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Graduate Studies

HEART RATE AND PERCEIVED EXERTION RESPONSES OF COLLEGE  
STUDENTS IN INDOOR VS OUTDOOR ROCK CLIMBING

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the  
Degree of Exercise and Sport Science—Physical Education Teaching

Josh Chelf

College of Science and Health  
Department of Exercise and Sport Science

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HEART RATE AND PERCEIVED EXERTION RESPONSES OF COLLEGE  
STUDENTS IN INDOOR VS OUTDOOR ROCK CLIMBING

By Josh Chelf

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the master's degree of Exercise & Sport Science—Physical Education Teaching with a concentration in Adventure Education

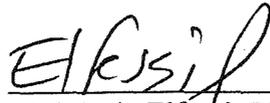
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\_\_\_\_\_  
Jeff Steffen, Ph.D.  
Thesis Committee Chairperson

7/13/09  
Date

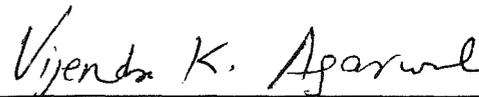
  
\_\_\_\_\_  
Rebecca Battista Ph.D.  
Thesis Committee Member

7/13/09  
Date

  
\_\_\_\_\_  
Abdulaziz Elfessi, Ph.D.  
Thesis Committee Member

7/13/09  
Date

Thesis accepted

  
\_\_\_\_\_  
Vijendra K. Agarwal, Ph.D.  
Associate Vice Chancellor for Academic Affairs

9/13/10  
Date

## ABSTRACT

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The purpose of this study was to compare the heart rate (HR) and rate of perceived exertion (RPE) responses during indoor and outdoor rock climbing in college aged students (N=18). During the indoor climbing trial, subjects climbed three consecutive routes while wearing a Polar Vantage XL heart rate monitor (HRM) to record HR every 15 seconds. During the outdoor trial, subjects climbed one route continuously while wearing the HRM. RPE responses were recorded immediately following the climbing trial. The routes were rated at the same difficulty and the same in vertical feet. The results of independent t-test was there was no significant difference between female and male indoor RPE (p-value = .232,  $p > .05$ ) or outdoor RPE (p-value = .255,  $p > .05$ ). There was also no significant difference female and male indoor HR (p-value = .184,  $p > .05$ ) or outdoor HR (p-value = .146,  $p > .05$ ). There was a disordinal interaction between female and male RPE in indoor and outdoor rock-climbing. The data suggests that both indoor and outdoor rock-climbing could be considered to improve fitness by increasing HR into the target HR zone.

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## INTRODUCTION

Across America, we have been fighting an ongoing battle with childhood obesity. Recent data has revealed that approximately 25 million children struggle with obesity, which confirms that we are faced with a real problem (Trost, 2007). To overcome this trend, we as a society need to intervene and take action. To fight this battle with obesity, physical education has been changing rapidly. Many curriculums are moving away from “traditional sports” such as basketball, football, and soccer to more “nontraditional” activities such as kickboxing, yoga, outdoor pursuits and adventure education (Muras, 2008). These “nontraditional” activities are generally lower impact, less competitive, and promote lifelong activity.

While the transition towards these “nontraditional” activities has caught on in many physical education programs, some schools seem to have lost touch with the value and importance of physical education itself. In a countless number of schools across the United States, physical education has been substantially reduced and even eliminated in response to budget cuts and increasing pressure to improve academic test scores (Trost, 2007). Although cuts are being made in physical education classes to allow for increased classroom time, evidence does not reveal that academic achievement will improve with this exchange of physical education for added classroom time (Coe, 2006). Furthermore, additional research suggests that children and youth who are more physically active tend

to perform better academically (Troost 2007). Increases in academic performance seen by those who are more physically active may be attributed to an increased attention span, reduced boredom, and increased self-esteem. These factors may also improve classroom behavior (Coe, 2006). With this said, it is clear that quality physical education can increase students' awareness of the importance of being physically fit, provide students with the tools they need to be physically active both in and out of school, and in turn may lead to an increase in academic success.

Not only can participation in physical activity benefit academic achievement, it offers opportunities for lifelong activities and hobbies. The leading contributor that places millions of children in obesity today is physical inactivity (Troost, 1999). Many schools are implementing programs to fight this epidemic and are focusing on activities that can be used throughout one's lifetime. One of the lifelong activities that has increased in popularity, among many other "nontraditional" activities, is rock climbing. While rock climbing has been around for many years, it was never viewed as a separate discipline. Rather, it was seen as a training mode or one of the many parts of mountaineering (Watts, 2004). Recently, a number of researchers have suggested that rock climbing is a sport that has experienced rapid growth and popularity over the last decades as both a recreational physical activity and as an international competition (Bas de Geus et al., 2006; Mermier, 1997; Scheel, 2004).

Students in traditional physical education classes can be uninvolved, excluded, or forced to participate in activities that do not make them feel comfortable. This in turn can give the student a negative perception of movement and being physically active. Rock climbing and other adventure activities are classified as "challenge by choice." In

other words, the student chooses at his/her own discretion the challenges he/she will perform in order to meet personal learning goals. Research has demonstrated that students who take control of personal learning are more likely to become lifelong learners and movers (Prouty et al., 2007). Therefore, if the goal of a quality physical education program is to create lifelong learners and movers, the implementation of rock climbing and other adventure education programs into the curricula should be considered.

Many studies have been done on the physiological responses and adaptations from rock climbing, however most of them were performed on elite climbers (Mermier, 1997; Booth, 1999; Scheel et al, 2003). There is little research investigating beginner, novice and/or student rock climbers. It is important to look at novice climbers because they are more likely to be encountered in a physical education or rock climbing setting. In addition, another area of study that lacks information is the comparison of the physiological responses between indoor and outdoor rock climbing within the same age. In other words, taking one group of participants, investigate the physiological responses on an indoor facility and then taking the same group and recording the physiological responses on an outdoor route.

Therefore, the purpose of this investigation was to compare the physiological and perceived exertion responses of novice climbers during indoor rock climbing to the climbers' responses when engaging in outdoor rock climbing on authentic rock formations. We hypothesized that there would be no significant difference in physiological responses or perceived exertion in indoor and outdoor rock climbing.

## **METHODS**

### **Subjects**

A total of 18 volunteers, six females and 12 males were recruited from an indoor rock climbing class, a physical education teacher education class and the general student body at the University of Wisconsin—La Crosse. All subjects read and signed an informed consent form (See Appendix B) prior to participating in the study. Students in the classes were not required to be in the study and participation did not effect any of the outcomes of the courses in which the participants were enrolled. The participants could withdraw from the study at any time without consequence. The participants ranged from first-time rock climbers to experienced rock climbers.

### **Instrumentation**

Heart rate (HR) responses were recorded using Polar Vantage XL heart rate monitors (HRM). Each monitor consisted of a watch-like receiver worn around the wrist and a transmitter that was worn around the chest and held in place by an elastic strap. The HRMs were put in place by the participants and then inspected by the investigator to ensure proper function. The data collection started one minute prior to climbing (resting), during entire duration of the climb (active), and one minute after climbing (post). The receiver was checked during climbing to ensure proper functioning.

## Procedures

A pilot study was performed at the University of Wisconsin-La Crosse's indoor climbing wall to ensure procedures were correct. From this, the investigators learned that multiple climbs indoors would have to be used in order to best simulate an outdoor climbing route. Therefore, it was important to be organized in switching the participants from one rope to the next so that the participant had the shortest break possible. From this pilot testing it was determined what was necessary to gather appropriate data.

Data collection consisted of each participant climbing twice, once indoors and once outdoors. For each climb, a belayer was used to assist the climber. The first trial was performed at the University of Wisconsin-La Crosse's (UWL's) indoor climbing wall. The second trial was performed at Devil's Lake State Park (DLSP) near Baraboo, WI. Both climbing routes selected were determined to be of equivalent difficulty rating and equal distance in vertical feet.

For each climb, heart rate and rating of perceived exertion (RPE) were recorded. In order to ensure more reliable data, participants were instructed on the use of heart rate monitors (HRM) and the use of Borg's 10-point Rating of Perceive Exertion (RPE) scale. The HRM was set to collect data one minute prior to climbing, during the actual climbing, and one minute post climbing. The HRM recorded the heart rate (HR) every 15 seconds during the collection process. During post climbing, participants recorded their RPE on the data sheet (see APPENDIX C).

The first collection was at UWL on the indoor rock-climbing wall. This wall was one third of the height (in vertical feet) of the outdoor climb at DLSP. To compensate and simulate the outdoor climb, there were three routes that were climbed consecutively

to attempt to give as little break as possible. Using the Yosemite Decimal Scale, the route was rated at 5.7. The equal ratings were from a previous study and a guidebook for DLSP. This rating suggested that most beginner climbers were able to achieve the climb without failure. Each participant climbed the first route, was lowered to the ground, disconnected from the rope and then reconnected to the next rope and then began the next route. Once all three climbs were attempted, the participant was lowered to the ground where they waited for one minute before they stopped the HRM and recorded their rating of perceived exertion.

The second climbing trial data collection took place at DLSP near Baraboo, WI. The route most appropriate for this study was chosen because of its similar vertical height and rated difficulty. This route was equivalent to the combined three routes used on the indoor rock wall totaling approximately 70 vertical feet. This particular route was also rated a 5.7 by the Yosemite Decimal Scale. The participants were instructed regarding where to climb and provided with reminders of how and when to use the HRM. The monitor was started one minute prior to climbing and the unit recorded the HR for the entire duration of the climb and then was stopped one minute after the route was completed or failure to complete the route occurred. Once the participant was back on the ground, RPE was recorded on the data sheet provided (see APPENDIX C).

### **Analysis**

Resting, active and post HR were recorded during both indoor and outdoor rock-climbing at five-second intervals. Mean resting, active and post HR were calculated for

each participant during both indoor and outdoor climbing trials. In addition, RPE was compared between both males (N=12) and females (N=6).

Independent t-tests ( $\alpha < .05$ ) were used to determine if there was a significant difference in mean responses for the following:

1. Male indoor active HR vs. female indoor active HR
2. Male outdoor active HR vs. female outdoor active HR
3. Male indoor RPE vs. female indoor RPE
4. Male outdoor RPE vs. female outdoor RPE

Because the subjects were the same for both indoor and outdoor rock-climbing, the researchers used a Repeated Measures Design to compare the following:

1. Male and female HR, indoor and outdoor HR and the interaction effects among them
2. Male and female RPE, indoor and outdoor RPE and the interaction effects among them

## RESULTS

The researchers used independent t-tests and repeated measures design. The mean HR for indoor rock climbing was =151.73 beats per minute (bpm) (SD = 26.54) and 149.72 bpm (SD = 19.31) for females and males respectively. The t-statistic was =.184 with  $df = 16$ . Since the p-value was =.856 and  $\alpha = .05$ , there was no significant difference between the mean HR for males and females on the indoor rock climbing. The mean HR for outdoor rock climbing was =161.94 bpm (SD = 8.03) and 150.24 bpm (SD = 17.62) for females and males respectively. The t-statistic was =1.530 with  $df=16$ . The p-value was =.146 and  $\alpha = .05$ , there was no significant difference in males and females in outdoor rock climbing. Results are presented in Table 1.

Table 1. Heart Rate Responses

	Indoor Mean HR (SD)	Outdoor HR (SD)
Females	151.73 bpm (26.54)	161.94 bpm (8.03)
Males	149.717 bpm (19.31)	150.24 bpm (17.62)

Comparisons of RPE for indoor rock-climbing between males and females revealed mean RPE's were 5.17 (SD = 1.47) and 6.00 (SD = 1.28) for females and males

respectively. RPE was also compared for outdoor rock-climbing. The mean RPE's for outdoor rock climbing were 6.50 (SD = 2.35) and 5.25 (SD = 2.01) for females and males respectively. It is evident that the responses increased for females and decreased for males from indoor to outdoor rock-climbing. This data is presented in Table 2.

Table 2. RPE Responses

	Indoor Mean RPE (SD)	Outdoor Mean RPE (SD)
Females	5.17 (1.47)	6.50 (2.35)
Males	6.00 (1.28)	5.25 (2.01)

The researchers used a repeated measures design to compare females, males, indoor, outdoor and the interaction among the variables. The p-value of .232 and  $\alpha = .05$  shows no significant difference between active HR whether indoors or outdoors. Sex and environment (indoor/outdoor) were examined for their interaction and resulted in a p-value of 0.279. This suggests no significant difference between females and males, indoor and outdoor rock climbing with the subjects in this study. However, examination of the means demonstrated a larger difference for females between indoor and outdoor rock-climbing. Females mean HR went from 151.73 bpm indoors to 161.94 bpm outdoors. Although this result was not statistically significant, it is worth noting. Male's HR was more consistent ranging from 149.72 bpm indoors to 150.24 bpm outdoors. Figure 1 presents the interaction effect.

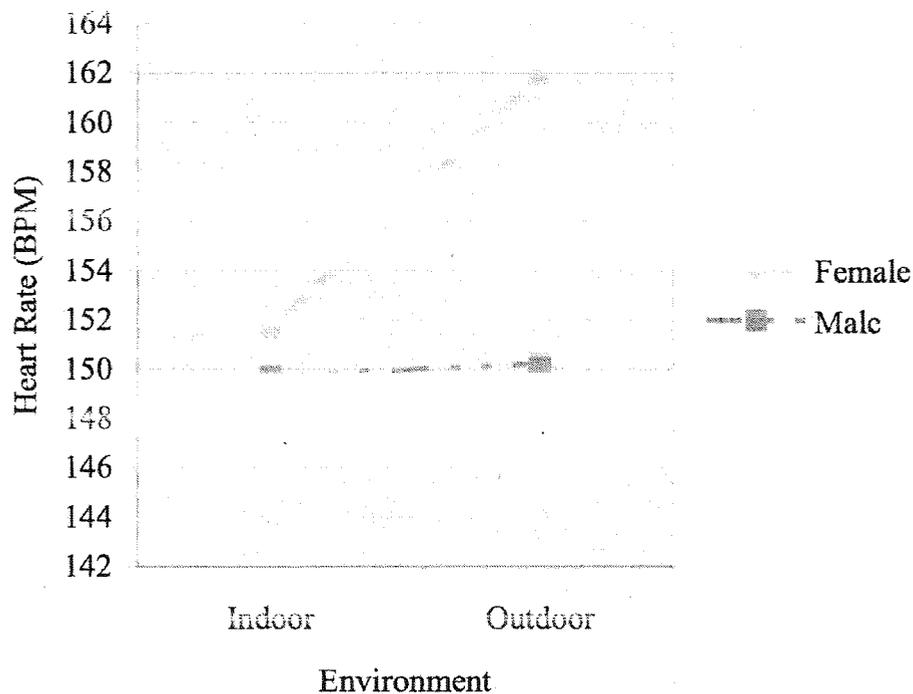


Figure 1. Heart Rate and Gender Interaction

A repeated measure design was also used to compare female and male RPE, indoor and outdoor rock-climbing and the interaction among the variables. Results showed a  $p\text{-value} = 0.458$  and  $\alpha = .05$ , indicating no significant difference in the perception of the difficulty of indoor versus outdoor climbing. The interaction of climbing environment and sex interaction revealed ( $p = .015$ ,  $\alpha = .05$ ) a significant difference. Females RPE went from 5.17 to 6.50 and males from 6.00 to 5.25 during indoor and outdoor climbing respectively. Because the regression lines intersect, this

type of interaction is disordinal. Figure 2 presents the interaction of RPE and the climbing environment.

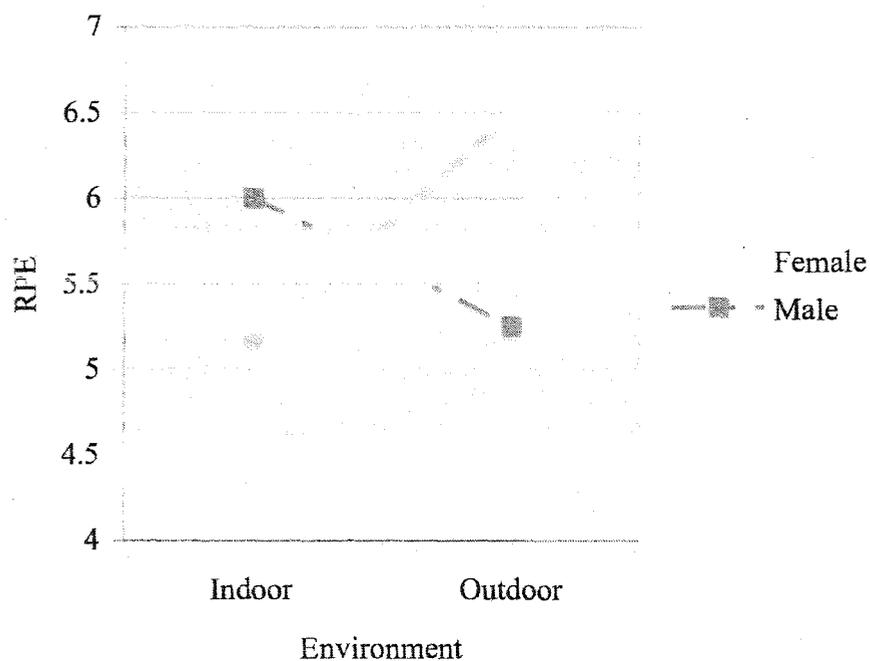


Figure 2. Rating of Perceived Exertion Interaction

## DISCUSSION

The purpose of this study was to determine if HR and RPE responses differed between indoor and outdoor rock-climbing. The results showed that there was no significant difference between active HR's and RPE while rock-climbing indoors compared to outdoors. However, an interaction between RPE and climbing environment did occur suggesting a difference in the perception of the difficulty in climbing indoors versus outdoors.

Although there was not a significant difference in HRs while rock-climbing, it is important to note that in both indoor and outdoor rock-climbing, HR responses were elevated enough to be classified as moderate to vigorous physical activity. Moderate to vigorous intensity is aerobic activity in which your heart beats at 50-85 percent of your predicted maximum (220-age). Activities in this intensity may include jogging, running, cycling, rowing, swimming, soccer, basketball, stair climbing and hiking (American Heart Association, 2008). This has direct implications on the importance of rock-climbing in the realm of physical education, physical fitness and health.

There are many factors that may have influenced the outcomes of this study. Indoor walls are built in a way to replicate what a person might see in the outdoor rock-climbing world. Knowing this and that other environmental factors are the same, one would hypothesize no significant difference—as long as vertical displacement and difficulty were equal. The data in the current study also supports this idea. A researcher

may predict RPE responses to coincide with HR values in that they would be the same between environments. This was not the case in the current study. This may have been due to factors such as anxiety, skill, body type, and comfort on the wall.

Rock climbing has been shown to elicit high HR's (Janot, 2000; Muras, 2008; Booth, 1999; Mermier, 1997). Mermier, 1997, suggested that the relatively high HRs could be attributed to the intermittent isometric contractions as well as the reliance on the arms as a major muscle group. Other factors such as anxiety and environmental conditions also have the potential to raise HR. Although there was not a statistically significant rise in HR from one environment to the other, in the current study there was a change in HR that was worth noting. Females had a lower HR ( $X = 151.73$  bpm) for the indoor rock-climbing compared to outdoor rock climbing ( $X = 161.94$  bpm) while males only had a mean change of less than one beat per minute. As suggested in earlier studies, the increase in female HR may have taken place as a result of factors previously suggested. The difference could also be attributed to smaller body size and/or physical differences in the climbing route that could have either helped or hindered females. An additional factor that may have played a role is the time of day of testing. Not all participants were able to test at the same time. Also, the indoor session was done during the afternoon while the outdoor session was done in the morning hours. These factors may have had an effect on the results.

In both environments (indoor/outdoor), HR values were well within our target heart rate zone. The American Heart Association defines this zone as 60% to 80% of a person's predicted maximum HR ( $220 - \text{age}$ ). The target HR zone for the participants in this study would have been from approximately 119-169 BPM. The mean HR achieved

fell well within the target heart rate zone indicating that rock climbing could be used as an activity to help and/or maintain physical fitness.

During climbing on the indoor wall, participants were able to rest while switching from route one route to the next. In a perfect design, the indoor wall would be have an equal vertical displacement as the outdoor rock wall in which the participant would have been able to climb the entire route without interruption. The indoor rock wall also had an overhang in which some participants could not make it past. The participants may have been limited by upper body strength and/or familiarity with the correct holds and technique to use to complete the overhanging wall. In fact, Bas de Geus (2006), demonstrated that climbing on various routes rated at equal difficulty, but different steepness and/or vertical displacement, led to higher peak and mean HR responses. It was also suggested that a route with a vertical displacement and an overhang wall is the most physiologically demanding. The overhang on the indoor course in the current study may have been a factor in the data collection process and the responses received from the participants. Although both indoor and outdoor routes were rated at the same difficulty, the indoor route may elicit different responses for different people because of the overhang.

In this study, there was also no significant difference between indoor and outdoor RPE responses when sex is not considered. When sex was considered, females had lower RPE responses than did males on the indoor course but much higher responses on the outdoor wall. This interaction is referred to as a disordinal interaction, meaning the females RPE regression line crossed that of male's RPE regression line (see Figure 2). There was a significant difference between RPE responses in females and males on the

indoor and outdoor rock walls. Again, this could have been due to many factors including the overhang on the indoor course or the type of climbing. The indoor course is set on painted plywood with handholds and footholds that protrude from the wall. Elements such as the size of the hand and footholds, the spacing between them, and the terrain all play a part in determining the physiological response (Bas de Geus, 2006). In addition, the outdoor climbing route was more of a “crack” climb where the participant had to reach back in the cracks and find something to hold on to. Any or all of these factors could have played a role in the RPE responses for all participants.

Hassmen (1996) suggested that females are more likely to listen to inner mood cues, whereas males tend to listen to environmental cues. Males should, in theory, change their rating more than females when exercise is performed in a less controlled environment (outdoors) compared to a laboratory (indoor). The current study seems to contradict this suggestion. The male’s RPE went from 6.00 to 5.25, a difference of 0.75, while females went from 5.17 to 6.50, a change of 1.33 on Borg’s 10 point scale. Although not statistically significant, a small difference is apparent. The females may have been affected more by anxiety or apprehension than were the males. When verbally communicating with the participants before climbing outdoors, the females appeared to be a bit more apprehensive about the outdoor rock wall. The apprehension was evident when hearing comments such as “That looks really high!” or “I’m scared to go to the top.” The females seemed less confident in their abilities outdoors as compared to their confidence indoors. Although the current study did not measure arousal levels, this may be the basis of a study in the future. Arousal may also be a factor in predicting RPE and/or HR while rock climbing. In addition, females and males may have different

arousal levels depending on the environment of the rock climbing. Based on the RPE results of the current study, females perceived outdoor rock-climbing to be harder while males perceived indoor rock-climbing to be harder.

In conclusion, it was determined that there was no significant difference between HR and RPE responses of college students in indoor vs. outdoor rock-climbing. The sample size may have been a factor in the study. Further investigation is needed using rock walls with the same vertical displacement. In the current study, participants were given a small break between the three consecutive climbs indoors, which may have changed the mean active climbing HR. From a fitness perspective, both climbing environments elicited responses that would consider the activity to contribute to the physical activity recommendations of the American Heart Association (American Heart Association, 2008.) The current study may be useful to physical educators, outdoor trip leaders, rock climbing guides, competitive and noncompetitive rock climbers and indoor rock-climbing gyms. Since there was no significant difference in physiological effects, it may be easier for the list of professionals in the previous sentence to justify using the indoor rock-climbing facilities as much or in conjunction with the outdoor rock climbing areas. Indoor courses may be more accessible and more readily available than outdoor areas and appear to have the same effects in terms of physiological and RPE responses.

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APPENDIX A  
REVIEW OF RELATED LITERATURE

## **REVIEW OF RELATED LITERATURE**

### **Introduction**

Rock climbing is a sport with a rapid growth in popularity over the last two decades as both a recreational physical activity and as an international competition (Bas de Geus, et al. 2006; Mermier, 1997; Sheel, 2004). Rock climbing has been a sport in itself for many years but has been around longer as part of mountaineering. Rock climbing was never seen as a separate task or sport, but rather as a training mode for mountaineers (Watts, 2004). It wasn't until the more recent years that people began to explore rock climbing as a separate challenge and a sport in and of itself. Many more people are being attracted to rock climbing because of its high safety standard, its sense of accomplishment, and as another way to stay fit through life.

Today, there are several different types of rock climbing. In the past, when rock climbing was part of the larger discipline of mountaineering, rock climbing was done outdoors on natural rock. With increase in popularity and an increase for easier access, rock walls began being constructed indoors where the weather and access were less of an issue.

With this study we are most concerned with indoor top-roping and outdoor top-roping. This type of climbing is very safe with many opportunities to practice high-level or new skills in the sport of rock climbing. As the name implies, a rope is attached to the climber, then runs to the top of the wall through an anchor and back down to a belayer

who will help protect the climber. Indoor rock climbing has seen a dramatic increase in the number of participants in the last two decades (Janot, 2000). The look and feel of indoor climbing courses has also become more authentic and representative of various types of real rock. With the increase in popularity of indoor rock climbing, Outdoor rock climbing has also seen a large increase in the number of participants.

The purpose of this paper is to examine the relevant literature to physiological effects and perceived exertion while rock climbing both indoors and outdoors. Literature on the topics of indoor rock climbing, outdoor rock climbing, heart rate monitors and their usefulness, perceived exertion, and physical activity in physical education were examined to get a better understanding. Through this examination, readers will be able to see the need for comparing indoor and outdoor rock climbing and the physiological effects of those two environments on climbing. There has been a lot of research done on these subtopics and a better understanding of this research must be completed in order to fully understand the variables that the researcher will be looking at for this study.

### **Indoor Rock Climbing**

Indoor rock climbing is a relatively new sport that has grown dramatically in the past two decades (Janot, 2000). Indoor rock climbing is a little bit different than outdoor rock climbing in that a specialized company must construct the indoor climbing walls. The wall is then outfitted with holds of various sizes and shapes and attached to the wall so that a climber has something on which to propel up the wall. The main advantage to indoor rock climbing facilities is that weather does not play a role in rock climbing. It will always be nice inside whereas outdoors is a little bit different. Indoor rock climbing

is characterized by gymnastic type movements on walls fitted with artificial hand and foot holds (Booth, 1999). It is also physiologically unique in that it requires sustained and intermittent isometric forearm contractions for upward propulsion (Sheel, 2004). Indoor climbing can also accommodate varying skill levels by modifying wall angles, hold size and placement (Mermier, 1997).

Janot et al.(2000) studied heart rate and rating of perceived exertion for beginner and recreational sport climbers during indoor climbing. Subjects were college aged males and females. The recreational climbers were enrolled in a class on rock climbing so they had more experience than the beginner climbers who had never climbed before. The subjects were to climb two different routes. One was rated a 5.6 (Yosemite Decimal Scale) and the other a 5.8. The 5.6 is considered achievable by beginning climbers and 5.8 is considered to be tougher for beginners but achievable by both beginners and recreational climbers.

Heart rate monitors were used during climbs to document the climber's HR. The HR was continuously recorded one min before, during and 10 min after climbing. While climbing, the subjects were not allowed to stop for more than 5 sec in order to keep the total time climbing as uniform as possible. All the participants were instructed to do both climbs, even if failure was encountered on the harder climb.

This study suggested that anxiety may play a role in HR before and while climbing. The beginning climber's HR was significantly higher pre-climb as compared to post-climb, again suggesting anxiety before climbing. HR overall for beginner climbers was 12-15% higher than the recreational climber's HR. Along with HR being higher, RPE was also higher for the beginning rock climbers, as expected.

The work by Janot et al. (2000) is extremely valuable in that several of the methods will be used in the current study. From this study, we can see that different level climbers are going to have a different RPE and also different HR. It also suggests that HR from one person to the next is going to be different depending on several variables such as experience and route difficulty.

Mermier et al. (1997) studied energy expenditure and physiological responses during indoor rock climbing. They used 14 experienced rock climbers on three route varying in difficulty: an easy 90 degree vertical wall, a moderately difficult 106 degree negatively angled wall, and a difficult horizontal overhand of 151 degrees. During each of the trials, expired air was collected, HR via telemetry unit was recorded, and blood samples were taken from the ear lobe to measure for blood lactate.

Mermier et al. (1997) found that indoor rock climbing expends energy at a relatively high rate. During this study, HR of participants reached an average of 74-85% of predicted maximal HR ( $220 - \text{age}$ ). According to American College of Sports Medicine, this is well within the recommended target HR zone for health related benefits. Mermier et al. (1997) also suggested that rock climbing would be a good activity for increasing cardiorespiratory fitness and muscular endurance. Though HR and  $\text{VO}_2$  were not linear in rock climbing as they are in many other activities such as running or cycling, there was a disproportional rise in HR due to isometric contractions in the forearms. Another factor in HR increase during rock climbing is the position of the arms. Most of the time, the arms are placed above the head, requiring the heart to pump more often to oxygenate those muscles.

Similarly, Watts and Drobish (1998) studied physiological responses to simulated rock climbing at different angles. The subjects were 16 experienced rock climbers. The subjects were to climb on a rock climbing treadmill at three different angles ranging from 80 to 102 degrees. HR was continuously measured,  $VO_2$  was determined at 20 sec intervals, RPE was recorded immediately after each bout, right and left handgrip force was obtained, as well as a blood sample to measure blood lactate. On a separate day, subjects were tested on a treadmill at a HR equal to the 86 degree climb.

Watts and Drobish (1998) found that while HR increased with climbing angle,  $VO_2$  did not significantly vary. Blood lactate began to increase with increased angle. Handgrip strength also diminished with increasing angle. Scores for RPE also increased with steeper angles on the treadmill climbing wall.

Rock climbing presents itself with a heavy workload. Even though blood lactate and RPE scores were similar to that of running, the relative exercise intensity elicited from simulated rock climbing is lower. Rock climbing increased the HR, but the oxygen uptake is not nearly as high as other activities. As a result, it is important to note the effect that climbing angle has on the responses of the participants. Steeper angles tend to elicit higher HR and RPE responses even though the oxygen uptake may still be at a lower level. This may have an effect in choosing two routes to compare.

Watts (2004) observed the physiological responses of difficult rock climbing in elite climbers. The goal was to explore existing research on the physiological aspects of difficult rock climbing. Findings were categorized into the areas of athlete profile and an activity model. All of this work was done on climbs that were a 5.10 (Yosemite Decimal

Scale) to 5.15 which is the very hardest rating on the scale. The climbers participating were some of the very best in the world.

The athlete profile determined by Watts (2004) showed a different climber versus the previously determined, large mesomorphic elite level climber. Today, the elite climber is a relatively small person with low percentage body fat, often below 10% for women and 7% for men. Flexibility seems to also play an important role in rock climbing. Watts (2004) found that most elite rock climbers had “average” scores on many of the flexibility tests. Elite climbers were found to have above average muscular strength and endurance when compared pound for pound of body mass. Maximal oxygen uptake scores for elite climbers were shown to be similar to those involved in team sports and gymnastics; activities that require quick recovery.

During rock climbing, Watts (2004) suggested that about 1/3 of the time is spent in a static position, requiring endurance in the forearm muscles to hold body close to the wall. In addition, it was shown that  $VO_2$  stays fairly constant during the whole climb, but at times can spike up due to extra needs of the muscles. As a long climb goes on, handgrip endurance decreases faster than handgrip strength with severe climbing and recovers at a slower rate.

The work by Watts (2004) helps clarify the physiology behind rock climbing and some of the variables that are involved in rock climbing. Characteristics of the climber as well as the route taken and other factors, play an important role in the success of rock climbing.

## **Outdoor Rock Climbing**

Outdoor rock climbing has developed from a mere training mode for alpine mountaineering into a specific recreational activity and leisure pursuit (Watts, 2004). Outdoor rock climbing involves ascending real rock walls using the body. A rope and harness are usually used for protection from falling. Outdoor rock climbing is accessible at several state parks and other recreational areas throughout the United States.

Bunting et al. (2000) measured the physiological response of the neuroendocrine system during outdoor adventure tasks. Outdoor adventure tasks involve a composite of both physical and psychosocial demands. This type of stress has not been studied much but is often the type of stressor encountered while participating in active leisure experiences. Outdoor adventure programs are being introduced to many different groups of people including students and middle-aged professionals. The experience of being out of one's comfort zone can stimulate a holistic type of growth within and individual and/or group. These types of growth are good for classes to companies that are looking to make a bond and learn to work together in a positive way.

Bunting used participants in a voluntary nine-day outdoor adventure program for adults. They were to participate in several outdoor activities including rock climbing, whitewater rafting, wilderness backpacking, and a ropes course. During these activities, urine samples were taken to measure urinary epinephrine and norepinephrine. It was shown that rock climbing elicited the largest effect on the neuroendocrine system. It was also found that less fit people elicited a greater response, which the authors suggested may be because of less experience with these types of activities. As a result Bunting et al. (2000) suggests that stress adaptation, or "toughening," plays a role for the more fit

subjects and when exposed to these types of situations, the sympathetic nervous system (SNS) is stimulated and learns to work more quickly and efficiently. These findings indicate that indeed the nervous system could be part of the reason for more fit subjects to have less of a response to outdoor adventure type activities.

Outdoor rock climbing is a strong elicitor of the neuroendocrine system and the “fight or flight” response. With this type of arousal, HR and other bodily functions are going to increase. There are strong demands on the physical as well as the psychosocial aspects of the body during outdoor adventure tasks, including rock climbing.

Booth et al. (1999) studied the energy cost of elite sport climbing in elite performers. The subjects were six men and one woman who were elite climbers. The subjects climbed on an indoor vertical climbing ergometer to test for maximal aerobic capacity and determined the  $VO_{2 \text{ climb peak}}$ . Climb Peak is similar to  $VO_2 \text{ max}$  but for the climber’s max while rock climbing instead of the usual  $VO_2 \text{ max}$  on a treadmill. Booth et al. (1999) compared the  $VO_{2 \text{ climb peak}}$  with climbing  $VO_2$  rather than many previous studies that compared a max  $VO_2$  from a treadmill test and determined climb peak was a better comparison to relative intensity while climbing outdoors. HR was continuously recorded throughout each bout. Blood lactate was also measured immediately after each climb.

During the outdoor climb, Booth et al. (1999) used a K2 portable telemetry system to measure oxygen consumed and heart rate while outdoor rock climbing. While climbing outdoors as compared to the maximal test on the climbing ergometer, the climbers reached 83%  $HR_{\text{peak}}$  and 75%  $VO_{2 \text{ climbpeak}}$ . This was different than previous tests because of the comparison between exhaustive climbing vs. exhaustive running or

other activities that climbing has often been compared to. Rock climbing elicit different responses than other exhaustive activities and is why the authors chose to establish a climb peak rather than just comparing climbing to those other activities.

Relative to exhaustive climbing, outdoor climbing uses a great deal of energy. If using ACSM's guidelines for target HR zones, when compared to the maximal  $VO_2$  climb peak, outdoor rock climbing is a great activity to increase the muscular strength and endurance of the muscles involved with that type of activity.

### **Heart Rate (HR) and Heart Rate Monitors (HRM)**

In order to achieve health-enhancing benefits of exercise, American College of Sports Medicine (ACSM) and the American Heart Association (AHA) recommend that adults achieve 30 minutes of moderate intensity cardiovascular exercise five days a week. The definition of moderate intensity physical activity is: working hard enough to raise the heart rate and break a sweat, yet still being able to carry on a conversation. ACSM offers many tips to help meet the guidelines. They suggest doing it in short bouts. Research has shown that three ten-minute bouts are just as good as one thirty minute bout of physical activity. ACSM also suggests mixing it up with moderate and vigorous intensity physical activity. They also suggest that the "gym" isn't necessary and to make exercising or physical activity a family affair.

AHA suggests exercising within a "Target Heart Rate Zone." This can be calculated quite easily. First, the maximal heart rate must be found which is often determined as  $220 - \text{your age}$ . Next, the maximal heart rate is multiplied by 60%-85% and provides the intended "Target Heart Rate Zone." For example, a 20 year old male or

female would have a maximal heart rate of 200 ( $220 - 20 = 200$ ) and 60-85% of HRMax is equivalent to heart rates of 120-170 beats per minute (BPM).

There are many activities that can elevate the heart rate into the intended target heart rate zone. These activities may not be thought of as “exercising” but in fact, are quite good example of activities that help achieve 30 minutes a day. Gunnar Borg, creator of the Rating of Perceived Exertion (RPE) scale once had an argument with a friend about whether or not gardening required any exertion. Needless to say, his friend didn’t think so, but that could be the topic of another thesis (Borg, 1998). Some activities raise the heart rate due to their cardiovascular nature and others activities raise the heart rate due to other factors.

The main use for HRM is to determine exercise intensity during a training bout or bout of exercise. HRM units are easy to use, relatively inexpensive, and readily available. The use of HRM can also help coaches and athletes in training and be used to detect overtraining. Studies have also shown that there is a strong relationship between HR and  $VO_2$  or oxygen uptake. Although HR has been shown to be 20% off from the actual values for oxygen uptake, it is still considered a good indicator of exercise intensity. Factors such as air temperature, hydrations and others can play a large role in HR (Achten, 2003).

As previously stated, HR and HRM are good indicators of exercise intensity. Several studies have been done to exemplify this statement. Esposito et al. (2004) studied the validity of HR as an indicator of aerobic demand during soccer activities in amateur soccer players. Esposito et al. (2004) used seven male amateur soccer players. The players were instructed to go around a soccer course that resembled actions during a

live soccer game which included two laps for each trial and a total of three trials; moderate, high and very high (maximal) intensities. The intensity was recorded via Borg's CR 10 scale. After each bout, a blood sample was taken and tested for blood lactate. Results showed, athletes had an average HR of 156, 173, and 186 and an average RPE of 2.3, 4.3, and 9.1 at the moderate, high, and very high intensities respectively. It was determined that HR could be used to determine oxygen uptake of amateur soccer players while on the field (Esposito, 2004) and thus shows that HR is a good indicator of exercise intensity.

Rock climbing is a little different than the sport of soccer though. Soccer involves extended amounts of running, shuffling, kicking, changing directions and even some walking. Rock climbing is an activity that requires a lot of bending, stretching, grabbing, pinching and pulling which require extended periods of muscle contraction. This type of contraction is referred to as an isometric contraction. It has been shown that these contractions tend to elevate the HR. Galvez et al. (2000) looked at the effects of muscle mass and intensity of isometric contraction on HR. This research wanted to find out the effect of muscle mass and the level of force on contraction-induced rise in HR. The subjects were randomly subjected to four trials. One was dominant handgrip strength and the other was turning a wheel with both hands to the dominant side. Each of these was done twice at 20% and 50% of maximal force. Galvez et al. (2000) found that HR increased during both isometric contractions and increased muscle mass. The maximal HR recorded always occurred at or very near the end of the trial in all the subjects. Knowing the effects of isometric contractions is important when looking at the HR during rock climbing. Rock climbing often involves the forearm muscles contracting

to hold on to a handhold. Often the hold is very small and/or slippery and must be gripped hard in order to stay on the wall.

Fitness levels may also play a role in HR. Someone who is very fit and lean is going to have a lower absolute HR than someone who is unfit and overweight exercising at the same intensity. Ekelund et al. (2001) stated HR can be an indicator of the intensity of physical activity in human adolescents. Participants included were 150 boys and girls. The participants were put on treadmills and put through an incremental exercise protocol. HR was measured continuously and expired gases were collected throughout. A finger prick was also used to measure blood lactate. The results showed that HR wasn't always a good indicator of exercise intensity. At 140 BPM, the activity might be strenuous for one individual but quite easy for another. Ekelund et al. (2001) suggests using  $\%HR_{max}$  instead of absolute HR for these activities. It was also suggested that the total amount of physical activity is more important than whether or not the adolescents are in the target HR zone. This is useful in that the absolute HR may not be the best indicator of exertion. This may also be looked in this study with the combined use of the CR 10 RPE scale and HRM.

Some HRM are inherently better and more accurate than others. Some work well at low intensities and others during mid to high intensity. Often, when purchased for personal use, price plays a major role in what monitor will be purchased with little attention to whether or not it is truly accurate. Donna Terbizan et al. (2002) observed the validity of seven commercially available heart rate monitors. Fourteen men were asked to exercise on a treadmill. Of the seven HRM evaluated, five received data via telemetry from a chest strap to a monitor worn on the wrist (Polar Vantage XL, Polar Accurex II,

Accumen Basix Performance, Cardiosport Excel ZW-8, and Cardiochamp—Sensor Dynamics, Inc.). Of the two other HRM, one was worn on the ear lobe (Cateye Model PL-6000) and the other was handheld (Instapulse HRM Model 100). The subjects all wore HRM and were connected to an electrocardiogram (ECG) via five silver electrodes. The subjects then were put on the treadmill. There were three levels of activity in which the subject must exercise for 10 minutes at that level. The results showed that none of the HRM were valid at the highest intensity or speed. Terbizan et al. (2001) classified a HRM valid only if it had a correlation between recorded HR and the corresponding ECG greater than or equal to .90 with a standard error of 5 bpm or less. At lower speeds, there were some monitors that were considered “valid” by the research team. The research concluded that if you want a HRM that is accurate, the Polar Vantage XL, Accurex II, Cardiochamp, and the Cateye—PL—6000 are the best choices.

This knowledge is very useful for this study. It is important that if HR measurements are being taken, that the data needs to be valid and accurate. Some HRM do not provide accurate and valid data while others do. As we can see, there are four HRM that will be more accurate and valid than the other three. This is reassuring knowing that the current study will be using Polar Vantage XL HRM.

### **Rating of Perceived Exertion (RPE)**

Since its development in the early 1960's, Rating of Perceived Exertion Scale (RPE) has been embraced by clinicians, researchers, and exercise enthusiasts as an inexpensive and simple technique for monitoring and adjusting exercise intensity. The scale, created by Gunnar Borg, is based on principle from psychophysics, which looks at

an individual's perception or an outside stimulus. Perception is different than sensation. Sensation is indentifying a stimulus, while perception interprets these external stimuli (Scherer, 1999).

The first scales were developed to measure a range of exercise sensations by putting categories on a number scale. Each category has a definition or description so subjects could categorize their effort or exertion. The scale relied on individuals to be able to assess their perception of effort relative to maximum effort (Scherer, 1999). The first scale Gunnar Borg created was the linear 21 point RPE scale. The scale ranged from 6-20. On this scale, a HR of 170 roughly correlated with a perceived exertion of 17. Since, in healthy persons, 170 was a common point of reference in estimating sub-maximal measurements of working capacity, it was given a rating of 17 and was easy to compare by dividing the HR by 10. A rating of six was the starting point because 60 was a fairly low resting HR for adults and it signified resting. All odd numbers were then anchored with a verbal cue such as "Very, very light" or "Hard" or "Very, very hard" (Borg, 1998). Because this scale does not reflect a linear relationship with work, new scales had to be developed and the 21 point scale is not recommended for use (Scherer, 1999).

During the 1980's a few changes had to be made to make the scale more accurate and precise. Number six was given the verbal cue of "No exertion at all," number seven was changed to "extremely light," and 20 was given the cue "Maximal exertion." This scale was a bit more accurate and with better reproducibility with the changed cues. The number 20 "maximal exertion" was an absolute maximum in which very few if any people should have ever achieved. Borg said that 19 represented the highest intensity

that most should have experienced and it may have included activities such as running extremely hard for several minutes or carrying a heavy object until nearly failing to complete the task (Borg, 1998).

Even though Borg's 15-point scale is very reliable and valid when used correctly, some still wanted an even simpler scale for rating perceived exertion. The Category-Ratio (CR) 10 scale was created. This scale describe categories in multiples, in which 4 is twice as hard as 2 (Scherer, 1999.) Since the CR 10 scale is very reliable and easy to use, it has become more popular than other CR scales (Borg 1998.)

Eston and Thompson (1997) studied the use of RPE for predicting maximal work rate and prescribing exercise intensity for patients taking atenolol. They had a control group of 10 men and 10 women with risk factors for cardiovascular disease but were not taking any drugs. The treatment group was 11 men and 11 women who were taking 25-100 mg of atenolol. Resting HR and blood pressures were taken after five minutes of quiet rest. Then patients were given time to practice and learn the exercise procedures and working with the RPE scale. Tests were conducted in two stages with at least two days rest. The control group performed a submaximal graded exercise test used to predict the maximal oxygen uptake or maximal work rate following YMCA's cycle ergometry protocol. The treatment group did a similar test to predict their maximal work rate. Two days later each patient was given an effort production test. The patients were requested to work at RPE's of 9, 13, 15, and 17 by changing the resistance to get to the predetermined RPE. Eston and Thompson (1997) found through these tests that there is evidence that RPE may be used to predict maximal functional capacity in patients receiving atenolol. The findings were similar for the control group as long as RPE was

used as the dependent variable. Results of this study illustrate that when RPE is used and facilitated correctly, it is a valuable tool in estimating effort and predicting maximal work rate.

Peter Hassmen (1996) studied the environmental effects on RPE in males and females. Hassmen looked at the differences reported in rating behavior between males and females; and between exercise performed in the lab as compared to exercise performed in the field. It has been said that subjects perceived running in the field to be significantly less straining than running in the laboratory at the same relative HR and blood lactate levels. When there are less external factors to focus on, the subject focuses on internal factors and perceived exertion rises. External stimuli such as music can distract the subject and perceived exertion is less.

Hassmen used 24 females and 24 males in his study. He made sure the two groups had prior and present participation in regular physical activity. Two tests were administered on the patients, and indoor cycle test on an electronically braked cycle ergometer and an outdoor run test. After a slight warm-up on the cycle, the test was administered. A 20 minute break was given and then the subjects were instructed to run on an outdoor park path that was 800 m long. They had to do two laps, one slightly faster than walking and then the next at a moderate pace. HR was continuously monitored and then RPE was reported at the end of each interval. Using the HR:RPE ratio (10:1) the males showed smaller deviations than did the females, especially at lower work loads. The females had a tendency to underestimate their perceived exertion. The female group rated their perceived exertion between two and three units lower than the male group. Both groups had a lower RPE than expected during the outdoor running task.

This study shows that environment definitely plays a role in subjects rating their perceived exertion and helps show what variables might play a role in determining RPE responses. Many factors in the environment for rock climbing may play a role including being indoors vs. outdoors, weather, temperature, climbing surface etc.

### **Physical Education and Physical Activity**

Today, obesity is one of the most pressing health concerns for our children. More than one-third of children and teens, approximately 25 million kids, are overweight or obese—and physical inactivity is a leading contributor to the epidemic (Trost, 1999). Children, on the average, spend up to five or six hours a day involved in sedentary activities, including excessive time watching television, using the computer, and playing video games. To make matters worse, children are bombarded with television ads from fast food chains and other sources of high fat, high sugar meals or snacks. These ads are specifically targeted towards children (Green & Reese, 2006).

Despite these astounding statistics, the percentage of schools that require daily physical education decreases from about 50% in the first five grades (1-5) to 25% in grade 8 and 5% in grade 12. The obesity epidemic cannot be helped with these statistics of daily physical education. Many studies have been conducted that show a positive relationship between physical activity and its affects. Few have shown no correlation or inverse relationships. It has been shown that students may improve academically due to increased arousal and reduced boredom, which may also lead to increased attention span and concentration (Coe, 2006).

There have been many studies on the effects of physical activity on children and students. The CDC (Center for Disease Control) suggests that children and adolescents should participate in 60 minutes (1 hour) or more of moderate to vigorous physical activity daily. Some of the daily activities should include aerobic activities, muscle-strengthening activities, and bone-strengthening activities (CDC, 2008). When these guidelines are met, it has been suggested that there will be positive effects not only the child's health but also performance in the classroom (Trost, 1999).

Coe et al. (2006) studied the effect of physical education and activity levels on academic achievement in children. A total of 214 sixth grade students from a single public school in western Michigan, were assigned, randomly, to physical education class. One group had physical education the first semester and the second had it the second semester. While not in physical education class, the students were assigned to an exploratory class (i.e., art and computer classes). The class was daily for 55 minutes. The students were assessed three times throughout the year.

Physical activity was estimated by using the 3-D physical activity recall (3DPAR), a variation of the previous day physical activity recall developed by Weston et al. (Coe, 2006). 3DPAR requires or asks children to recall their activity from the previous three days activities. The recalled activities were broken into 30 minute blocks. If a student did more than one activity, they were asked to record the one they did most of the block. The child also provided an intensity level for the activity. Scores of 1 (no activity), 2 (some activity) and 3 (activity that meets Healthy People 2010) were given.

Academic achievement was based on individual grades for each student in the core classes (Math, Science, English, and World Studies). Letter grades were converted

to numerical data. Each grade would receive a number (A=5, B=4, C=3, D=2, and F=1). Therefore, the students could receive a score ranging from 8 to 40. Terra Nova standardized test score were also used to measure academic achievement of the students.

To assess the amount of fitness instruction during physical education classes, the System for Observing Fitness Instruction Time (SOFIT) was used. Both student and teacher behaviors were assessed by a single observer. This data was used to provide the quantity of physical activity performed during physical education class.

According to this study, the timing of physical education class did not affect the students' academic achievement when comparing students who had physical education class first semester or second semester. Terra Nova standardized test score were also not affected. Although timing of physical education class did not affect achievement, students who met Healthy People 2010 gridlines did have higher academic scores when compared with the other students who didn't meet the guidelines.

Physical education classes, according to the SOFIT assessment, for the sixth grades students, provided an average of 19 of 55 minutes of moderate to vigorous physical activity. This is not even half of what the Healthy People 2010 suggest for daily activity. This could help explain the results of the investigation.

Student achievement was also compared with out-of-school physical activity. The amount of moderate physical activity did not affect student achievement. However, there was a significant association found between vigorous activity and academic achievement. Knowing this, it is important to provide for our students, through physical education class, with the tools and skills needed to help them be able to seek out and participate in *vigorous* physical activities.

Verstraete (2006) attempted to increase children's physical activity levels during recess periods in elementary schools in order to look at the effects of providing game equipment. Since many previous studies have focused on physical education classes providing physical activity for students, Verstaete decided to focus on the effects of promoting or providing physical activity during recess periods. Time in physical education is limited and cannot, in most cases, provide the 60 minutes of moderate to vigorous physical activity needed by students.

A random sample of seven elementary schools participated in the study. Three schools were randomly selected to be the control group and four schools selected as intervention schools. There were a total of 235 children evaluated with 122 in the intervention group and 113 in the control. All schools had a morning recess about 16 minutes, a lunch break of about 86 minutes with an average of 53 minutes of playtime, and an afternoon recess of about 13 minutes. At the start, all the schools had comparable playground space and equipment with no organized activities.

Each class was given its own set of game equipment for managerial issues. The classroom teachers were encouraged to rotate the equipment so that students would keep interested. The teachers were also given task cards in which the students would try to complete during recess periods.

The children's activity level was measured using accelerometers and the data was expressed in percentage of recess time, to control for the varying length of recess periods. The children's physical activity levels were measured before (pre-test) and three months after (post-test) providing the game equipment in the intervention schools. The children

were not told the purpose of the accelerometers until after the post-test measurements to ensure valid activity levels of the students.

Verstraete (2006) found the time spent on moderate intensity activities increased significantly in the intervention group and decreased in the control group. The time spent on low intensity activities increased more in the control group when compared to the intervention group. There were also significant differences between genders in this study. Providing equipment and activities had a significant difference in the girls' activity levels during recesses by increasing the amount of moderate activity and lowering low intensity times. There was no significant change in boys' moderate activity levels during the intervention, but there was an increase in boys' low intensity activity levels for both the intervention and control groups.

Providing equipment for students during recess breaks helps increase moderate to vigorous physical activity in both boys and girls. At pretest the intervention group was active 48% of recess. This percentage is similar or maybe a little bit higher than the average school might see. After the intervention, 61% of the recess time students were engaged in moderate to vigorous activity—quite the increase. This study also showed that the intervention was as effective in “active” as it was for “less active” students. The implication of this is that we can help both active and less active students become even more active by giving them simple tools such as equipment during recess. If we also give them the skills, through physical education, to seek out and find the activities they enjoy outside of class, students may spend even more time outside of the school setting engaged in moderate to vigorous physical activity.

Blais (2008) was interested in promoting physical activity outside of school. Specifically, they took a closer look at a program called "The Health Passport." This program was designed to be taught in physical education and completed at home outside of school with friends, family or by themselves. The "passport" took the form of a learning contract with goals to be achieved, a formal personal commitment on the part of the student and the presence of significant witnesses. Each week the students were asked to perform activities taught in their physical education classes and then record them by drawing on the provided calendar, which was part of the "Passport." Then they had to get a signature of a significant witness, usually parents.

Students, physical education teachers, classroom teachers, and parents were actively involved in the study. Classroom teacher's and parent's main role was to follow up on student activities and to incite the students to complete the tasks in the passport. Parents were also the significant witness. The physical education teacher's role was to teach the activities in the passport and also to follow up with students on how they were doing.

After many interviews, Blais discussed the findings from the study and how the students reacted and participated in "The Health Passport." The student's engagement in the passport was broken into several different categories. First was "Regularly meets task requirements." About four to eight students in each class (average 25 per class) were regularly active during each month. These students were enthusiastic about the program and asked question to make sure they were doing the correct things. These students were also well supported by their parents. Next was "Transforms task." This category consisted of 10-15 students per class on average. Students exploring the limits of the

tasks that were required by the physical education teacher characterized this group of students. Some students decided to upgrade the tasks and do more than was required by the passport. Others diminished the activity and would often make an excuse as to why they didn't do the whole activity. Students who upgraded the activities were often supported well by their parents and those who diminished the activity had parents who tolerated their activities. "Starts strong and burns out" was the next category of students. These students, as can be predicted, started out very enthusiastic and active. As time went on, those students didn't record as often or had things come up. Often these students would get motivated again and record as required by the passport. This created a roller coaster like activity levels. This didn't mean the students were not active, but it meant that the students didn't record regularly as required by the passport. Students who were in this category often were not correctly supported at home. Next was "Keeps aloof." These students, three to six per class, decided deliberately to not become involved in the Health Passport because it did not meet their needs and/or they stated they were already active. Parents of these students also stated similar statements. The last category, which included one or two students per class, was "Disguises Lack of Participation." These students would fake completion of the tasks in the passport. These students would have well completed passports but would then not be able to complete the tasks or "forget how" when asked to do so during physical education. Some would go as far as signing for their parents.

Even though the students, who acted as co-researchers, were only 7-10 years old, 60-80% of the students elected to perform the Health Passport task on a regular basis.

The students in the study were held accountable by several methods. They included supervision, informal assessment, and reward or public recognition.

This study showed that physical education teachers could effectively promote physical activity outside the school setting. Simply talking and encouraging students may not be enough though. One particular strategy that seemed to be most effective was collaboration of adults. Those students who had great support at home often were the students who regularly filled out and completed the passport. Adults at home helped the students stay on task and complete the activities in the passport.

Overall, physical education can have positive effects on both the student's health and the student's academic achievement. Through physical education, teachers can help give students the tool needed in order to be competent in activities that one chooses to participate in. The time spent in physical education is not enough, so we must find ways to keep students active. Simply providing game equipment during a recess period is a good way to use the skills learned in physical education to become more active outside of class. Other skills such as rock climbing may be another alternative for many students.

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**APPENDIX B**  
**INFORMED CONSENT**

**Protocol Title:** Heart Rate and Rating of Perceived Exertion in Indoor vs. Outdoor Rock Climbing

**Principal Investigator:** Josh Chelf  
1414 Pine St #  
La Crosse, WI 54601

**Emergency Contact:** Megan Chelf  
1414 Pine St #  
La Crosse, WI 54601

➤ **Purpose and Procedure**

- The purpose of this study is to determine if heart rate (HR) and rating of perceived exertion (RPE) responses differ between simulated (indoor) rock climbing and authentic (outdoor) rock climbing
- My participation will involve wearing a heart rate monitor and documenting ratings of perceived exertion during the indoor climbing session and at Devil's Lake State Park, which are both part of ESS 310.
- No extra time is required beyond participation in ESS 310

➤ **Potential Risks**

- I may experience a fall during indoor or outdoor rock climbing
- I may get injured while participating in rock climbing
- The watch and/or chest band of the heart rate monitor may be uncomfortable to wear

➤ **Rights and Confidentiality**

- My participation in this study is completely voluntary
- I can withdraw from the study at any time for any reason without penalty
- The results of this study may be published in scientific literature or presented at professional meetings using grouped data only.
- All information will be kept confidential through the use of number or letter codes. My data will not be linked with personally identifiable information.

➤ **Possible Benefits**

- I may learn about HR and how to use HR monitors
- I understand that the possible benefits are not going to impact me directly.

Questions regarding study procedures may be directed to Josh Chelf (715) 966-1739, the principal investigator, or the study advisor Dr. Jeff Steffen, Department of Exercise and Sport Science, UWL (608) 785-6535. Questions regarding the protection of human subjects may be addressed to the UW-La Crosse Institutional Review Board for the Protection of Human Subjects, ((608) 785-8124 or ).

Participant \_\_\_\_\_ Date \_\_\_\_\_

Researcher \_\_\_\_\_ Date \_\_\_\_\_

**APPENDIX C**  
**BORG'S 10-POINT RATING OF PERCEIVED EXERTION SCALE**

Name: \_\_\_\_\_

HR Monitor #: \_\_\_\_\_

Circle your Perceived Exertion:

## **10 Point Scale**

- . 0 - Nothing at all
- . 1 - Very light
- . 2 - Fairly light
- . 3 - Moderate
- . 4 - Some what hard
- . 5 - Hard
- . 6
- . 7 - Very hard
- . 8
- . 9
- . 10 - Very, very hard

**APPENDIX D  
CLIMBING ROUTES**

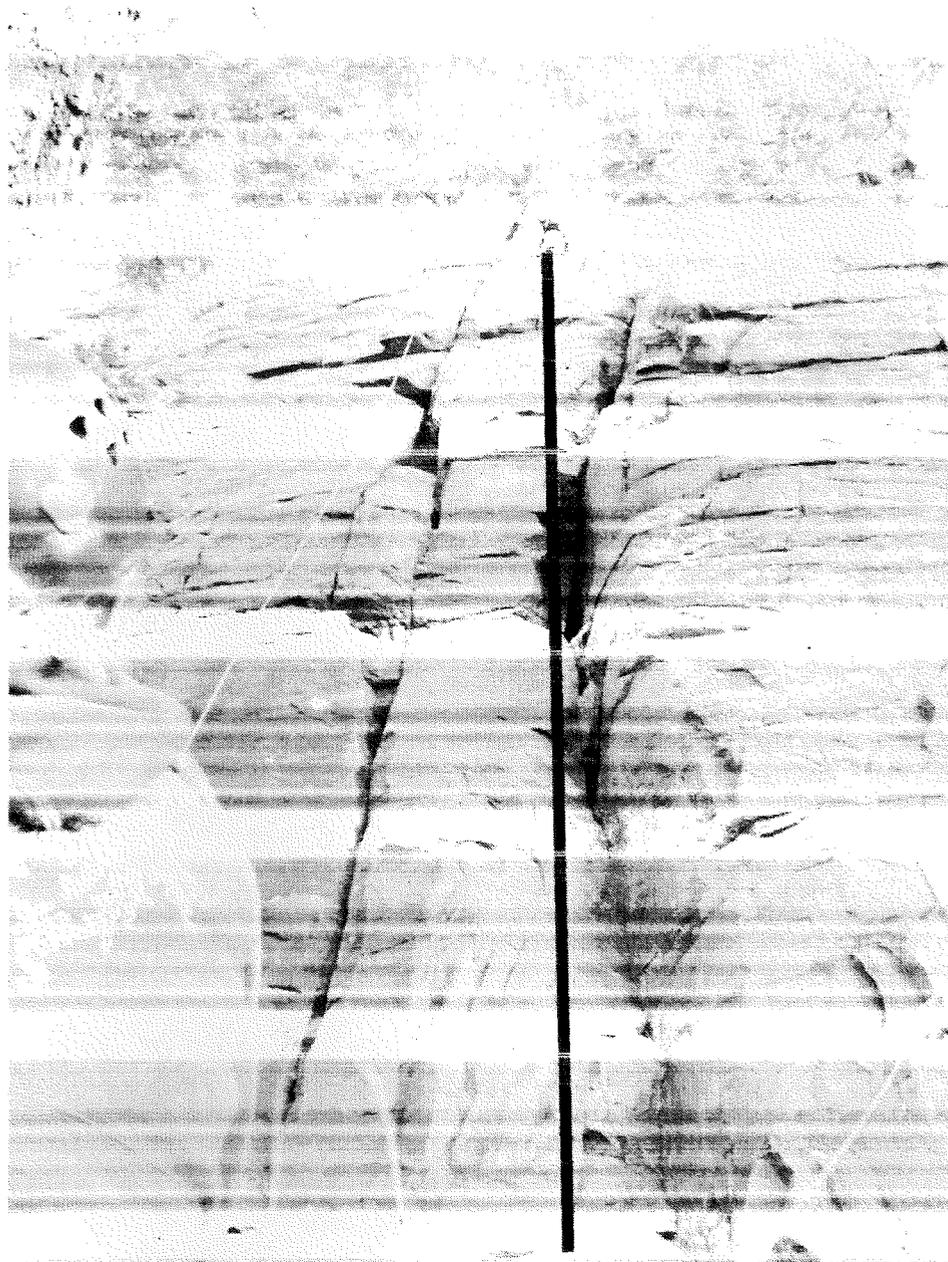


Figure 3. Outdoor Climbing Route

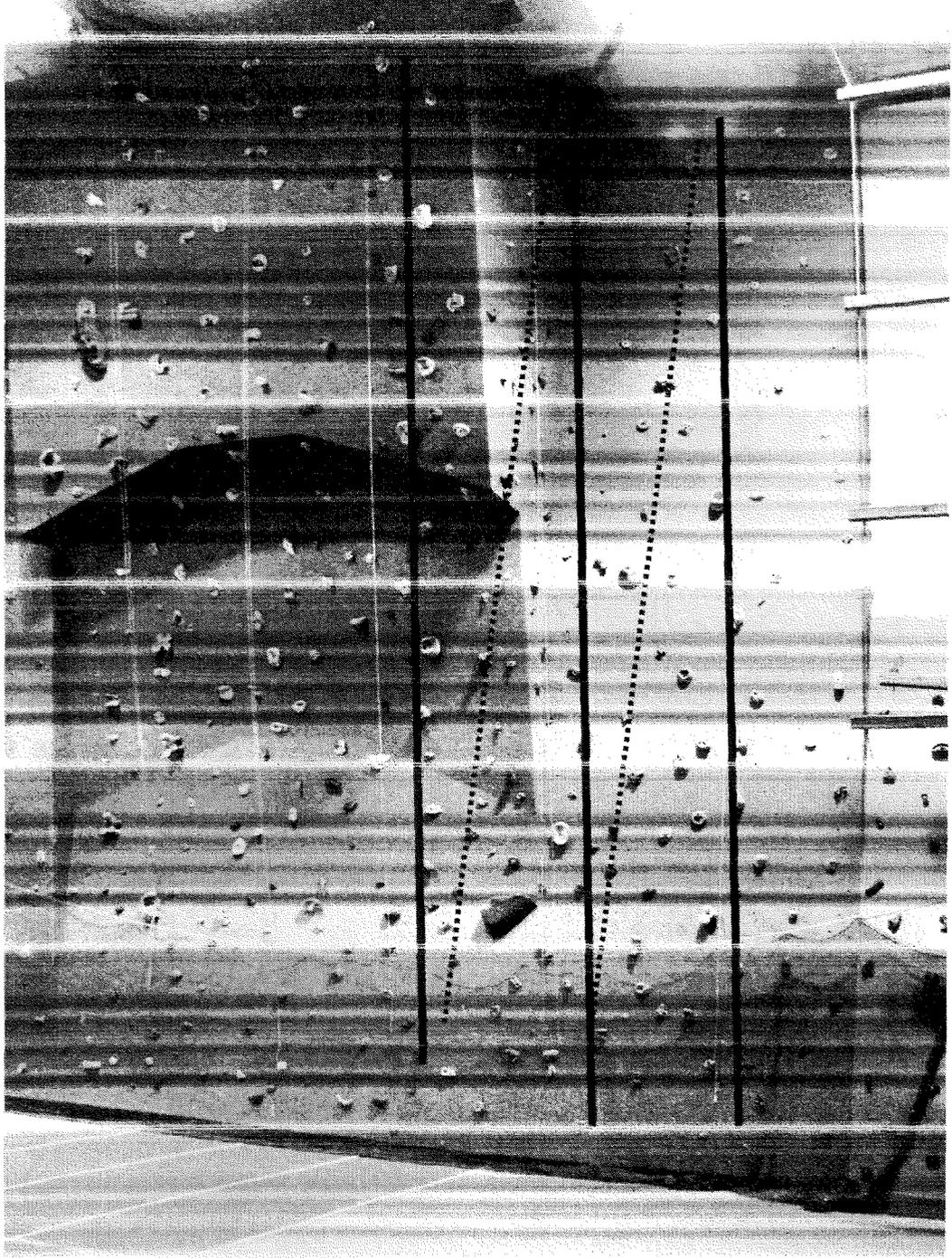


Figure 4. Indoor Climbing Route

APPENDIX E  
HEART RATE DATA

Name	Sex	Indoor RPE	Indoor Pre Climb HR	Indoor During Climb HR	Indoor Post Climb HR	Indoor Max HR
1	F	5	115.2	169.93	119.86	183
2	F	6	95.88	139.95	116.67	168
3	F	6	95.83	164.67	142.5	189
4	F	4	76.83	102.41	89.83	142
5	F	3	111.6	165.63	160.75	181
6	F	7	90	167.79	141.5	184
7	M	7	96.43	168.67	125.8	190
8	M	7	88.22	143.84	148.75	163
9	M	5	95	145.76	136.75	188
10	M	7	130.6	184.37	178.75	201
11	M	5	104.8	139.55	108.75	157
12	M	8	79.6	157.25	124.75	188
13	M	4	78.4	130.95	103	151
14	M	4	92.4	162.45	144.75	194
15	M	7	59.73	119.71	113.25	171
16	M	6	97.8	151.38	142.4	179
17	M	6	65	125.21	93.3	158
18	M	6	98	167.46	145.5	186
<b>Mean</b>		5.722222222	92.85111111	150.3877778	129.8255556	176.2777778

Subject #	Sex	Outdoor RPE	Outdoor Pre Climb HR	Outdoor During Climb HR	Outdoor Post Climb HR	Outdoor Max HR
1	F	4	119.44	161	134.8	180
2	F	8	117.125	168.22	146.6	185
3	F	7	94	169.14	136.5	184
4	F	4	109.5	147.29	127	168
5	F	6	113.57	160.37	133	174
6	F	10	128.83	165.61	144.5	180
7	M	8	109.75	172.62	139.75	183
8	M	4	101.33	137.14	115.5	151
9	M	3	104.5	147.23	135	181
10	M	8	140	188.25	166	203
11	M	7	120	163.48	136.75	179
12	M	8	90.8	154.63	109	182
13	M	3	107.86	132.13	115.8	148
14	M	3	90.83	132.13	110	155
15	M	5	70	137.61	84.75	155
16	M	5	103	137.69	113.4	156
17	M	5	107	142.2	109.88	168
18	M	4	112.5	157.82	125.2	173
<b>Means</b>		5.666666667	107.7797222	154.1422222	126.8572222	172.5

APPENDIX F  
UNIVERSITY IRB PROPOSAL

Institutional Review Board  
UW-La Crosse

Narrative Statement

Josh Chelf

9/10/08

**Heart Rate and Perceived Exertion Responses in Indoor vs. Outdoor Rock Climbing**

1. The purpose of this study is to determine if heart rate (HR) and rating of perceived exertion (RPE) responses differ between indoor rock climbing and outdoor rock climbing.

Data will be collected during two separate sessions. The first session will be an indoor rock climbing experience at Mitchell Hall on the rock climbing wall on the East end of the field house. The subjects will be wearing heart rate monitors with a wrist watch which will record the subject's heart rate before during and after climbing the wall. The second session will take place at Devil's Lake State Park near Baraboo, WI. The subjects will again be wearing heart rate monitors before during and after the climbing. In both sessions, rate of perceived exertion (RPE) will be asked and recorded by the investigator. Data will be collected between October 1<sup>st</sup> and December 1<sup>st</sup> of 2008.

2. **Subjects:** This study will involve students enrolled in the fall semester of ESS 310-Outdoor Pursuits. This is a required course to complete ESS teaching or Physical Education. The subjects range from 19-25 years of age and are apparently healthy young adults. This population was chosen because of the availability of the students. The students would be doing the same activities as part of their required course.
3. **Vulnerable Populations:** N/A
4. **Informed Consent:** Voluntary informed consent will be given by each subject prior to participating in the study. Subjects will be informed of the study and the procedures by the investigator prior to providing informed consent.
5. **Confidentiality:** All data in the study will be kept in a secure place where only the investigator will have access to it. No names or identifiable personal information will be used in the write-up of this study nor will it be distributed to anyone.
6. **Risks:** Rock climbing, both indoor and outdoor, inherently has risk involved. Possible injuries may occur from falls, ropes, and/or climbing surface. Injuries could include but are not limited to: cuts, scrapes, bruises, muscle strains, sprains, etc. By being in the study, there is no further risk involved than as would be assumed in ESS 310.

7. **Procedures to minimize risk:** Subjects in ESS 310 are belay trained prior to any climbing on the rock walls. Standard protocols and safety practices will be used to help minimize risk involved with rock climbing. All climbers will be attached to an anchor point at the top of the wall/rock. A certified rope will be attached to the climber, up to the anchor, and back down to a belayer and back-up belayer to prevent falls and help the climber. The lead instructor, investigator and others will be on-site to supervise the students as they climb and use the rock walls. With these procedures in place, the risk is minimal.
8. **Anticipated Benefits:** The students will receive very few if any benefits beyond the scope of ESS 310. The students may learn more about heart rates, heart rate monitors, and perceived exertion while participating in this study.