

**Cardiovascular Demands of Snowmobiling**  
University Honors Capstone Project

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## **Undergraduate Research Opportunity (UROP) Proposal**

### **Purpose**

The purpose of this proposed UROP is to determine the cardiovascular (CV) demands of snowmobiling.

### **Introduction**

In 2014, there were 1,991,538 registered snowmobiles in the United States and Canada, according to the International Snowmobile Manufacturers' Association (ISMA, 2014). With an estimated 212,873 miles of groomed snowmobile trails in North America, the average snowmobiler rides 1,620 miles a year (ISMA, 2014). While snowmobiling, the rider is required to maneuver an approximately 500 pound machine through manual operation of the handlebars and by body transfer techniques (Prusak, 2010). However, according to the Centers for Disease Control and Prevention (CDC), with only 20% of the US population meeting aerobic and muscle strengthening guidelines (CDC, 2013), the physical demands of snowmobiling may be a potential barrier to the enjoyment of this popular winter recreational pursuit.

Whereas no previous research has specifically examined the CV demands of snowmobiling, similar research analyzing the physiological demands of all-terrain vehicle (ATV) and off-road motorcycle (ORM) riding found such activities were correlated with a moderate-intensity cardiovascular demand and fatigue-inducing muscular strength challenges (Burr et al., 2010). Snowmobiling shares many characteristics with off-road vehicle riding in terms of how one must maneuver the machine; as a result, similar aerobic and strength demands are likely required. Therefore,

the purpose of this proposed UROP is to determine the cardiovascular (CV) demands of snowmobiling.

### **Methods**

The research design will be a descriptive analysis comparing the cardiovascular demands of at least 10 habitual snowmobilers, during a groomed trail ride, to their maximal aerobic capacity via a graded exercise treadmill assessment. Male and female participants who recreationally snowmobile and have completed their snowmobile safety course will be recruited for this study. The desired target age range is 19-26 years old. Participants will complete a laboratory and field assessment, each of which will be conducted on separate days. The laboratory assessment will begin with the collection of a resting heart rate, followed by the completion of a maximal graded exercise treadmill test. The field test will consist of a 20-minute groomed trail ride at a speed of approximately 40 miles per hour.

Data that will be collected include heart rate (HR), oxygen (O<sub>2</sub>) consumption, and perceived exertion (RPE). Indirect calorimetry will be used for both the laboratory assessment (Parvo metabolic cart) and field assessment (OxyCon Mobile) to collect the participants' O<sub>2</sub>, HR, and RPE for subsequent data analysis. To ensure that the participants' safety is not compromised during the field assessment, a modular helmet will be used, which will not interfere with the OxyCon Mobile mouthpiece.

Descriptive statistics consisting of means and standard deviations will be the method of comparison between the laboratory and field assessments. Additional analysis comparing male and female CV responses will be performed via independent t-tests. Level of significance for all tests will be set at  $p < 0.05$

**Budget**

Full \$1400 stipend + \$300 for the purchase of two modular helmets (sizes M and L)

**Timeline**

*October 2014:* Submission of proposal to UROP committee.

*November 2014:* Pilot studies to hone data collection process; IRB submission at end of fall semester.

*January-March 2015:* Subject recruitment to begin January 20; Laboratory assessments to begin January 26; Field assessments to begin January 31 (dependent on snow conditions)

*April 2015:* Statistical analysis and research summary.

*May 2015:* Submit summary of results.

## **Synthesis of Literature**

*(Since no current research has analyzed the physiological effects of snowmobile riding, a synthesis of literature was derived from alternative off-road vehicle riding that shares characteristics with snowmobiles in terms of operation.)*

### **Introduction**

Motorized vehicles such as all-terrain vehicles (ATVs), off-road motorcycles (ORMs), and open and closed-wheel racecars are commonly used for competitive and recreational activities (1,2,4,6,7). The operation of these vehicles require some manual manipulation, whether that be steering and/or body transfer techniques. There is developing evidence that motorized vehicular use exhibits some physiological strain on the body, although the direct physiological involvement is largely under-researched (2,4,6,7). Current research is primarily focused on the cardiovascular demands of oxygen consumption and heart rate (2,4,6,7). Additionally, the idea that motorized vehicular use as a mode of exercise has been in question in recent years (1, 2). Therefore, the purpose of this review of literature has two components: to examine the cardiovascular demands of motorized vehicular riding; and to determine whether motorized vehicular riding could be classified as a form of exercise.

### **Synthesis**

Physiological components of the cardiovascular system, oxygen consumption and heart rate, have been shown to increase while riding motorized vehicles (2,4,6,7). Kontinen and colleagues compared the physiological responses of a maximal aerobic treadmill test to a riding test in nine elite motocross participants. A 15-minute motocross ride used an average of 71% of the oxygen consumed during the maximal treadmill test, and the heart rate averaged 95% of the subjects' max (7). Similarly, Burr et al. found

oxygen consumption increased in subjects riding ATVs and ORMs, but to a smaller degree, 39.3% and 51.3% respectively. Comparably, studies conducted using open and closed-wheel racecars found similar increases in cardiovascular demands (4,6). Specifically, Jacobs et al. found cardiovascular responses of 79% maximal oxygen consumption and 82% of maximal heart rate in open-wheel racecars, while Gordon et al. found a 37-87% maximal oxygen consumption and 79.6% maximal heart rate throughout the closed-wheel driving tests (4,6). Although there are differences in degree in which physiological responses occur across studies, there tends to be a significant increase in both oxygen consumption and heart rate as a response to operating a motorized vehicle (2,4,6,7).

A limited number of studies have analyzed the operation of motorized vehicles as a means of exercise (1). Burr et al. conducted research analyzing the purposeful training of ATV and ORM riding. After a six week training program using off-road vehicles, subjects showed significant improvement in their systolic and diastolic blood pressures, fasting glucose, body mass, waist circumference, and body fat percentage (1). Sports such as motocross, which uses ORMs, have been found to draw mainly upon aerobic metabolism (7). Additionally, the use of motorized vehicles has shown cardiovascular demands associated with moderate to vigorous-intensity levels (2). Therefore, the use of motorized vehicles could potentially meet the ACSM's requirements for exercise recommendations (2).

### **Critical Analysis**

Inconsistencies between studies include vehicle type, subject demographics, and research design. For example, the two studies by Burr et al. and the single study by

Konttinen et al. used off-road vehicles (ATVs and ORMs), whereas the studies conducted by Jacobs et al. and Gordon et al. used open and closed-wheel racecars (1,2,4,6,7).

Consequently, the results are specific to the vehicle type used and cannot be associated with other vehicles regardless of similarities in operation. Additionally, subject demographics must be considered when assessing the results and how they can be used in the general population. Studies by Jacobs et al., Gordon et al., and Konttinen et al. used professional subjects whereas Burr et al. used habitual riders (24,6,7). Furthermore, the research analyzing the purposeful training by Burr et al. used non-experienced riders (1). The inconsistencies between these subject groups may be the reason for the differences in the degree of cardiovascular requirement. For example, experienced riders may be more conditioned for these activities, while novice riders may need to use more effort while operating motorized vehicles (2). Finally, the difference in research designs cause limitations. For example, the study Burr and colleagues conducted was the only research assessing how motorized vehicles could be used specifically for health and fitness benefits (1). The other studies served as more observational studies analyzing specific physiological characteristics during a riding session (2,4,6,7). For these reasons, researchers cannot be sure whether the increase in cardiovascular demands during the operation of motorized vehicles will elicit the same benefits as a more traditional exercise regimen.

Additionally, the studies examining the direct physiological effects of motorized vehicular use found the heart rate response was significantly higher than that of the oxygen consumption (2,4,6,7). These discrepancies give rise to the question of possible confounding variables. Typically, these differences are associated with isometric muscle

activity and psychological reactions to situational stress, which often results in an increased heart rate (2,4,6,7).

### **Conclusion**

To summarize, the operation of motorized vehicles is associated with increased oxygen consumption and heart rate (2,4,6,7). The elevation of these physiological demands is associated with cardiovascular exercise. Respectively, the study Burr et al. conducted using off-road vehicle riding as a training mode found these activities do have potential health and fitness related benefits (1). However, the limited number of studies conducted using motorized vehicles and the differences in research protocol, make it difficult to apply the results to a general population. Additional research regarding the use of motorized vehicles, as a training style, is necessary to determine whether these changes in cardiovascular demands can be associated with health and fitness benefits as seen in more traditional forms of exercise.

# Cardiovascular Demands of Snowmobiling

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## INTRODUCTION

- Snowmobile riding requires the maneuver of an approximately 500 pound machine through manual operation of the handlebars and by body transfer techniques.
- Previous research analyzing the physiological demands of all-terrain vehicle (ATV) and off-road motorcycle (ORM) riding, found such activities were correlated with a moderate-intensity cardiovascular (CV) demand and fatigue-inducing muscular strength challenges.
- To date, no previous research has specifically examined the CV demands of snowmobiling.

## PURPOSE

- To determine the CV demands of snowmobiling.

## METHODS

- Habitual snowmobilers, ages 19-26 (n=6; 2 males, 4 females) were recruited.

### Procedures

- Subjects performed a max treadmill test to determine baseline fitness levels ( $VO_{2max}$  36±2 ml/kg/min, estimated max HR 192±1 bpm).
- On a separate day, subjects performed a field assessment in which they completed a trail ride (29:25) on a snowmobile at a speed of approximately 40 miles per hour.
- Heart rate (HR) and oxygen consumption ( $VO_2$ ) from each assessment were measured via portable indirect calorimetry (OxyCon Mobile).

### Analysis

- Descriptive statistics consisting of means and standard deviations were the method of comparison between the two assessments.

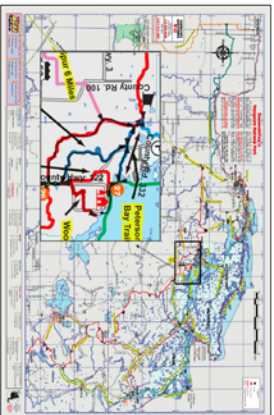


Figure 1. Snowmobile trail



Figure 2. Snowmobile



Figure 3. Oxycon Mobile with modular helmet

## RESULTS

- Heart rates while snowmobiling averaged 54% of max HR, with an average peak of 70% of max HR.
- $VO_2$  while snowmobiling averaged 24% of max  $VO_2$ , with an average peak of 42% of max  $VO_2$ .

Table 1. CV demands of maximum treadmill test and field test.

	HR <sub>max</sub> (bpm)	AVG HR	VO <sub>2max</sub> (ml/kg/min)	AVG VO <sub>2</sub>	MET max	AVG MET
Max Treadmill Test	192±1	-	36±2	-	10.4±0.6	-
Field Test	134±22	104±7	15±0.9	9±2	4±0.2	3±0.4

Table 2. CV demands of snowmobiling.

%HR <sub>max</sub> (average)	%HR <sub>max</sub> (peak)	%VO <sub>2max</sub> (average)	%VO <sub>2max</sub> (peak)
54±4	70±12	24±4	42±1

## CONCLUSIONS

- The results of this study found an increase in CV demands during snowmobiling.

### Challenges

- Due to equipment malfunctions the HR max for the treadmill tests were estimated using the Gellish Formula.
- The values for the male subjects were disregarded due to unreasonably low  $VO_2$  values during the field tests.
- Appropriate weather conditions limited the number of tests that were able to be completed.

## ACKNOWLEDGEMENTS

This study was funded by the University of Minnesota's Undergraduate Research Opportunities Program.

## Results

### **Summary and Reflection of Research**

The purpose of my research was to determine the cardiovascular (CV) demands of snowmobiling. Snowmobile riding requires the maneuver of an approximately 500 pound machine through manual operation of the handlebars and by body transfer techniques. Previous research analyzing the physiological demands of all-terrain vehicle (ATV) and off-road motorcycle (ORM) riding, found such activities were correlated with a moderate-intensity cardiovascular (CV) demand and fatigue-inducing muscular strength challenges. To date, no previous research has specifically examined the CV demands of snowmobiling.

The research design was descriptive in nature. A total of six subjects, between the ages of 19 and 26, were recruited for this study. Participants completed a laboratory and field assessment. The laboratory assessment consisted of a maximum treadmill test to determine baseline fitness levels of the subjects. On a separate day, subjects performed a field assessment in which they completed a 30-minute groomed trail ride on a snowmobile at a speed of approximately 40 miles per hour. During each assessment, heart rate (HR) and oxygen consumption ( $VO_2$ ) were measured via portable indirect calorimetry (OxyCon Mobile). Descriptive statistics consisting of means and standard deviations were the method of comparison between the laboratory and field assessments.

The results of this study found an increase in CV demands during snowmobiling. Heart rates while snowmobiling averaged 54% of max HR, with an average peak of 70% of max HR. While oxygen consumption averaged 24% of max  $VO_2$ , with an average peak of 42% of max  $VO_2$ . Overall, the results are descriptive in

nature, and with the low number of subjects no solid conclusions can be formed at this time.

Although conclusions were vague, there were many possible implications to my study. The snowmobile community may be encouraged to improve their health and fitness levels. More specifically, snowmobilers may be encouraged to become more physically fit for increased enjoyment of the sport. Finally, given the high rate of obesity and low levels of physical activity in the United States, those who do not currently snowmobile may find this activity more appealing than more traditional forms of cardiovascular training. Before any implications will truly be applicable, additional research is necessary to find more consistent data.

During my research many challenges arose. For example, this study was highly dependent on appropriate weather conditions. The low levels of snowfall this year, limited the number of days I was able to conduct field assessments. Additionally, I encountered complications with the equipment. The OxyCon Mobile is a new device for the college of CEHSP; therefore, the malfunctions that occurred took time away from testing additional subjects. Correspondingly, maximum heart rates during the treadmill test were not consistently measured using the OxyCon Mobile. Therefore, the Gelish Formula was used to estimate the subjects' maximum heart rates. Finally, while analyzing the data I noticed the  $VO_2$  values for the male subjects, during their field assessments, were unreasonably low. As a result, these subjects' scores were disregarded and the results previously discussed were based solely on the four female subjects. Although these challenges were frustrating, I was able to complete the study and draw some conclusions.

Despite the challenges, I felt I accomplished my objectives. Research is never guaranteed to be successful or produce the expected results. However, even in failed attempts there is success. I believe one should not look at challenges or unexpected results as failure; instead they should be viewed as learning opportunities. Although I was unable to reach my original goal of analyzing at least 10 subjects and assessing perceived exertion, I was able to successfully measure the key variables of heart rate and oxygen consumption of 6 subjects (4 successfully). Furthermore, I was able to descriptively analyze the CV demands of snowmobiling, which was my main purpose of this research.

Overall, I felt this research opportunity enhanced my academic coursework. This was my first time to be an integral part of a research project, and to be the principle investigator made me apprehensive at first. However, while conducting the research I was able to feel more confident in my ability and knowledge about the topic. Additionally, I felt I had enough faculty support when I faced challenges. These challenges, although initially frustrating, allowed me to see different aspects of research, such as having to adapt to unexpected outcomes or equipment malfunctions. Looking back at this project, I feel more competent in my ability to design, conduct, and analyze a research experiment. I feel this opportunity was extremely beneficial to my current and future field of study.

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