provider before engaging in exercise. You might benefit from using a facility with a ***professionally qualified exercise staff*** [†] *to guide your exercise*

____ None of the above

You should be able to exercise safely without consulting your physician or other appropriate health care provider in a self-guided program or almost any facility that meets your exercise

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* Modified from American College of Sports Medicine and American Heart Association. ACSM/AHA Joint Position Statement: Recommendations for cardiovascular screening, staffing, and emergency policies at health/fitness facilities. Med Sci Sports Exerc 1998: 1018