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Effect of a 7-Week Rock Climbing Class on Physical Fitness and Performance

Justin Scott Cargo

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EFFECT OF A 7-WEEK ROCK CLIMBING CLASS ON PHYSICAL FITNESS AND PERFORMANCE

by

Justin Scott Cargo

A thesis submitted to the Graduate College
in partial fulfillment of the requirements
for the Degree of Master of Science
Human Performance and Health Education
Western Michigan University
June 2015

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EFFECT OF A 7-WEEK ROCK CLIMBING CLASS ON PHYSICAL FITNESS AND PERFORMANCE

Justin Scott Cargo, M.S.
Western Michigan University, 2015

The purpose of this study was to assess changes in physical fitness and performance by rock climbing twice a week over a 7-week time period. Rock climbing is on the rise in popularity as seen in the rise of indoor climbing gyms and the increase in rock climbing competitions (Wall, C. B., Starek, J. E., Fleck, S. J., & Byrnes, W. C., 2004). Notably, the International Federation of Sport Climbing has held the Climbing World Championships biennially since the first event in 1991 (Schoffl, Burtscher, & Coscia, 2013), which emphasizes the importance of this research to apply to training programs.

To better understand the sport of rock climbing a variety of tests were used to assess physical fitness and performance. The tests included grip strength (kg), grip endurance (seconds), pinch strength (kg), the sum of 7-site skinfold thicknesses (mm), percent body fat, upper body aerobic power (ml•kg•min⁻¹), and time to complete a graded route on the climbing wall (seconds). 16 subjects, 3 females and 13 males, who were enrolled in a 7-week rock climbing course at Western Michigan University participated in the study.

Significant improvements were observed in right hand grip endurance (pre 33.52±9.5, post 40.61±12.57, p = .034), left hand grip endurance (pre 29.86±7.31, post 42.74±16.91, p = .001), right hand pinch strength (pre 9.93±1.87, post 11.1±2.6, p=.001), pinch strength average (pre 9.89±1.81, post 10.62±2.18, p=.002), and timed climb, or time to the top of a graded route (pre 116.89±68.02, post 55.73±43.24, p=.001). It was concluded that 7-weeks of rock climbing twice a week showed improvements in some physical fitness and performance variables.
ACKNOWLEDGEMENTS

Most importantly I would like to thank my family for all their love and support. Without my mother and father’s guidance and encouragement I would not have been able to pursue a higher education. Without the constant support of my wife I would not have been able to stay on track and maintain motivation throughout this assignment. Without my sister’s direction and my admiration towards her and her accomplishments, this project and my academic career would not be what it is.

Thank you Dr. Weideman and Dr. Hanson for all the positive support you gave to every part of the project. Dr. Michael deserves a big “thank you” for helping me throughout the entire project and my graduate career. Your support, ranging from narrowing down the research design in the beginning to running the statistics and making the final revisions in the end, made all the difference. All in all, the support I received throughout the project was much appreciated and not only by the mentioned people and names but also from my coworkers, participants, classmates and good friends.

Justin Scott Cargo
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INTRODUCTION

Rock climbing itself was once used solely as a training mode for mountaineering. It is still used as a training mode for mountaineering; however, now it has developed into its own recreational activity and athletic endeavor. Unlike running, cycling, swimming, or weight lifting, rock climbing is not a commonly practiced type of physical conditioning. However, climbing as an activity is similar to that of running or swimming where basic movements are used to accomplish a goal of movement across a terrain with minimal amounts of equipment needed. Interestingly, it is increasing in popularity partly due to the rise in indoor climbing gyms, where the estimates indicate there are about 400 climbing gyms in the U.S. alone (Wall, C. B., Starek, J. E., Fleck, S. J., & Byrnes, W. C., 2004). In 1995 the International Olympic Committee recognized rock climbing as a competitive sport (Gajewski, J., & Jarosiewicz, B., 2008); however, the sport has not yet made it into the Olympic games. Notably, the International Federation of Sport Climbing has held, for males and females, the Climbing World Championships in all three climbing disciplines (lead, bouldering and speed) biennially since the first event in 1991 (Schoffl, Burtscher, & Coscia, 2013). This competition emphasizes the importance of this research.

The increased interest and competitions in the sport has also sparked an increase in training and conditioning programs that are specific to rock climbing. Similar to how a running athlete will train to better their time in a previous race, a rock climber will train in order to complete a harder route, pitch, or problem. However, once an individual develops an interest in the sport and begins to rock climb, how long can they expect to train until they start to see improvements in physical fitness and climbing performance or
if improvements will even occur? Also, which variables should be measured that best represent physical fitness and performance specific to rock climbing?

In previous research, variables that have been assessed included the sum of skinfold thicknesses (Bertuzzi, Franchini, Kokubun, & Kiss, 2007; España-Romero, Jensen, Sanchez, Ostrowski, Szekely, & Watts, 2012; España-Romero, Ortega Porcel, Artero, Jiménez-Pavón, Gutiérrez Sainz, Castillo Garzón, & Ruiz, 2009; Limonta, Veicsteinas, & Esposito, 2008; Watts, Daggett, Gallagher, & Wilkins, 2000; Watts, Joubert, Lish, Mast, & Wilkins, 2003; Watts, 2004), muscular strength and endurance (España-Romero et al., 2012; Gajewski & Jarosiewicz, 2008; Limonta et al., 2008; Wall et al., 2004; Watts et al., 2003; Watts, 2004), upper body aerobic power (Bertuzzi et al., 2007; España-Romero et al., 2012; España-Romero et al., 2009; Rosponi, Schena, Leonardi, & Tosi, 2012; Watts et al., 2000), and rock climbing performance (España-Romero et al., 2012; España-Romero et al., 2009; Wall et al., 2004). To our knowledge, these variables have not been assessed in novice subjects over a period of rock climbing training (course/class) in order to gauge possible improvements or track their fitness progress.

As a means to monitor rock climbing progress in a standardized manner, a classification system exists, which is used to describe moving across various types of terrain and, more specifically, the difficulty of various rock climbing routes. This classification system begins with class 1 – walking over flat terrain, class 2 – walking across a hiking trail, class 3 – walking across an inclined hiking trail with the occasionally obstacle, class 4 – walking across a steeper inclined hiking trail were hands will be occasionally used, class 5 – terrain steep enough that a fall could be fatal,
therefore climbing equipment (ropes, harnesses, belay device, etc.) need to be used to ensure safety, and class 6 – known as aid climbing because the climbs are impossible to complete without the use of aiding equipment (Watts, 1996). Class 5 climbing is the main focus of this research study. Class 5 climbing is known as technical climbing or “free climbing,” where ropes, harnesses, and other types of equipment are used for protection only and not to assist in the climber’s progress (Watts, 1996). The term “free climbing” does not mean the climber is “free” of safety equipment (that describes is “free soloing” and is performed by very few climbers) but “free” to move up the rock face without the aid of their equipment.

There are three main types of rock climbing which fall into the category of class 5 climbing. These include bouldering, lead climbing, also known as sport climbing, and top-roping. Top-roping is the type mainly used by beginners, indoor climbing gyms, or someone training for harder, more difficult routes, due to its high level of safety and its minimal requirement for technical-skill knowledge. Top-roping and bouldering were the only two types of climbing that were used over the 7-week period of rock climbing with top-roping being the main type performed and the one used to test the timed climb.

For these three main types of rock climbing there are a few subjective rating systems that have been developed by rock climbers used for rating the difficulty of individual routes, rope length climbs, or pitches (Watts, 2004). The most commonly used subjective rating system to measure a climber’s progress is the Yosemite Decimal System (YDS) (Watts, 1996). The YDS uses the number 5 to represent class 5 climbing, or “free climbing,” where no artificial means are utilized to aid progress, followed by a decimal point and another number as a means to distinguish the route’s difficulty (Bertuzzi et al.,
2007; Watts et al., 2000; Watts & Jensen, 2003. Watts et al., 2003; Watts, 1996; Watts, 2004). For example, 5.0 is the easiest rating, up to 5.15, which is currently the most difficult rating (Watts, 1996). There are also subclasses of each difficulty rating represented by a (easiest), b, c, and d (most difficult). An example would be a 5.12c, or a more challenging 5.12. This further delineates the difficulty of the route. Two main characteristics of rock faces or indoor climbing routes that are accountable for the climb’s difficulty is the angle of the wall relative to vertical and the size of the holds used for hands and feet. Other subjective rating systems are used such as the French, Australian, or V-scale for bouldering (Watts, 1996). For this study, the YDS scale was the subjective rating system used since top-roping was the focus of this study.

Due to the various types of rock climbing, the physical demands of the athlete will differ slightly. Top-roping and lead climbing involve routes that are much higher than bouldering routes, challenging the athlete’s muscular and aerobic endurance. Some lead climbing or top-roping routes can be anywhere from 45 to ≥200 feet, while a bouldering route may be 15-20 feet. Bouldering involves short, yet difficult routes, which challenges the athlete’s muscular strength and anaerobic power. For this particular study the subjects focused on top-roping due to it being used mostly by beginners, its high level of safety, and its use as a training aid. Though no matter the type of rock climbing, the forces being placed on the fingers and forearm musculature of novice rock climbers are common throughout. The finger and forearm forces produced to maintain contact with the handholds during rock climbing and the various unusual grips used on the handholds are why handgrip strength has been studied extensively when paired with rock climbing.
In previous studies, grip strength values achieved by experienced rock climbers are usually compared to a non-climbing control group or less experienced rock climbers (España-Romero et al., 2009; Limonta, 2008; Wall et al., 2004; Watts et al. 2003). Strength values have also been compared bilaterally in the same subject (Watts & Jensen, 2003) as well as between genders (España-Romero et al., 2009; Watts et al., 2003), between different types of climbing (Fanchini, Violette, Impellizzeri & Maffiuletti, 2013) and as a ratio to body weight (España-Romero et al., 2009; Gajewski & Jarosiewicz, 2008). There are a few contrasting results when it comes to measured grip strength values. Some researchers have found rock climbers to have greater maximal voluntary contraction (MVC) values than controls (Limonta, et al. 2008) while others have found no significant difference between the two (Watts et al., 2003). However, it is commonly accepted that rock climbers have a significantly higher strength-to-bodyweight ratio when compared to controls (España-Romero et al., 2009; Gajewski & Jarosiewicz, 2008; Limonta et al., 2008; Wall et al., 2004; Watts et al., 2003; Watts, 2004). For this study, grip strength-to-bodyweight ratio was calculated and grip MVC and pinch MVC was measured. The aforementioned unusual handholds and subsequent unusual grips used on the handholds is why pinch strength was included in the measurements.

Previous research has focused on grip strength and the various ways to measure it. The most common method is by the use of a hand dynamometer; however, the procedures differ from study to study. Watts, Joubert, Lish, Mast & Wilkins (2003) used a hand dynamometer to measure handgrip force while their subjects were seated with a 90° flex in the elbow. The right and the left maximum values were then averaged. A handgrip ergometer has also been used while the subject was seated with the elbow fixed
at 0° (Limonta, et al., 2008). Other studies have used the handgrip dynamometer to test for maximal voluntary contraction (MVC) or grip endurance using between 50 and 80% of the subject’s MVC (España-Romero et al., 2009; Gajewski & Jarosiewicz, 2008; Limonta et al., 2008; Watts et al., 2000; Watts et al., 2003; Watts, 2006).

In previous research, grip endurance has been measured by holding 50-80% of each subject’s MVC in an isometric contraction until the subject fatigues (Limonta, et al., 2008; Watts, 2004) or performing multiple MVC’s with rest intervals then calculating a fatigue index by subtracting the first value by the last then dividing by the first (España-Romero et al., 2009). The protocol used for this study was 80 percent of the subject’s MVC held until the subject fatigues. The value for grip endurance is expressed in seconds. This study used a handgrip dynamometer and followed the procedures for strength and endurance outlined by Limonta, et al., (2003). To our knowledge, grip strength and endurance has not been measured before and after a 7-week period of rock climbing in subjects new to the sport.

Anthropometrics of rock climbers include, with little variation between studies, age, height, bodyweight, BMI (body mass index) and the sum of skinfold thicknesses (Bertuzzi et al., 2007; España-Romero et al., 2009; España-Romero et al., 2012; Limonta et al., 2008; Watts et al., 2000; Watts et al., 2003). What differentiates rock climbing anthropometrics is the use of arm span and the ape index (Bertuzzi et al., 2007; España-Romero et al., 2009; Limonta et al., 2008). The significance of rock climbers’ anthropometrics has been outlined as an athlete profile in a literary review by Watts (2004), explaining that experienced rock climbers generally are small in stature, low in body mass, and low in percent body fat. The athlete profile also described rock climbers
to have high upper body strength-to-body mass ratio, high isometric muscular endurance, and high upper body aerobic power.

With regard to upper body aerobic power and its association with rock climbing, cardiorespiratory fitness has been measured in a number of ways. The use of a portable metabolic system while climbing a specific route (España-Romero et al., 2012; Watts et al. 2000) or while on a climbing ergometer or Treadwall™ (España-Romero et al., 2009) has been assessed. A cycle ergometer has been used for the lower body (Rosponi et al., 2012) as well as adapted for use by the upper body to measure VO$_{2peak}$ as a performance variable (Bertuzzi et al., 2007). Bertuzzi, Franchini, Kokubun, and Kiss (2007) used a maximal incremental exercise test adapted to the upper body was used to measure peak oxygen uptake (VO$_2$). First the subjects performed a 3-minute warm-up using only the inertial resistance of the cycle. The subjects then exercised at a cranking frequency of 90rpm with an increment of 23 Watts per stage until fatigue. In this study, the protocol used involved 2-minute stages with a possible 8 stages ending at 200 Watts. The first stage began at 25 Watts and increased 25 Watts per stage at a cranking frequency of 50 rpm until volitional exhaustion.

One characteristic missing from the maximal incremental arm ergometer test is its specificity to rock climbing performance, since the cyclical pattern used during the test is not used during climbing. Therefore, a climbing performance test was included in the measurements. In a study by España-Romero et al., (2012), they observed energy expenditure adaptations in experienced rock climbers during repeated ascents of the same climbing route over a period of 10-weeks as a means to measure climbing performance. The subjects climbed the route a total of 9 times over the course of ten weeks and the
results indicated that climbing time was significantly higher for ascent 1 compared to ascent 9 and energy expenditure during the actual climbing was significantly higher in ascent 1 compared to ascents 6 and 9. The authors concluded that progressively faster climbing resulted in less energy expenditure during the actual climbing. Also, an increase in recovery energy expenditure was observed as a consequence of the faster rate of climbing. The described study used subjects who were experienced rock climbers and measured the variables time and VO$_2$ during climbing and recovery.

However, as far as a practical universal climbing-performance test is concerned, it could not be found in the literature. However, Wall, Starek, Fleck, and Byrnes (2004), used various boulder and roped routes on an indoor climbing wall to test performance. The performance score was the total number of successful hand movements completed on the route. However, climbing time to exhaustion on a climbing ergometer (Treadwall$^{TM}$) measured in seconds has also been used as a performance variable (España-Romero et al., 2009), but few have such a device available to them.

Although rock climbing has become a popular activity and research has been done to evaluate rock climbers, few if any studies have evaluated the impact of a rock climbing course offered to novices. Therefore, the purpose of this study was to measure possible improvements in grip and pinch strength, grip endurance, aerobic power, anthropometrics and time to complete a graded route before and after a 7-week rock-climbing course in subjects new to rock climbing.
METHODS

Subjects

16 students, 3 females and 13 males, who were enrolled in a 7-week rock climbing course at Western Michigan University, participated in this study at Western Michigan University. All subjects were new to rock climbing or had not been rock climbing indoors or outdoors in the last 12 months, which was determined using the rock climbing experience questionnaire. Individuals classified as greater than low risk for cardiovascular disease according to the American College of Sports Medicine and men older than 45 years and women older than 55 years were factors that excluded them from participation in the study.

All participants signed an informed consent approved by the University’s Institutional Review Board after having the testing procedure explained to them in detail. Following the signing of the informed consent document, study participants were asked to complete an AHA/ACSM Health/Fitness Facility Pre-participation Screening Questionnaire, a rock climbing experience questionnaire, and a liability waiver required by the Student Recreation Center (Appendix). These were used in order to determine risk classifications, any current injuries, and to ensure the participants had not been rock climbing within the last 12 months. Once the documents were signed the student investigator collected them and scheduled the pre-testing measurement meeting, which was conducted in Western Michigan University’s Human Performance Research Laboratory. The pre-testing measurement meeting was scheduled within 7 days of the first class period and the post testing measurement meeting was scheduled within 7 days of the last class period. A detailed description of the subjects can be seen in Table 1.
Table 1 Demographics of subjects.

<table>
<thead>
<tr>
<th>Age</th>
<th>Height (m)</th>
<th>Mass (kg)</th>
<th>Arm Span (m)</th>
<th>Ape Index</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.69 ± 1.30</td>
<td>1.755 ± 0.076</td>
<td>71.29 ± 15.81</td>
<td>1.775 ± 0.096</td>
<td>1.012 ± 0.028</td>
<td>23.1 ± 4.3</td>
</tr>
</tbody>
</table>

(M±SD; N=16)

Study Design

All participants were enrolled in a 7-week rock climbing course at Western Michigan University. Each subject met with the student investigator three times, an informational meeting and twice for measurement purposes: once to complete pre-testing, which was completed before the end of the first week of class, and once to complete post-testing, completed during the last week of class or the week after. Pre and post testing measurements were performed in the Human Performance Laboratory with the one exception of the timed climb, which was performed on the rock climbing wall in Western Michigan University’s Student Recreation Center (SRC). The measurements that were completed before and after the 7-week rock climbing course included height (meters), mass (kilograms), arm span (meters), the sum of 7-site skinfold measurements (millimeters), upper body aerobic power (ml•kg⁻¹•min⁻¹), timed climb (seconds), handgrip strength (kilograms), pinch strength (kilograms), and handgrip endurance (seconds).

Informational Meeting

The informational meeting included a detailed description of the study, an opportunity for questions, explanation of the expectations of the participants, signing of an informed consent document, completion of an AHA/ACSM Health Fitness Facility Pre-participation screening questionnaire and a rock climbing experience questionnaire. Also, before a student can climb the rock wall at the SRC, a liability waiver must be signed, which is document required by the SRC. The informed consent was verbally
explained as well as the description of the study and the expectations of the participants after which time was given for potential questions from the participant. After the explanation of the study and informed consent document was completed, and questions were answered, the individual could sign the informed consent if he/she agreed to the terms of the study. Once the informed consent were signed, they were collected and reviewed. the completed questionnaires. Participants were scheduled for the pre-testing measurement session if they fell within the predetermined risk assessments and climbing experience.

*Anthropometrics/Body Composition*

Upon arrival to the Human Performance Research Laboratory (HPRL), pre-testing began with the measuring of anthropometrics. Height (m) was measured using a wall-mounted stadiometer and mass (kg) was measured using an electronic scale. Height and mass were then used to calculate Body Mass Index (BMI; kg/m$^2$), which can be seen in table 1. Skinfold measurements were taken by the student investigator using a Lange™ caliper at 7 different sites on the body. The 7 sites measured were subscapular, tricep, chest, midaxillary, iliac crest, abdomen, and mid-thigh. Each site was measured twice; however, a third time was used if the measurements were not within 1 millimeter of the first measurement. At each site the two or three measurements were averaged, which contributed to the sum. The sum was taken and used in the procedures of Jackson and Pollock (Jackson & Pollock, 1978) to estimate body density, with percentage of body fat subsequently calculated using the Siri equation (Siri, 1961).

Arm span was measured using a tape measure. The subject was instructed to stand with their back against a whiteboard with their middle finger of their right hand touching
the very edge of the whiteboard. Both of the subject’s arms were fully extended to the sides at shoulder level. The student investigator marked on the whiteboard where the middle finger of the left and right hands touched the board. The student investigator then used the tape measure to measure the subject’s greatest tip to tip distance (arm span) in meters. This process was repeated for each subject. Ape index was calculated as a ratio by taking the subject’s arm span divided by the subject’s height. A summary of arm span and ape index can be seen in Table 1.

Grip and Pinch Strength Assessment

The participants were instructed to sit with their arm at their side, elbow flexed to 90 degrees and with a neutral wrist position. Two warm up sets of 10 repetitions of finger flexion using a hand dynamometer (Takei, T.K.K. 5001) were completed before the tests began. The subject was allowed to adjust the grip of the hand dynamometer and that same grip distance was noted and used for the post testing assessment. This particular hand dynamometer has a maximal force needle, which means once it reaches the maximal force produced the needle stays stationary. After the warm up sets the subject rested for a period of 2 minutes. Once the rest period was complete the subject would grasp the hand dynamometer, the student investigator would count to 3 then say “go,” and the subject would perform a maximal voluntary contraction (MVC). The subject would switch hands and repeat the process for two trials. All values were recorded and the highest value of the two trials was used as the subject’s MVC.

For pinch strength assessment the protocol was exactly the same as grip strength assessment. The only differences were the device, which was a pinch dynamometer (Baseline Evaluation Instruments, Mechanical Pinch Gauge 12-0201) and the grip used
on the device. The subject was still instructed to maintain a neutral wrist position and the subject was instructed to place their thumb on the back of the pinch dynamometer and their index and middle finger on the front. The highest value of the two trials was used as the subject’s MVC.

*Grip Endurance Assessment*

Once the subject completed the grip and pinch strength assessment, they then rested for a period of 5 minutes. During the rest period the student investigator calculated 80% of the subject’s MVC for each hand and explained the grip endurance protocol to the subject. After the rest period, 80% of the subject’s MVC was the value the subject held for the grip endurance test and they were instructed to hold that value for as long as possible within ±2kg. Time was recorded to the nearest 100th of a second.

The subject was seated throughout the test and maintained the same position as the grip strength test, which was arm at their side, elbow at 90° and a neutral wrist position. A different hand dynamometer was used for the grip endurance test than the one used in the grip strength assessment. The reason for this was that during the grip endurance test, the force needle needed to move throughout the test, opposed to the dynamometer used in the grip strength assessment where the needle stopped once maximal force was reached.

After the rest period was complete the test was ready to begin. The subject and student investigator sat so that both could see the dial on the hand dynamometer. The student investigator used a Timex™ stopwatch to time the test and terminated the test once the force value fell below 2kg of the subject’s 80% MVC.
Upper Body Aerobic Power Assessment

Upper body aerobic power testing used a cycle ergometer (Monark, Ergomedic 828 E) that was outfitted with hand pedals instead of foot pedals. The ergometer was then placed securely on top of a classroom table near the edge so that the subject seated at the edge of the table could grasp the pedals. To minimize movement, the table was placed against a wall in the laboratory and the cycle was placed on an anti-slip mat. The subjects were instructed to pedal at 50 revolutions per minute (rpm). Each stage lasted 2 minutes with an increment of 25 Watts per stage until fatigue. The first stage acted as a warm-up for the participants. It was important that the subjects maintained contact with the back of the chair, which minimized reaching of the arms and shoulder rolling. This localized the muscle activation to the arms and upper body.

Heart rate and rating of perceived exertion (RPE) was measured during the test and oxygen uptake (VO₂) was measured breath-by-breath using a Medgraphics (CPX express) metabolic cart. The metabolic cart was calibrated according to manufacturers specifications before each test. The highest VO₂ value generated during the test was expressed relative to body mass (ml·kg⁻¹·min⁻¹) and represented the subject’s upper body aerobic power. Throughout the test, verbal encouragement was given to the participants by the student investigator.
Timed Climb Assessment

The timed climb assessment was the only assessment that did not take place in the laboratory. The timed climb assessment occurred during the first week of class for the pre-test and the last week of class for the post-test. The route that was used was rated as a 5.8 on the YDS, which is a beginner level climb, and was set by the student investigator. The participants were allowed to climb the route once before the climb was timed. The route was marked off with tape at each hold they were allowed to use. The participants were allowed to use hands or feet at each hold, no specification was made for only foot or only hand holds. The participants were allowed to skip holds if necessary (taller participants may not have needed to use a specific hold), but were not allowed to use holds that were not taped as a part of the route.

The participants were instructed to place hands and feet at the starting hold positions and once a hand or foot left that starting position the student investigator started the time. This occurred after the participants were properly tied in and all participants were competent in belay technique. Once the participant touched the end point marked off with tape the student investigator stopped and recorded the time, which was kept using a Timex™ stopwatch. Verbal encouragement was given throughout the test.

For the post testing assessment, a different yet very similar 5.8-rated route was used that was not placed on the wall until the day before the last week of class. The reason behind this was so the participants did not continuously climb the original route over and over again, which would have showed improvements due to becoming habituated to the route. The route distance differed by 1.01 feet and one handhold.
Statistical Analysis

Pre and post data were analyzed using dependent pair T-tests. Significance was determined using 2-tailed test at $p \leq .05$ level. Pearson correlations were completed to determine relationship between select variables.

RESULTS

Anthropometrics

No significant changes were observed between mass pre ($M = 71.29$, $SD = 15.81$), and post ($M = 71.19$, $SD = 15.67$), sum of skinfold measurements pre ($M = 103.8$, $SD = 46.37$), and post ($M = 99.38$, $SD = 44.26$), percent body fat pre ($M = 14.98$, $SD = 7.92$) and post ($M = 14.37$, $SD = 7.6$), No changes were seen between pre and post body mass ($p=.732$), sum of skinfold measurements ($p=.059$) and percent body fat ($p = 0.073$).

Values for these variables are shown in Table 2.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre</th>
<th>Post</th>
<th>$p =$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass (kg)</td>
<td>$71.29\pm15.81$</td>
<td>$71.19\pm15.67$</td>
<td>0.732</td>
</tr>
<tr>
<td>Sum of skinfolds (mm)</td>
<td>$103.8\pm46.37$</td>
<td>$99.38\pm44.26$</td>
<td>0.059</td>
</tr>
<tr>
<td>Percentage body fat (%)</td>
<td>$14.98\pm7.92$</td>
<td>$14.37\pm7.60$</td>
<td>0.073</td>
</tr>
</tbody>
</table>

($M\pm SD; N=16; \%bf\ calculation: Jackson-Pollock & Siri$)

Grip and Pinch Strength

Over the 7-week intervention period, no significant differences were observed for grip strength right hand pre ($M = 40.53$, $SD = 10.17$) and post ($M = 42.00$, $SD = 9.15$), grip strength left hand pre ($M = 38.34$, $SD = 10.64$) and post ($M = 39.06$, $SD = 8.36$), and grip strength average pre ($M = 39.44$, $SD = 10.27$) and post ($M = 40.53$, $SD = 8.53$). The
mean grip force for left hand, right hand, and average for pre and post conditions are displayed in Figure 1.

Figure 1. Grip strength (mean + SD; N=16) no significant observations

A significant difference was observed between right hand pinch strength pre ($M = 9.93, SD = 1.87$) and post ($M = 11.1, SD = 2.6$), $p = .001$, and pinch strength average pre ($M = 9.89, SD = 1.81$) and post ($M = 10.62, SD = 2.18$), $p = .002$, which can be seen in Figure 2. Over the course of the 7-week rock climbing class, no significant change was observed for left hand pinch strength ($p=.235$).
All changes observed for grip and pinch strength, including grip strength-to-body weight ratio can be observed in Table 3.

Table 3  Grip and pinch strength

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre</th>
<th>Post</th>
<th>p =</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grip Strength Right Hand (kg)</td>
<td>40.53±10.17</td>
<td>42.00±9.15</td>
<td>0.263</td>
</tr>
<tr>
<td>Grip Strength Left Hand (kg)</td>
<td>38.34±10.64</td>
<td>39.06±8.36</td>
<td>0.542</td>
</tr>
<tr>
<td>Grip Strength Average (kg)</td>
<td>39.44±10.27</td>
<td>40.53±8.53</td>
<td>0.353</td>
</tr>
<tr>
<td>Grip Strength to Bodyweight Ratio</td>
<td>0.558±0.111</td>
<td>0.576±0.092</td>
<td>0.282</td>
</tr>
<tr>
<td>Pinch Strength Right Hand (kg)</td>
<td>9.93±1.87</td>
<td>11.10±2.60</td>
<td>0.001</td>
</tr>
<tr>
<td>Pinch Strength Left Hand (kg)</td>
<td>9.86±2.07</td>
<td>10.14±2.16</td>
<td>0.235</td>
</tr>
<tr>
<td>Pinch Strength Average (kg)</td>
<td>9.89±1.81</td>
<td>10.62±2.18</td>
<td>0.002</td>
</tr>
</tbody>
</table>

(M±SD; N=16)
Grip Endurance

A significant difference was observed between right hand grip endurance pre ($M = 33.52, SD = 9.5$) and post ($M = 40.61, SD = 12.57$), $p = .034$. This was also seen for left hand grip endurance pre ($M = 29.86, SD = 7.31$) and post ($M = 42.74, SD = 16.91$), $p = .001$, and can be seen in figure 3.

Figure 3. Grip endurance ($mean + SD; N=16$) * $p=.034$, **$p=.001$

Upper Body Aerobic Power

No significant changes were observed between upper body aerobic power pre ($M = 23.19, SD = 4.31$) and post ($M = 23.54, SD = 3.94$), maximum heart rate pre ($M = 162.94, SD = 14.48$) and post ($M = 164.19, SD = 13.25$). Results can be seen in Table 4.
**Table 4**  Upper body aerobic power

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre</th>
<th>Post</th>
<th>p =</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper body power (ml•kg⁻¹•min⁻¹)</td>
<td>23.19±4.31</td>
<td>23.54±3.94</td>
<td>0.635</td>
</tr>
<tr>
<td>Max heart rate (BPM)</td>
<td>162.94±14.48</td>
<td>164.19±13.25</td>
<td>0.631</td>
</tr>
</tbody>
</table>

(M±SD; N=16)

**Timed Climb**

A significant difference (fig. 4) was observed after the completion of the 7-week rock climbing course between pre ($M = 116.89, SD = 68.02$) and post ($M = 55.73, SD = 43.24$) timed climbs. It is worth noting that the pre and post routes used for the timed climb were different, yet very similar (both rated a 5.8 on the YDS scale). However, the distance climbed was within 1.01 feet of one another and the number of holds used were within 1 (Table 5). The significant difference can be observed in Figure 4.
Figure 4. Timed climb (*mean + SD; N=16) * p = .001

**Table 5**  Timed climb

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre</th>
<th>Post</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Holds</td>
<td>29</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Distance Climbed (ft)</td>
<td>42.65</td>
<td>43.64</td>
<td></td>
</tr>
<tr>
<td>Timed climb (seconds)</td>
<td>116.89±68.02</td>
<td>55.73±43.24</td>
<td>0.001</td>
</tr>
</tbody>
</table>

(M±SD; N=16)
Correlation

A significant correlation was found between pre testing climbing time and upper body aerobic power \( (p = .032) \), as seen in Figure 5. What is interesting to note, is that the post testing (Figure 6) of these very same variables were non-significant \( (p = .079) \) and had a lower correlation value. This may be due to the improvements in climbing time and upper body aerobic power. Once this happened the sample was more homogenous thus causing the correlation to decrease and be non-significant.
Figure 5. PRE peak VO$_2$ and PRE climbing time (mean + SD; N=16) p = .032

![Graph showing PRE peak VO$_2$ vs. PRE climb time]

Figure 6. POST peak VO$_2$ and POST climbing time (mean + SD; N=16) p = .079

![Graph showing POST peak VO$_2$ vs. POST climb time]
DISCUSSION

The purpose of this study was to assess physical fitness and performance changes by rock climbing twice a week over a 7-week time period. The participants of the study were all enrolled in a 7-week rock climbing course at Western Michigan University, which served as the intervention for the study. Variables were measured before and after the 7-week rock climbing class for the purpose of investigating changes that occurred over the time period.

In order to obtain a complete profile, many variables were tested. The variables included in this study were mass, the sum of 7-site skinfold thicknesses, percent body fat, grip strength, pinch strength, grip endurance, upper body aerobic power, and a timed climb.

Since rock climbing is on the rise in popularity, partly due to the rise in indoor climbing gyms where the estimates indicate there are about 400 climbing gyms in the U.S. alone (Wall et al., 2004), and notably due to the increase in rock climbing competitions, there is an importance for further research in this particular sport discipline. The importance is also described in a review article by Watts (2004) explaining the need for rock climbing training studies in order to understand the physical components related to success of rock climbers. What made this study original was the use of participants new to rock climbing. To the best of our knowledge, this is the first study to use participants who were new to this particular sport discipline and subsequently tested for physiological responses before and after completion of a rock climbing course. This study will further research in the field, it will also benefit the fitness community, since rock climbing is becoming a popular form of exercise.
To understand the physical components related to success of rock climbers, previous research has focused on physiological variables compared between rock climbers of various ability to non-rock climbing controls. In a study done by Limonta et al. (2008), 11 elite rock climbers were compared to non-rock climbing controls. In relation to anthropometrics, body mass (kg), BMI (kg/m²), and skinfold measurements (cm) were all significantly different when compared to the non climbing controls. In the current study, over the course of 7-weeks, observations in anthropometrics did not show significant improvements in the sum of 7-site skinfold measurements (mm; p=.059) or body fat percentage (p=.073). However, if the study were to continue over a longer time period, there is a possibility that the participants would have improved significantly in both sum of skinfold measurements and body fat percentage, improving the participants’ body composition.

Arm span was measured using a tape measure while the subjects stood with both arms fully extended to the sides at shoulder level. The subject’s greatest fingertip-to-fingertip distance (arm span) was measured in meters. Ape index was calculated as a ratio by taking the subject’s arm span divided by the subject’s height. No correlation between ape index and climbing ability was found in the current study, which is similar to the finding of Watts et al. (2003).

When it comes to measured grip strength values, there are a few contrasting results with previous research. Some researchers have found rock climbers to have greater maximal voluntary contraction (MVC) values than controls (Limonta et al., 2008) while others have found no significant difference between the two (Watts et al. 2003). However, outlined by España-Romero et al., (2009), grip strength in rock climbers, in
absolute terms, is not higher than normal populations, but when expressed relatively, as in strength-to-bodyweight ratio, climbers are significantly higher when compared to controls. Some researchers have found rock climbers to have greater MVC values than controls (Limonta et al., 2008) while others have found no significant difference between the two (Watts et al., 2003). However, it is commonly accepted that rock climbers have a significantly higher strength-to-bodyweight ratio when compared to controls. However, Limonta et al., (2008) did observe, that when compared to non-rock climbing controls, grip strength or maximal voluntary contraction, measured in Newtons (N), was significantly different between the elite climbers and controls. The current study observed no significant differences between the pre and post test measurements for grip strength.

In the current study, pinch strength was also a variable measured before and after the 7-week course. To the best of our knowledge, the pinch strength protocol used is unique to this study. The subjects were instructed to maintain a neutral wrist position and the subject was instructed to place their thumb on the back of the pinch dynamometer and their index and middle finger on the front of the pinch dynamometer. This position translates well to a rock hold that is very small and oriented vertically. The use of pinch strength in the current study is similar to previous research, in that a rock climbing-specific hold was tested for strength measurements. The hold does not necessarily have to be a pinch hold, as in the study done by Watts & Jensen (2003) and Danion (2006), where an apparatus was constructed to measure strength of a climbing specific hold. In a review article by Watts (2004), four common hand positions were outlined and pictured, one being pinch, a very similar hold to the pinch dynamometer used in the current study.
To the best of our knowledge, the pinch strength assessment used was unique to this study and the results indicate that rock climbing improves pinch strength. Observations in the current study revealed that pinch strength average and pinch strength in the right hand increased significantly after the course, suggesting that when an individual starts to rock climb, the unusual and challenging handholds increases demands placed on the hands and fingers causing strength adaptations specific to unusual holds, like the pinch grip.

Not only does rock climbing challenge pinch and grip strength, grip endurance is also challenged throughout the sport. There are many different methods to test muscular endurance. The primary two methods are isometric holds and multiple contractions. Previous research by Limonta, et al., (2008), compared grip endurance of elite rock climbers to non-climbing sedentary participants. Grip endurance was tested using 80% of the participants’ MVC held in an isometric contraction until the participants could no longer hold the value within ±5%. The researchers observed that grip endurance time for rock climbers were 43% longer compared to the controls’ grip endurance time. The current study also showed a significant improvement in both right and left hand grip endurance over the 7-week period. However, a possible limitation to the study was the use of a different hand dynamometer for the grip endurance test than the one used in the grip strength test. The reason for this was that during the grip endurance test, the force needle needed to move throughout the test, opposed to the dynamometer used in the grip strength assessment where the needle stopped once maximal force was reached.

Due to the improvements observed in grip endurance, an argument could be made that grip endurance is a better predictor of rock climbing performance than is grip
strength. This is due to the nature of rock climbing, since when a subject grasps a hold on a rock wall, especially a beginner or novice, maximal force production is not necessary to maintain contact with the wall. When the handholds become smaller and more advanced routes (greater angle of the rock wall) are climbed, subjects need greater force production to maintain contact with the holds. However, regardless of the climber’s ability, grip endurance is constantly challenged while climbing, especially during longer routes, which is common among top-roping. Also, grip endurance is challenged especially in beginners for the amount of time they spend holding onto handholds while they are trying to judge which hold to use next when attempting a route. This forces the subject to hold an isometric contraction that they maintain until they either fatigue or continue to the next handhold. Therefore, if a subject has greater grip endurance then they will be able to hold onto the wall longer or attempt longer routes before fatigue of the forearm musculature sets in.

Another method of testing handgrip endurance is by means of repeated contractions, which is outlined in a study by España-Romero et al., (2009). An electronic handgrip dynamometer was used and the participants were asked to perform 20 maximal voluntary contractions, alternately with both hands, with a rest interval of 2.5 seconds. A handgrip fatigue index was then calculated by subtracting the first value from the last and dividing by the first value. No significant differences were found between elite and expert rock climbers using this method. However, this method could be used in future research to test fatigue index between novice and elite climbers or before and after a rock climbing training period. This method of testing grip endurance was not used in this study because an electronic handgrip dynamometer was not available for use and would have been
difficult to maintain the 2.5 second rest period while manually recording the force produced after each contraction.

In the current study, oxygen uptake was measured breath-by-breath using a metabolic cart and a cycle ergometer adapted for the upper body. Previous research by España-Romero et al., (2009) and Bertuzzi et al., (2007) have used portable metabolic carts to measure VO₂ while performing a climbing specific task. España-Romero et al., (2009) used a Treadwall™, which is a similar to a vertical treadmill with artificial climbing holds secured to the track, which rotates around 2 axles producing a moving wall for the climber. The participants climbed until volitional exhaustion. The only measured parameter in that particular study to show a significant difference between expert and elite rock climbers was time to exhaustion. This was not assessed in the current study due to a Treadwall™ being inaccessible.

Climbing on a Treadwall™ does not mimic climbing perfectly since an actual rock wall does not move in front of the climber, the actual climber moves up the rock wall. A preferred method of testing O₂ consumption during climbing was executed by Bertuzzi et al., (2007), where the participants’ VO₂ was measured before, during, and after climbing actual routes on a 10-meter high wall using a portable metabolic system, as well as measured using a cycle ergometer adapted to the upper body (VO₂ peak-arm (ml·kg⁻¹·min⁻¹)). No significant differences were observed for VO₂ peak-arm (ml·kg⁻¹·min⁻¹) between recreational climbers and elite climbers. However, oxygen uptake during climbing actually exceeded VO₂ peak-arm. This likely has to do with the greater intensity and/or muscle mass involved during climbing. The current study observed no significant changes in upper body aerobic power over the 7-week period. Compared with the
research performed by Bertuzzi et al., (2007), this suggests that the preferable method of testing oxygen uptake, a variable of rock climbing performance, is to measure during actual rock climbing using a portable metabolic system.

Rock climbing performance can also be measured by the time it takes an individual to climb to the top of a route. In a study by España-Romero et al., (2012), the researchers used a 10-week intervention with experienced rock climbers climbing the same route once a week over the 10-week period. The study focused on energy expenditure and time to the top and found that the participants improved their climbing time and decreased their energy expenditure during climbing due to becoming familiar with the climb.

A timed climb was used in the current study and found improved times over the course of the 7-week rock climbing period. However, the limitation to using this parameter is that not all rock climbing competitions or rock climbing routes are meant to be climbed quickly. This parameter only caters to speed climbing competitions while there are many other types of rock climbing, including bouldering, top-roping, and lead climbing/sport climbing.

CONCLUSION

In conclusion, the data from this study suggests that rock climbing twice a week over a 7-week period improves some physical fitness and performance variables specific to rock climbing. Statistically significant differences were observed between pre and post measurements for pinch strength right hand, pinch strength average, grip endurance both left and right hand, and timed climb. Observations for anthropometrics and body composition of the participants did not show any differences between the pre and post
measurements including body mass, the sum of 7-site skinfold measurements, and percent body fat. Other non-significant variables include grip strength – right, left, and average, pinch strength left hand, upper body aerobic power, and maximal heart rate.

Based on previous research, grip endurance time for rock climbers was longer in duration when compared to grip endurance time for controls. Due to the observations amongst the variables analyzed in this study, an argument could be made that grip endurance is a better predictor of rock climbing performance than is grip strength due to the statically significant improvements over the 7-week period and the contrasting results for grip strength from previous research.

The findings of this study suggest that rock climbing challenges the musculature of the forearms and fingers leading to an improvement in pinch strength and grip endurance. This is most likely due to rock climbing using many unusually shaped handholds. The forces produced through the hands while rock climbing need to be maintained for extending periods of time in order to sustain contact with the handholds while climbing. The practical applications of these findings may be through the use of training programs specific to rock climbing athletes or for someone who wishes to start a new fitness program and is considering rock climbing. Athletes and coaches could use the findings of this study to develop training programs that complement pinch strength and grip endurance, while novice rock climbers can expect to see improvements in their climbing performance, grip endurance, and pinch strength. However, further research is required for the sport of rock climbing. Due to the findings of this study a few areas of further research can be suggested. (1), evaluate the impact of a longer training/intervention period. (2), are there differences in training adaptions in regards to
sex, (3), does age influence adaptations to rock climbing, (4), evaluation of the best practice for the use of oxygen uptake measurements during climbing, and (5), very little research has evaluated flexibility and its influence on rock climbing performance.
REFERENCES


Appendix A: Informed Consent Document

Western Michigan University
Human Performance Health Education

Principal Investigator: Timothy Michael, PhD
Co-principal Investigator: Carol Weideman, PhD & Nicholas Hanson, PhD
Student Investigator: Justin Cargo
Title of Study: Effect of a 7-Week Rock Climbing Class on Physical Fitness

You have been invited to participate in a research project titled "Effect of a 7-Week Rock Climbing Class on Physical Fitness." This project will serve as Justin Cargo’s thesis project for the requirements of the Master of Science in Exercise and Sports Medicine/Exercise Physiology degree. This consent document will explain the purpose of this research project and will go over all of the time commitments, the procedures used in the study, and the risks and benefits of participating in this research project. Please read this consent form carefully and completely and please ask any questions if you need more clarification.

What are we trying to find out in this study?
The purpose of this study is to measure physical fitness before and after a rock-climbing period of 7 weeks in subjects new to rock climbing.

Who can participate in this study?
You must be between 18 and 45 years old for males and 18 and 55 years old for females and be considered low-risk in order to participate in the study. Your risk will be determined by your answers to a Screening Questionnaire developed by the American Heart Association and the American College of Sports Medicine. This study is specifically looking at subjects new to rock climbing. Any subjects classified as moderate to high risk, have been involved in rock climbing activities within the last year, or who have injuries preventing them from performing any part of this study will be excluded and unable to participate.

Where will this study take place?
This study will take place on the first floor of the Student Recreation Center in room 1055 (Exercise Science Lab) and at the rock climbing wall in the SRC on Western Michigan University’s campus.

What is the time commitment for participating in this study?
The study will take place over a period of 8 weeks and require the participants to commit to approximately 8.75 hours outside of the designated class period. The orientation session will require approximately 1.75 hours to fully review the informed consent, fill out the questionnaire, and for any questions that wished to be answered during that time. If you choose to participate, physical fitness tests will be conducted before and after a rock climbing period of 7-weeks. The total time it will take to perform
the before and after tests will be approximately 7 hours, 4, 1.75 hours sessions, 2 sessions before and 2 sessions after, for a total time commitment of 8.75 hours.

**What will you be asked to do if you choose to participate in this study?**

If you choose to sign this informed consent document during the orientation session, you will then be asked to complete a Screening Questionnaire developed by the American Heart Association and the American College of Sports Medicine. If we determine you can participate in the study, you will then be scheduled for the first one-on-one testing session. You will be asked to complete two pre- and two post-testing sessions. The pre-testing sessions will occur before the 7-week rock climbing period and the post-testing sessions will occur after the 7-week rock-climbing period. Additionally, you will be notified during the orientation session to bring comfortable clothing to exercise in. When you arrive at the testing facility for your pre-testing session, you will be shown the equipment that will be used then body measurements will be taken including height, mass, & skinfold thickness.

Next, you will be instructed on how to properly perform the handgrip strength and endurance and pinch strength test. After the handgrip tests, if you haven’t already done so, you will be asked to put on comfortable exercise clothes then you and the student investigator will walk out to the rock climbing wall. You will be asked to put a heart rate monitor onto your chest area then instructed on how to dress (put on) a harness properly. The student investigator will be there for instruction and supervision and will make necessary changes to maximize safety. The student investigator will then perform the three proper knots to your harness. The student investigator will belay (a term meaning controlling the rope to protect the climber against falls) for you and you will be asked to climb a designated route – marked with tape – up the wall. Once you return to the ground safely the student investigator will record your heart rate and ask how hard it was while climbing the route. This will conclude our first measurement session.

The next scheduled measurement session will be within 48 hours of the previous session but not the next day. This session will include the arm pedaling test. You will be instructed on how to properly perform the test, which includes a 3-minute warm-up pedaling with your hands against no resistance. You will then be asked to perform the test at a set speed and the resistance will increase until you cannot continue the test. The procedures will be identical for both the pre- and post-testing sessions. Both the post-testing sessions will occur within 7 days of the last class period.

**What information is being measured during the study?**

The information that will be measured during the study includes grip strength (how hard you can grip) and endurance (how long you can hold your grip), pinch strength (how hard you can pinch) upper body aerobic power (the amount of air you can use while arm pedaling) body measurements (height, mass, & skinfold thicknesses) and time to complete a graded route on Western Michigan University’s rock climbing wall.

**What are the risks of participating in this study and how will these risks be minimized?**

Potential risks associated with this study include those associated with aerobic exercise and indoor rock climbing. Aerobic exercise risks include dizziness, muscle
soreness, and nausea. If you happen to experience any of these symptoms at any time, you have the right to stop the test. Indoor rock climbing risks include abrasions on knees and hands, sprained ankles, muscle soreness, fatigue, and aching feet due to the formfitting shoes. Falls from various heights off the wall are possible but are extremely unlikely. All necessary precautions will be taken in order to prevent any such accidents, such as proper harness dressing, proper knot tying, and proper supervision and belaying by the student investigator. However, as in all research, there may be unforeseen risks. If an accidental injury were to occur, appropriate emergency measures will be taken. No compensation or additional treatment will be made available except as otherwise stated in the consent form.

What are the benefits of participating in this study?
While there are potential benefits to participating in the rock climbing class, such as improved fitness levels, there is little benefit to you for participating in the research other than gaining experience in exercise/fitness testing.

Are there any costs associated with participating in this study?
There are no monetary costs associated with participating in this research study. However, it will require a time commitment of approximately 8.75 hours outside of classroom time that will be split before and after a 7-week rock climbing period.

Is there any compensation for participating in this study?
There is no compensation or extra credit for participating in this study.

Who will have access to the information collected during this study?
All data will be confidential and only made available to the investigators named in this consent document.

Do I have to participate in the research project if I take the class? Will my participation in the research project effect my grade in the class?
The student investigator will also be the Rock Climbing instructor for the class. Because he is the instructor for the class you may feel as though you have to participate in the research project, you do not. There is no advantage or disadvantage in your participation or non-participation in the research project. Your grade will not be affected based upon your participation or non-participation in the research project.
What if you want to stop participating in this study?
You can choose to stop participating in the study at anytime for any reason. You will not suffer any prejudice or penalty by your decision to stop your participation. You will experience no consequences either academically or personally if you choose to withdraw from this study.

The investigator can also decide to stop your participation in the study without your consent.

Should you have any questions prior to or during the study, you can contact the primary investigator, Dr. Timothy Michael at 269-387-2691 or tim.michael@wmich.edu. You may also contact the Chair, Human Subjects Institutional Review Board at 269-387-8293 or the Vice President for Research at 269-387-8298 if questions arise during the course of the study.

This consent document has been approved for use for one year by the Human Subjects Institutional Review Board (HSIRB) as indicated by the stamped date and signature of the board chair in the upper right corner. Do not participate in this study if the stamped date is older than one year.

I have read this informed consent document. The risks and benefits have been explained to me. I agree to take part in this study.

Please Print Your Name

Participant’s signature  Date
Appendix B: AHA/ACSM Health Fitness Facility Pre-participation Screening Questionnaire

AHA/ACSM Health/Fitness Facility Preparticipation Screening Questionnaire

Assess your health needs by marking all true statements.

History
You have had:

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

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

Other health issues

- You have diabetes
- You have or asthma other lung disease.
- You have burning or cramping 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.

Symptoms

- You experience chest discomfort with exertion.
- You experience unreasonable breathlessness.
- You experience dizziness, fainting, blackouts.
- You take heart medications.

Cardiovascular risk factors

- You are a man older than 45 years.
- You are a woman older than 55 years, you have had a hysterectomy, or you are postmenopausal.
- You smoke, or quite within the previous 6 mo.
- Your BP is greater than 140/90.
- You don't know your BP.
- You take BP medication.
- Your blood cholesterol level is >200 mg/dL.
- You don't know your cholesterol level.
- You have a close blood relative who had a heart attack before age 55 (father or brother) or age 65 (mother or sister).
- You are physically inactive (i.e., you get less than 30 min. of physical activity on at least 3 days per week).
- You are more than 20 pounds overweight.

If you marked two or more of the statements in this section, you should consult your physician or other appropriate healthcare provider before engaging in exercise. You might benefit by using a facility with a professionally qualified exercise staff to guide your exercise program.

None of the above is true.

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

Lippincott Williams and Wilkins http://www.lww.com

www.acsm-msse.org/gpte/template-journal/msse/media/0596c.htm
Appendix C: Climbing Experience Questionnaire

Climbing Experience Questionnaire
Have you ever rock climbed before?

If you answered yes to the question above, did you climb inside (indoor gym climbing) or outside and where?

When, in relation to the present (number of days/weeks/months/years ago), did you climb?

Subject ID: ______________

Questions modified from Wall, Starek, Fleck, and Byrnes (2004).

References
WESTERN MICHIGAN UNIVERSITY
STUDENT RECREATION CENTER

ACKNOWLEDGMENT AND ASSUMPTION OF RISK AND RESPONSIBILITY, AGREEMENT, COVENANT NOT TO SUE, RELEASE AND WAIVER OF LIABILITY.

I, the undersigned, acknowledge and agree that I know and understand the risk of climbing indoors. I am also fully aware that such climbing involves many inherent risks, dangers and hazards, including but not limited to personal injury or death resulting from slips, trips or falls while using the Western Michigan University Student Recreation Center facilities or equipment, climbing wall, bouldering areas, landing pits, or workout area and stairs (collectively "facilities") and/or "equipment"; abrasions from or entanglement with ropes or other equipment as well as failure to participate or climb safely or within one's ability, or misuse of the facilities; failure of equipment; or injuries or death resulting from the fall of the other persons or equipment who may come into contact with myself or other persons. I am also aware that the risks and dangers referred to above exist in all aspects of climbing including the use of the facilities, or participation in classes related to physical activities or activities sponsored by Western Michigan University or other organizations. I know that injury or death could occur while using these facilities or equipment. I acknowledge that I am solely responsible for my own safety and well-being with respect to using these facilities.

Understanding and accepting these terms and conditions, I choose to use the Western Michigan University's facilities. In consideration of being allowed to use the facilities, I freely accept and fully assume all such risks, dangers, hazards and the possibility of personal injury, death, property damage or loss resulting there from and agree to the following:

1. To the fullest extent permissible by law, I waive any and all claims that I have or may have in the future against Western Michigan University, including the president, officers, employees, operators, volunteer assistants, agents and representatives of the University (collectively referred to as "releasers"), including those that arise from releasers' negligence; and

   (Participant Initial here)

2. To the fullest extent possible by law, I covenant not to sue for, and release from, any and all liability for any loss, damage, injury or expense that I may suffer as a result of the use of the Recreation Center or participation in the University's climbing wall and use of facilities; including that which arises from releasers.

   (Participant Initial here)

3. To the fullest extent permissible by law, I shall hold harmless and indemnify the releasers from any and all liability from any and all property damage or personal injury to myself and any third party resulting from any use of the Recreation Center, climbing wall, or other facility at the University, including that which arises from releasers' negligence; and that this release and agreement shall be my only claim in the event of any injury or death.

   (Participant Initial here)

*** NOTE: INJURY OR DEATH CAN RESULT BY USING THESE FACILITIES AND EQUIPMENT. IF YOU DO NOT WISH TO ACCEPT THE RISKS INHERENT TO THE SPORT OF CLIMBING THEN DO NOT SIGN THIS RELEASE OR USE THESE FACILITIES! ***

I have read and understand this Agreement prior to signing it, and I am aware that by signing this Agreement I am waiving certain legal rights which I or my heirs, next of kin, executors, administrators and staff may have against the University or its releasers, and I voluntarily sign it.

Date: ____________________  Participant WIN # ____________________

Participant Signature: ____________________  Participant's Name (PRINTED) ____________________

Residence Hall
Date: October 22, 2014

To: Timothy Michael, Principal Investigator
    Justin Cargo, Student Investigator for thesis
    Nicholas Hanson, Co-Principal Investigator

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 14-09-42

This letter will serve as confirmation that your research project titled “Effect of a 7-Week Rock Climbing Class on Physical Fitness” has been approved under the expedited category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may only be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., you must request a post approval change to enroll subjects beyond the number stated in your application under “Number of subjects you want to complete the study”). Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: October 21, 2015
<table>
<thead>
<tr>
<th>Subject#</th>
<th>Time:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Height</strong></td>
<td>Meters</td>
<td><strong>Arm Span</strong></td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Kilograms</td>
<td> </td>
</tr>
</tbody>
</table>

### Grip Endurance

<table>
<thead>
<tr>
<th>Right Hand</th>
<th>Left Hand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to Fatigue</td>
<td></td>
</tr>
</tbody>
</table>

Upperbody Aerobic Power

Timed Climb

### Skinfolds

<table>
<thead>
<tr>
<th>1 Chest</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Subscapula</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Midaxilla</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Suprailliac</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Iliac Crest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Abdomen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Triceps</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Thigh</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 calf</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Grip Strength

<table>
<thead>
<tr>
<th>Right Hand</th>
<th>Left Hand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trial 1</strong></td>
<td><strong>Trial 2</strong></td>
</tr>
</tbody>
</table>

### Pinch Strength

<table>
<thead>
<tr>
<th>Right Hand</th>
<th>Left Hand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trial 1</strong></td>
<td><strong>Trial 2</strong></td>
</tr>
</tbody>
</table>
Appendix G: Flyer for Subject Recruitment

Can Rock Climbing Improve your Fitness?

A research study will be taking place
January 2015

The research study will be measuring your fitness before and after a 7-week Wall Climbing class. Just enroll in a PEGN-1750 Wall Climbing class for spring of 2015 and you could be part of it. There are 12 students allowed per class and only 3 or 4 classes available so be quick to register! Note: You can take the class without participating in the study.

- You can participate in the study if:
- You are enrolled in PEGN-1750 Wall Climbing for Spring of 2015
- You are new to rock climbing (or haven’t climbed within the last year)
- Between the ages of 18 – 55
- You are injury free and in good health standings
  - Contact Justin Cargo if you are interested or have any questions!

justin.s.cargo@wmich.edu

Justin Cargo
Justin Cargo
Justin Cargo
Justin Cargo
Justin Cargo
Justin Cargo
Justin Cargo
Justin Cargo
Justin Cargo
Justin Cargo

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