12-2010

The Relationship of snowmobile year, track length, and riding terrain to the occurrence of musculosketetal symptoms in recreational snowmobile drivers

Erica L. Heisler
University of Nevada, Las Vegas

THE RELATIONSHIP OF SNOWMOBILE YEAR, TRACK LENGTH, AND RIDING TERRAIN TO THE OCCURRENCE OF MUSCULOSKELETAL SYMPTOMS IN RECREATIONAL SNOWMOBILE DRIVERS.

by

Erica Lynn Heisler

Bachelor of Science
University of North Dakota
2007

A thesis submitted in partial fulfillment
of the requirements for the

Masters of Science in Exercise Physiology
Department of Kinesiology and Nutrition Sciences
School of Allied Health Sciences
Division of Health Sciences

Graduate College
University of Nevada, Las Vegas
December 2010

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

THE GRADUATE COLLEGE

We recommend the thesis prepared under our supervision by

Erica Lynn Heisler

entitled

The Relationship of Snowmobile Year, Track Length, and Riding Terrain to the Occurrence of Musculosketetal Symptoms in Recreational Snowmobile Drivers

be accepted in partial fulfillment of the requirements for the degree of

Master of Science in Exercise Physiology
Department of Kinesiology and Nutrition Sciences

Jack Young, Committee Chair

Richard Tandy, Committee Member

Lawrence Golding, Committee Member

Daniel McLean, Graduate Faculty Representative

Ronald Smith, Ph. D., Vice President for Research and Graduate Studies
and Dean of the Graduate College

December 2010

ABSTRACT

The Relationship of Snowmobile Year, Track Length, and Riding Terrain to the Occurrence of Musculoskeletal Symptoms in Recreational Snowmobile Drivers.

By

Erica Lynn Heisler

Dr. Jack Young, Examination Committee Chair
Professor and Chair, Department of Kinesiology
University of Nevada, Las Vegas

The purpose of this retrospective study was to examine the occurrence of musculoskeletal symptoms in recreational snowmobile drivers and relate them to the manufacture year of the snowmobile, the length of the track, and/or the riding terrain. Participants included 186 males and 57 females (n=243), aged 18 years and older, and were all snowmobile drivers. Subjects were asked to complete either an online survey or a paper survey to gather information about the year of snowmobile they drove, the track length of that snowmobile, the typical riding terrain they drove on, and any musculoskeletal symptoms they developed from driving snowmobile. Each variable (snowmobile year, track length, and riding terrain) was compared to the musculoskeletal symptoms reported to find the percentage of each symptom (soreness in the neck and shoulders, arms, lower back, legs, and no soreness reported) reported in each category. In all three categories (snowmobile year, track length, and riding terrain) musculoskeletal symptoms in the neck and shoulder (45%) regions were most commonly reported followed

by, symptoms of the lower back (33%) and drivers reporting to have multiple symptoms (33%) (those who reported more than one symptom).

ACKNOWLEDGEMENTS

Many individuals assisted me in completing this thesis. I would like to express my appreciation and thank all of the volunteers that participated in the survey. Thank you for taking the time to participate; without you this would not have been possible. To my fellow graduate students, thank you for your words of encouragement and support.

To my parents, thank you for your support, encouragement, and unwavering love and dedication throughout my academic career. To Dan, thank you for your patience, sacrifice, encouragement, and support throughout this process. Without all of you this would not have been possible.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

"Snowmobiling, a popular winter activity for millions of people, originated when the Canadian J.A. Bombardier designed a four cylinder Ford model T engine on sleigh runners in 1923." (James et al, 1991) "Since their introduction in the early 1960's, snowmobiles have had a profound effect on the economic and recreational life styles of many Canadians." (Daniel and Midgley, 1972) Not only has the introduction of the snowmobile affected many Canadians, but it has also impacted areas of the United States and Europe. "Snowmobiles are defined as any motor vehicle designed for travel on snow or ice and steered and supported in whole or in part by skis, belts, cleats, runners or low-pressure tires." (Skokian et al, 2001) "The snowmobile was developed to move people and supplies, and for emergencies in regions where heavy snow prohibited the use of conventional vehicles. Today, snowmobiling has become a popular winter sport enjoyed by more than 2 million people of all ages in North America." (Pierz, 2003) "Most snowmobiles are used for recreation and a few for logging, reindeer breeding, police and customs duties." (Bauer, 1979)

Snowmobiling has gained in popularity as both an individual and family sport. (Skokan et al, 2001) "Snowmobiling is the fastest growing winter sport in North America, increasing 35% yearly compared to 20% for the remainder of the recreational industries." (Karleen, 1973) In

Sweden the number of snowmobiles being used doubled between 1976 and 1980, reaching 63,000 in use by January of 1980. (Bjornstig et al, 1984) In the winter season of 2003-2004, 1,774,232 snowmobiles were registered in the United States. (Sy and Corden, 2005) Many states have state wide trail systems that snowmobilers can enjoy during the winter season. The increase in available trail riding may influence the number of snowmobiles currently registered, and the increase in the use of snowmobiles as a recreational activity. For example, "Wisconsin residents can enjoy over 25,000 miles of marked snowmobile trails connecting all parts of the state." (Sy and Corden, 2005) In Alaska during the winter season of 1993-1994, an estimated 75 million miles were driven by snowmobiles. (Landen et al, 1999) The continual increase of recreational snowmobile driving is evident by the number of registered snowmobiles continues to climb. "Michigan is the leading snowmobiling state in the United States with over 350,000 registered snowmobiles in 2001." (DeCou et al, 2003)

As the use of the snowmobiles has increased more people use them as a recreational tool, and the reports of injuries and musculoskeletal symptoms have increased. "The machine itself appears to be an important contributor both to the initiation of the event and to the type and severity of injury." (Waller and Lamborn, 1975) With the modern day snowmobile weighing in at approximately 600 pounds and capable of reaching speeds of 110mph, there is no surprise at the increase in

reported musculoskeletal symptoms and injuries. As reported by Astrom et al (2006), "Driving terrain vehicles is also related to experiencing musculoskeletal symptoms in the neck, shoulders, and wrist." Individuals report musculoskeletal symptoms of the arms, shoulders, legs, lower back, and neck regions. These symptoms seem to be caused by the ergonomics of the snowmobile, subjection to whole-body and hand-arm vibration, riding terrain, and riding posture. "Highly significant positive correlations were found between hours on snowmobile and exposure to cold, vibration, heavy lifts, static work, rotated head and bent back." (Daerga et al, 2003) The results of a study by Astrom et al (2006), "show increased odds for numbness, sensation of cold, white fingers and musculoskeletal symptoms in the neck, shoulders, and wrists, among professional drivers of various terrain vehicles." The study consisted of drivers of forest machines, snowmobiles, and snowgroomers. An ergonomic evaluation of the snowmobile done by Habes et al (2003) reported that "The National Park Service personnel, mainly rangers and maintenance workers, reported musculoskeletal disorders of the hands, arms, shoulders, and back from riding the snowmobiles for up to 10 hours per day during the winter months." As the advancement of the snowmobile has progressed, adjustments such as shock-absorbers, handlebar warmers, and adjustable seats and handlebars have made an appearance on newer

models. These advancements may provide the tools needed to decrease the effects of riding on the body.

Purpose of the Study

The purpose of this retrospective study was to examine the occurrence of musculoskeletal symptoms in recreational snowmobile drivers and relate them to the manufacture year of the snowmobile, the length of the track, and/or the riding terrain.

Research Question

Are the snowmobile year, track length, and riding terrain associated with musculoskeletal symptoms that occur in recreational snowmobile drivers?

Significance of the Study

Most recreational snowmobile drivers sustain some sort of musculoskeletal symptom(s) while riding a snowmobile. As this type of recreational activity has grown the number of symptoms recorded has seen a dramatic increase.

Studies have shown an increase in injuries and the type of symptoms prevalent in snowmobile drivers; the vibration effects of driving a snowmobile; and the ergonomic evaluation and ergonomic recommendations for snowmobile drivers.

It is imperative that snowmobile riders be educated about the possible causes of the musculoskeletal symptoms they acquire while driving a snowmobile.

Definition of Terms

The following definitions are given for the purpose of clarification:

Track Length: The length of the track measured from the front of the track located under the front of the snowmobile to the back of the track. A short track will measure 120”-128”, a medium track will measure 130”-146”, and a long track will measure 151” or more.

Riding Terrain: A groomed trail, which would be a smooth surface made by a grooming machine, or an ungroomed trail, which would include: deep snow with no previously cut trail, mountainous terrain with no previously cut trail, cross country riding with no previously cut trail, or a previously cut trail that is not groomed on a regular basis.

Musculoskeletal Symptoms: Any type of soreness related to snowmobile driving. Including, but is not limited to soreness in the following areas: arms, shoulders, hands, neck, lower back, legs, knees, and feet.

CHAPTER 2

REVIEW OF RELATED LITERATURE

History of the Snowmobile

The history of snowmobile can be traced back to the early 1900's. In 1908, the very first vehicle to travel on snow was built. It was built by Alvin Lombard in Waterville, Maine; weighing in at 20 tons this machine was only used in log hauling. In 1913 Virgil White, a Ford dealer from New Hampshire, invented a track and ski conversion system for the Model T Ford (Campbell, 2004).

The first snowmobile patent was issued in 1927, to Carl J. Eliason of Sayner, Wisconsin. It was a wooden toboggan fitted with two skies, which were steered with ropes, powered by a 2 ½ horsepower Johnson outboard motor. Over the next 15 years Eliason's snow vehicles went into production through Sayner. They were quickly refined and developed into larger models, only 40 were built and no three were identical. (Campbell, 2004) Between 1927 and 1962 thirteen patents were granted for snow vehicles. These thirteen patents lead to the modern snowmobile. "By 1955 Polaris Industries had made a commitment to the development, testing, and manufacturing of the definitive single track snowmobile, however, the company faced delays when they ran into design problems with in "Comet" model in 1963." (Allyson, 2010)

In 1958 the modern snowmobile was born. Joseph Armand Bombardier began manufacturing snow machines able to carry up to 12 passengers, by 1947. These machines were designed to be used by the military but were soon adopted by the Canadian police, mining and oil companies, and ski resorts. In the 1950's Bombardier had ambitions to build a lightweight, fast driving individual snow machine. By 1959, Bombardier's Ski-Doo has come into existence. The modern engines had become small enough and light enough to make this design possible. Bombardier's design revolutionized the snowmobile industry with its tunnel mounted engine, combined chassis/hood, and an endless rubber track affixed via sprung bogie wheels. (Ingram, 2000) By 1962 his endless track design had been patent in both Canada and the U.S. However, "it was not until 1964 that the machine became available in mass production." (Karleen, 1973)

By 1965 Ski-Doo's competitor, Arctic Cat, had revolutionized the suspension design. The company replaced the bogie wheels that were being used in Bombardier's design, to keep the machine on the track, with a pair of slide rails running on the cleats of the track. This design allowed for shock absorbers to be added, which would aid in smoothing the ride of the snowmobile. The very next year Arctic Cat redesigned yet another feature of their snowmobile. The new design moved the engine from on top of the drive unit, located behind the driver, and placed it in the front of the track tunnel, in the belly pan of the front of the machine.

By moving the engine they were able to lower the center of gravity of the snowmobile, which balanced it with the rider's body weight. This proved for substantially better handling and performance. (Ramstad, 1999) This design is still used by all four major snowmobile manufacturers today. Within just two years, Arctic Cat was able to launch the snowmobile design forward into the unexplored territory of sport riding and performance vehicles.

Yamaha manufactured its first snowmobile in 1968. There were only 350 snowmobiles manufactured by Yamaha that year; These snowmobiles were the forerunners of the most successful snowmobiles ever made. By the mid-1970s snowmobile racing had become of popularity. Yamaha went straight to the top of the racing scene in 1976 with their introduction of their SRX440 snowmobile. (Allyson, 2010) By this time there were more than 250 major races sanctioned by the U.S. Snowmobile Association.

The 1980s provided additional advancements in the technology of the snowmobile. Heated handlebar warmers were one of the leaps forward for snowmobile design. Gerard Karpik, a cross-country snowmobile racing legend from Minnesota, pioneered the M-10 suspension. This suspension system allowed the front and rear suspension to communicate so that when a bump was hit by the front of the machine it could be avoided by the rear of the machine. This advancement allowed for harder riding over rougher terrain. (Ingram, 2000)

Electronic fuel injection was the launch of the 90's. Polaris led this revolution based on the 1987 design by the Injection Research Specialist. They designed the Polar Indy 650 RXL with EFI in 1991. These machines boasted better fuel economy, a smoother ride, and improved performance. (Rodengen and Hubbard, 2003) Electronic fuel injection has become another snowmobile standard and is still used by all four major manufacturers today.

In 2001 Ski-Doo redesigned the engine-forward chassis originally introduced by Arctic Cat. This redesign placed the rider one foot forward of what use to be standard riding position. The mass of the machine was now centralized on the chassis and the suspension forces were spread about the engine, causing the rider's own weight to become the balancing element of the machine. (Ingram, 2000) A recent introduction by Arctic Cat called Infinite Rider Positioning has launched into the industry. This advancement in technology makes adjustment of the seat and handlebars as easy as the flip of a switch.

There have been many advancements in snowmobile technology and design over the last century, and there are many more to come. From the start of a large 20 ton machine designed for log hauling, so the design of Bombardier, which launched the snowmobile industry into a new dimension, to the introduction of electric start, heated handlebars, IRP technology, to heated seats. As technology and design advances the snowmobile will prove to become more comfortable and safer for the

rider. These advancements provide increased comfort and performance which will continue to lead these manufacturers to new and improved machines. As the popularity of riding snowmobile continues to grow the introduction of new technology will be welcomed. Today there are over 200,000 snowmobiles sold annually in the U.S., Canada, and Europe; Many being used for not only recreational purposes but also in some occupations. (Allyson, 2010)

Whole Body Vibration

As seen in many studies, (Rehn et al, 2005; Rehn et al, 2004; Bovenzi and Hulshof, 1999; Kjellberg and Wikstrom, 1985; Rehn et al, 2002; National Institute for Occupational Safety and Health, 2001) whole-body vibration (WBV) exposure, awkward body positioning, as well as shock to the body caused by sudden jolts while riding a snowmobile potentially have a detrimental effect to the musculoskeletal system. "The magnitude of exposure to WBV is a result of several combined factors such as operating technique, vehicle type, terrain type, and seat suspension. WBV is transmitted from the seat, the backrest and the foot support in a vehicle and can have an adverse health effect on the musculoskeletal system." (Rehn et al, 2002) It is also mentioned by Rehn et al (2002), that "the generation of WBV and shock is dependent on for example, vehicle type, speed and terrain conditions." Furness and Maschette (2009) found that "During WBV, changes in gravitational conditions are produced by the vibrations of machinery (ie, vehicles and vibration

platforms). Gravity is a component of WBV because the product of amplitude and frequency is acceleration. Manipulations of amplitude or frequency can affect the rate of change of the WBV (ie acceleration) acting on an individual. Thus, the gravitational forces acting on the body are varied in most WBV environments (ie, recreational and occupational). Because the position of the whole body in space is changing, a role of the neuromuscular system during WBV must be to perceive and attenuate changes in body position for optimum performance and/or comfort."

The development of musculoskeletal symptoms and disorders is a great concern for many snowmobile riders and has been addressed in many studies (Rehn et al, 2005; Rehn et al, 2004; Bovenzi and Hulshof, 1999; Kjellberg and Wikstrom, 1985; Rehn et al, 2002; National Institute for Occupational Safety and Health, 2001). Rehn et al (2002) suggests that "WBV and shock likely occurs in both the vertical and horizontal planes. This may be of particular importance for the development of musculoskeletal symptoms in the neck and shoulders since these muscles have to maintain balance and perform lever work simultaneously." "Compared with studies on other vehicle types, the most distinct feature for WBV characteristics in ATVs is the strong influence of lateral vibration. This may account for the pattern of musculoskeletal symptoms observed for drivers of ATVs as reported by Rehn et at (2002) i.e. musculoskeletal symptoms primarily in the neck region." (Rehn et al, 2005) "Exposure to shock and vibration that should

occur in both horizontal and vertical directions for all-terrain vehicles may be of particular importance, in developing symptoms of musculoskeletal disorders, as the worker has to have tensed muscles to maintain balance during exposure and to be able to handle the lever at the same time." (Rehn et al, 2002).

"Awkward body postures and constrained positions due to mechanical workload are examples of potential confounding risk factors that are inherently associated with prolonged seated WBV exposure." (Rehn et al, 2005). "Epidemiological investigations have led to suspicions that whole-body vibration above all constitutes a risk for the development of injuries and functional disorders of the skeleton and of joints." (Kjellberg and Wikstrom, 1985). Low back pain has been an ongoing concern in association to whole-body vibration exposure. "Biodynamic experiments have shown that WBV exposure, combined with a constrained sitting posture, can put the lumbar intervertebral disc at risk of failure." (Bovenzi and Hulshof, 1999). As found by Bovenzi and Hulshof (1999), "both cross-sectional and cohort epidemiologic studies indicate that there is an increased risk for lower back disorders among occupational groups exposed to WBV when compared to non-exposed control groups." "The expected consequences result from the mechanical influences of the vibration which may induce tissue strain and compression." (Kjellberg and Wikstrom, 1985) "An excess risk for lumbar disc disorders, including herniated disc, was also found in the WBV-exposed

occupational groups compared with the control groups. Biodynamic and physiological experiments have shown that seated WBV exposure can affect the spine by mechanical overloading and excessive muscular fatigue." (Bovenzi and Hulshof, 1999).

Exposure to whole-body vibration has been linked to an increase in muscle activity. "Recording of electromyogram (EMG) have shown that muscles may be activated during exposure to vibration. It is suggested that muscle activity is a combination of control movements to stabilize the body, and so-called tonic reflexes generated by passive movements. Vigorous active muscle contractions seem to accompany shocks and very low-frequency vibrations which have high intensity later components. Under these circumstances symptoms of stress may occur, which in themselves may lead to a further increase in muscle activity." (Kjellberg and Wikstrom, 1985) Similar findings were reported by Torvinen et al (2002), they reported that "vibration applied directly to the muscle belly or tendon or to whole body has been shown to elicit a response name 'tonic vibration reflex." The vibration-induced TVR involves activation of muscle spindles, mediation of the neural signal by 1a afferents, and activation of the muscle fibers via large alpha-motor neurons. The TVR induced by the vibration is also capable of causing an increased recruitment or motor units via activation of muscle spindles and polysynaptic pathways which is seen as a temporary increase in muscle activity." Snowmobile drivers are subjected to whole-body vibration

continuously during a riding session. This may be the cause of many of the reported musculoskeletal symptoms.

Hand-Arm Vibration

Hand-arm vibration associated with driving terrain vehicles has been known to cause vibration-induced white finger, frost-bite, temporary loss of grip strength, and other detrimental effects on the upper extremity. "The hand-arm vibration is caused by the motor, the driving terrain or the resonance phenomena in the frame or steering yoke." (Anttonen et al, 1995) "Steering devices in terrain vehicles have been reported to transmit hazardous levels of vibration-acceleration to the upper limbs." (Astrom et al, 2006) According to the measurements and the results of the questionnaire by Anttonen and Virokannas (1994), the "vibration syndrome can be caused by hand-arm vibration associated with snowmobile driving." As reported by Astrom et al (2006), "driving terrain vehicles are related to experiencing some symptoms related to hand-arm vibration syndrome (HAVS), such as numbness, sensation of cold and white fingers, suggesting that there is a possible association between exposure to HAV generated from steering devices in terrain vehicles and symptoms of HAVS."

"Neurological, vascular, and musculoskeletal symptoms in the hands, such as numbness, white fingers and pain, are phenomena of HAVS." (Astrom et al, 2006) "The exposure to hand-arm vibration can cause intimal lesions and hypertrophy in the wall of arteries. It can increase

blood viscosity, and cause functional changes in vessels." (Virokannas and Anttonen, 1994) As reported by Virokannas and Anttonen (1994), "the exposure to hand-arm vibration and cold reduces circulation in the hand in a synergistic manner. The mechanism of the combined effect may be transferred via the sympathetic nervous system." "Exposure to vibration can also lead to hyperreponsiveness to noradrenaline in the smooth muscle or arties, which results in a stronger vasoconstriction reaction to sympathetic stimuli such as cold." (Virokannas and Anttonen, 1994) A reaction such as this can contribute to the occurrence of white-finger syndrome and frostbite due to the decrease in circulation to the extremity.

Frostbite is often a concern for individuals who enjoy recreational activities outdoors during the winter season. Studies have shown (Virokannas and Anttonen, 1993; Virokannas and Anttonen, 1994; Anttonen et al, 1995; Anttonen and Virokannas, 1994) that vibration-induced white finger syndrome (VWF) may increase the risk of frostbite, especially to the upper extremity. "The vibration syndrome in the hands occurs more often in cold than in warm conditions, which indicates that a cold climate may facilitate the generation of vibration-induced white finger." (Virokannas and Anttonen, 1994) "As snowmobiles are used in winter the effect of cold and the static driving posture in the cold airstream can contribute to the prevalence of VWF." (Anttonen and Virokannas, 1994) In a study by Virokannas and Anttonen (1994) it was

reported that “cold and hand-arm vibration both reduce blood flow in the fingers in a synergistic manner, and it was to be expected that the subjects with VWF rather frequently incurred frostbite on the fingers when driving snowmobiles.” Anttonen et al (1995) reported that “the dose-relationship for the snowmobile group showed a consistent increase in the prevalence of white finger with increasing exposure.” “The relationship between the total vibration exposure time and the prevalence of white finger indicated that white finger is mostly induced by vibration.” (Virokannas and Anttonen, 1993) “Hence, there is a need for health care, technical improvements, change of working habits and other protective means to reduce the symptoms of vibration in driving terrain vehicles.” (Anttonen and Virokannas, 1994)

Ergonomics of the Snowmobile

There are numerous studies (Nayha et al, 1994; Rehn et al, 2005; Rehn et al, 2004; Rehn et al, 2002; National Institute of Occupational Safety and Health, 2001; Tostrup, 1994; Habes et al, 2003) that have assessed ergonomic risk factors associated with snowmobiling, some of which include: pronated forearms, hand-arm vibration, extreme wrist posture, twisted trunk posture, non-neutral neck posture, elevated arms, prolonged seated posture, whole-body vibration, and shock. “The driving posture is mostly bent or twisted, due to the inappropriate height of the steering yoke and the seat, which may be highly stressful to the back.” (Nayha et al, 1994) The study conducted by the National Institute for

Occupational Safety and Health (2001) assessing Yellowstone National Park personnel confirmed that, “when rangers were asked to sit on their snowmobiles in their preferred position, the chosen seat back position often resulted in shoulder postures of about 90 degrees (recommended is 45 degrees) and elbow joints at about 180 degrees (recommended is 60-70 degrees) and the hand in non-neutral postures.” This occurred “because most of the rangers tend to sit far back on their seats to allow for clearance between the steering bar and the bulky equipment and heavy clothing they wear during their regular duties.” (NIOSH report, 2001) Recreational snowmobile drivers would have these same issues in accordance to seated posture due to the fact that they would be wearing similar heavy clothing due to the low temperatures of the winter season. “The posture typical of snowmobile driving is usually considered to cause stress upon the back and legs.” (Nayha et al, 1994) “By sitting down the back changes from lordotic to a kyphotic shape. Grandjean claimed that the backward position of the pelvis puts the spine into a state of kyphosis which, in turn, increases the pressure within the disk.” (Tostrup, 1994) This may explain the reason for low back pain and soreness in the back associated with snowmobile driving.

Many snowmobile drivers complain of soreness and fatigue in the arms and shoulders and studies (Rehn et al, 2005; Rehn et al, 2004; National Institute for Occupational Safety and Health, 2001; Tostrup, 1994; Habes et al, 2003) have shown that these symptoms are related to

the placement of the handlebar and the diameter of the handgrip. "Drivers may also be required to sustain an elevated arm position which may further contribute to overload of the neck and shoulder muscles." (Rehn et al, 2002) As found in a study by Rehn et al (2005), "the reach to the handlebar causes awkward postures of the shoulder and arm, and hand forces to grip and control the throttle control are high and increased by the small diameter of the steering control." "Due to the sheering of the vehicle it is not possible to let the upper arm be parallel to the sideline of the body and the elbow at about 100°. That would give too little lever and therefore too little muscle power to steer, since power is the product of weight and lever." (Tostrup, 1994) "Because snowmobile driving requires the arms to be outstretched to reach the handle bars, with considerable grip force required to control the snowmobile, a potential physical fatiguing condition exists for the driver." (National Institute for Occupational Safety and Health, 2001) "When the elbow joint is kept in pronation by the biceps muscles, the insertion of the muscle may be pinched between the radius and ulna. With the hand in lateral deviation and dorsally flexed there is a possibility that the median nerve and veins might get stretched which could lead to carpal tunnel syndrome and be a contributing factor to the white-finger syndrome." (Rehn et al, 2002) Rehn et al (2005) found that 'the most important feature to adjust is the steering bar, which is moved closer to the body with grips oriented to provide for neutral wrist positions while

in typical use, would reduce grip forces and improve shoulder and arm positions." "The diameter of the hand grip (just over one inch) is smaller than the generally recommended 1.5 inches, and the wearing of gloves when riding further increases the amount of grip force the operators must exert to stabilize themselves and maneuver the snowmobile." (Habes et al, 2003) Related to the diameter of the hand grip is a study by Fioranelli and Lee (2008) evaluating the diameter of the standard Olympic bar used in weight lifting. Fioranelli and Lee (2008) suggest that "the fat bar is the same length and has the same circular shape as a standard Olympic bar, but the griping portion has a greater diameter. It measures 51mm (2 inches) in diameter as opposed to a standard Olympic bar diameter of 28 mm (1.1 inches). Proponents for the thicker bar claim that the oversized grip elicits greater muscle activation, especially within the forearm muscle group, therefore enhancing the strength of the muscles used for the exercise." Their findings indicate "that bar diameter can influence neuromuscular activation during an isometric unilateral bench press exercise." (Fioranelli and Lee, 2008) They also state "with reguards to neuromuscular activation of the forearm muscles, we report greater electromyographic activity with using the THIN bar." (Fioranelli and Lee, 2008) These findings relate to the hand grip diameter as the reported diameters are similar. The recommendation for hand grip diameter, as suggest by Habes et al, 2003, is 1.5 inches. The Fioranelli and Lee (2008) study shows that the thin

bar, with a diameter of 1.1 inches shows greater muscle activation, which in the case of their study is beneficial. However, when concerned with the hand grip diameter of a snowmobile the increase in muscle activity may not be seen as beneficial, but may contribute to the musculoskeletal symptoms in the upper extremities reported by snowmobile drivers. Another concern reported is the use of the thumb operated throttle. Tostrup (1994) found that "the use of the thumb muscles for giving gas is tiring for the muscles. It may also result in arthrosis of the thumb joints." "The force to depress the throttle control on the steering bar is appreciable, and not sustainable for continuous use." (National Institute for Occupational Safety and Health, 2001) NIOSH (2001) suggests to "redesign of the throttle control mechanism so that the activation method does not require palmar pinch forces involving the thumb." NIOSH reports (2001) "test results suggest that snowmobile use, particularly depressing the throttle control with the thumb, fatigues the muscle of the hands and arms." Habes et al (2003) reported that "several NPS rangers indicated that it would be beneficial if the steering bar could be moved closer to the body and lowered, without having to move the seat back closer. This feature would allow the arms to be used more effectively in stabilizing the body position on the seat as the snowmobile is driven, particularly under bumpy road conditions."

The seat and the position of the rider on the seat while driving has been known to cause back and neck problems. "The role of the seat is

not only related to vibration but also to the support function of the back during driving." (Anttonen and Niskanen, 1994) Tostrup (1994) stated that "the hardness of the seat is also of importance in reducing vibrations and impact from the ground." "The support for the back provided by the seat is rarely satisfactory, and the shock absorbers are often insufficient." (Nayha et al, 1994) The seated position of the rider may cause the rider to hold the head in a non-neutral position causing musculoskeletal problems in the neck, shoulders, and upper back. "A correct spine posture in the snowmobile rider will decrease asymmetrical loading." (Roberts et al (1971) A non-neutral neck position is common among riders due to the safety need of wearing a helmet. "Counteracting for the weight of the head when the cervical spine is flexed forward and excessive exposure times with the arms in flexed or abducted positions are associated with static muscle activity in the neck and shoulder area. A non-neutral neck position, occurring simultaneously with exposure to excessive shock would be undesirable." (Rehn et al, 2005) Driving in a standing position, or on the knees, causes the driver to be bent forward shifting the body mass away from the supporting point increasing the physical force needed by the hands to hold the steering yoke. (Nayha et al, 1994) "Further achievements may be gained by instructions given to the drivers regarding the appropriate driving posture." (Nayha et al, 1994) Although many advancement have been made in the design of the snowmobile there remains room for improvement. As stated by Waller et

al (1975), “There appears to have been an attempt by some manufacturers during the past year or two to upgrade the design and quality of the machines through options that the use may purchase if he wishes.”

Musculoskeletal Symptoms

Musculoskeletal Symptoms are a concern for many snowmobile drivers. These Musculoskeletal Symptoms may be influenced by many factors. Rehn et al (2002) reported that “musculoskeletal symptoms in the neck, shoulders and upper back are 2 to 3 times more prevalent among professional drivers of ATVs compared to a control group not using ATVs at work.” “A cross-sectional study by Rehn, showed that occupational drivers of all-terrain vehicles, such as forest machines, snowmobiles, and snowgroomers, exhibited significantly increased risks for musculoskeletal symptoms primarily from the neck and shoulder region…” (Rehn et al, 2005) “The highly significant correlations between exposure to snowmobile riding and most of the other physical risk factors suggest that extensive usage of snowmobiles and motorcycles strongly increase the risk of acquiring musculoskeletal problems.” (Daerga et al, 2003) “Four studies, Sara, Aira, Nayha, and Tostrup show a high prevalence of lumbar back pain, neck and shoulder pain, arm pain and knee pain. The same authors showed a correlation between driving time and musculoskeletal and joint symptoms.” (Tostrup, 1994)

Nayha et al (1994) found that “38% of their subjects reported complaints in their upper limb or shoulder, which according to their own judgment was caused by riding snowmobile, 34% reported troubles with their knees and 42% reported symptoms in their back. Close to half (46%) of their subjects reported pain, aching or tenderness upon movement they had felt in at least one joint during the year, the most common location for symptoms being the back (30%), shoulder (22%), neck (21%), and knees (20%).” Astrom et al (2005) reported a “prevalence of musculoskeletal symptoms in the neck (43-61%), shoulder (26-43%), and wrist (15-30%) were high in the driver groups and reindeer herders compared to the referents (8-31%).” Astrom et al (2005) also reported “increased odds of musculoskeletal symptoms in the neck for all drivers groups and the reindeer herders.” Rehn et al (2002) also reported “the prevalence of symptoms was larger in the neck, shoulder and thoracic regions in drivers of all-terrain vehicles compared to the control group. Compared to controls, the driver group also showed an increased prevalence of severe symptoms in the neck, shoulder and lower back.” Rehn et al (2004) reported that “among drivers, complaints concerning the musculoskeletal system are most frequently reported from the neck, shoulders, and lower back.” “During a self-reported health survey of reindeer herders, Tostrup found that they had a high prevalence of musculoskeletal disorders of the lumbar back, neck, shoulder, arm, and knee.” (Habes et al, 2003).

Riding Terrain

The riding terrain encountered by snowmobile drivers is another factor that may affect the musculoskeletal symptoms reported and may also be a contributing cause of snowmobile accidents. "The whole body vibration (WBV) in snowmobile riding is caused by the driving terrain resulting in different kinds of resonance phenomena in the structure of the snowmobile." (Anttonen and Niskanen, 1994) "Two major environmental problems were involved in almost 40% of all injury events and almost 60% of events in which there was an environmental contribution. The most important of these was a bump or other rough terrain…" (Waller and Lamborn, 1975) In a study by James et al (1991) "Thirty-nine (46.2%) of the 84 patients were thrown from their snowmobile: 15 when the snowmobile encountered a bump, ditch, or snow ridge and 24 after hitting a tree stump, tree, embankment, or dirt wall."

It is stated in the National Institute for Occupational Safety and Health report (2001) that "the jolts sustained by NPS personnel while riding snowmobiles for long hours under conditions of severely deteriorated roads are extremely higher, may be associated with the musculoskeletal symptoms reported by the workers, and amplify the effects of the design shortcomings of the snowmobiles used in the park." As terrain conditions deteriorate it becomes more difficult for drivers to avoid terrain hazards. Deteriorating road conditions may affect

musculoskeletal symptoms as well as propose difficulty in handling the snowmobile, which may cause injury. According to Waller and Lamborn (1975) "younger persons and those of relatively light weight appeared to have difficulty in handling the machine more often than did individuals of greater weight." The effects of riding terrain on musculoskeletal symptoms may be related to the suspension and available adjustments that are present on the snowmobile. In a study reviewing ergonomics of the snowmobiles used by the National Park Service personnel by Habes et al (2003) it was found that "the snowmobiles do not have the necessary features or adjustments in suspension components to significantly reduce the jolts the riders experience on the deteriorated trails."

Injuries

"Snowmobiling is a popular wintertime family activity and generates billions of dollars in revenue in the northern United States and Canada. However, snowmobiling has been associated with significant morbidity and mortality among adults and children." (DeCou et al, 2003) "In 2005, the US Consumer Product Safety Commission reported 136,100 injuries and 767 estimated deaths associated with ATV use." (Sanfilippo et al, 2008) Of those 767 estimated deaths associated with ATV use, "the consumer product safety commission estimates there are 100 deaths each year are related to snowmobile use." (Sy and Corden, 2005) Decreasing risk of injury is imperative to the snowmobile driver's

safety. "A study in Minnesota indicates that one out of every 25 snowmobilers can expect to be injured during his snowmobiling career." (Karleen, 1973) According to Landen et al (1999), "for 1993-1994, injury death and hospitalization rates were greater for snowmobiles than for on-road motor vehicles. When rates by miles driven are calculated for injuries associated with each vehicle, the rate ratio becomes even greater and approaches a more accurate measure of the relative risk of injury associated with snowmobile use." In the winter of 2000-2001, the Canadian institute for health reported there were 137 admissions to the hospital related to sever injuries from snowmobiling. (Hoey, 2003) "In the United States, more than 10,000 patients sought medical attention in an emergency room for snowmobile-related injuries during 1997 and 1998." (Sy and Corden, 2005) As reported by Karleen (1973), "the accident rate is rising due to carelessness and negligence in snowmobile operations."

There are many risk factors, and/or behaviors, that contribute to the both the frequency and severity of snowmobile incidents. (Nayci et al, 2006) "New high-powered machines, burgeoning numbers of riders, and a larger percentage of inexperienced riders are all possible factors" relating to the cause and increase of snowmobile incidents. (Beilman et al, (1999) "The most common accident mechanism was falling off the machine due to jumps and unexpected terrain irregularities." (Sundstrom et al, 1994) In a study by Karlstad and Trousdale (2003),

"Collisions accounted for 24 (n=78) of the accidents. Thirty-seven lost control of their vehicle as a result of the terrain, whereas 5 others were injured by snowmobile machinery." More than three-fourths of the 137 accidents reported by Bjornstig et al (1994) occurred during leisure activities and racing. DeCou et al (2003) reported that "the most common mechanism of injury was collision with a fixed object – this occurred in 13 cases (42%). The remaining mechanisms were rollover (3 cases), passenger falling off a moving snowmobile (2)…" Related to snowmobile injuries is the injuries sustained during motocross riding. "Motocross injuries usually result from falls after high jumps and direct impact against the ground at relatively lower speeds…" (Gorski et al, 2003) Waller and Lamborn (1975) found that "the injured population tended to have machines with higher horsepower engines than did the comparison group." There are many contributing factors to injuries associated with snowmobile driving, however, most snowmobile related injuries could be prevented by increasing the drivers awareness of the risks involved.

The types of injuries reported from riding snowmobile are not concentrated on one area of the body; however, the lower extremity proves to be at the greatest risk for injury. A study conducted by the CDC assessing injuries and deaths in Maine from 1991-1996 reported that "of the 903 injuries, 282 (31%) involved a lower extremity, 165 (18%) an upper extremity, 151 (17%) the head or neck, 79 (9%) the chest or

trunk, and 63 (7%) the back. Specific types of injuries included fractures (32%); lacerations (10%); contusions (4%); abrasions (3%); dislocations (2%); burns (2%); exposure (1%); internal or puncture (<1%); drowning (<1%); and unspecified, other, or unknown (37%)." Waller and Lamborn (1975) reported that "overall 30% of events resulted in fractures, 38% in contusions or lacerations, 22% in sprains, 3% in concussions, and 6% in other injuries." In a study by Beilman et al (1999) "types of injuries were classified as spine injuries, head injury, intraabdominal injury, thoracic injury, pelvic fracture, facial injury, and extremity fractures. Number of injuries reported in each category: extremity fractures (67%), head injury (34%), facial fractures or soft tissue injury (32%), thoracic injury (29%), spine injury (18%), intraabdominal injury (15%), and pelvic fracture (11%)." Injury to the extremities is the most common injury reported. Skokan et al (2001) reported that "more than 63% of the patients had serious isolated injuries involving the extremities, the internal organs, or the head." In a study conducted by Sundstrom et al (1994) "The lower extremities were exposed to one third (32%) of the injuries, while the upper extremities and the head and neck region accounted for 21% and 19% of the injuries respectively." An additional study by Soininen and Hantula (1992) stated that "half of all the injuries (50%) were in extremities. Sixty-six (18%) were head injuries, 41 (11%) thorax injuries, 8% back injuries, 3% abdominal, 3% on spine or neck and 6% in other parts of the body." The injuries reported in this study were typically in

the extremities consisting of fractures in the legs and fractures and luxations in the upper extremities. (Soininen and Hantula, 1992) As these studies report the extremities are the most common location for injuries sustained while driving a snowmobile. Bauer and Hemborg (1979) reported that "it seems that the lower limbs are insufficiently protected in snowmobile accidents, as shown by the distribution of the injuries over the body." Accidents and injuries are seen in all types of sport and recreational activity. Participants in these activities, including snowmobiling, need to take all necessary precaution while participating in their chosen recreation.

CHAPTER 3

METHODOLOGY

Subject Characteristics

Subjects were 18 year of age or older (Table 1) and drive a snowmobile recreationally during the winter season. Participants could either own a snowmobile or rent a snowmobile during the riding season. Subjects came from the northern regions of the United States including; North Dakota, South Dakota, Minnesota, Montana, Wisconsin, Michigan, and Maine.

Instrumentation

A survey was distributed to Snowmobile Clubs in both North and South Dakota, snowmobile rental facilities in West Yellowstone, Montana, and to the International Snowmobile Manufacturer's Association. The survey consisted of questions regarding the occurrence of musculoskeletal symptoms sustained while participating in snowmobile driving, snowmobile machine characteristics, and rider characteristics. (Appendix I and II)

Collection of the Data

Data were collected through an online survey and from participants returning a paper copy of the survey via of a self-addressed envelope that was included with the mailing of a paper copy of the survey.

Survey Questions

The questions included on the survey were created to collect the data needed for this particular study.

The purpose of each question is as follows:

1. The year of the snowmobile will be used to compare to questions 4-7 to determine if snowmobile year is associated with the musculoskeletal symptoms that were reported.
2. The length of the track will be used to compare to questions 4-7 to determine if the track length is associated with the musculoskeletal symptoms that were reported.
3. The riding terrain will be used with to questions 4-7 to determine if riding terrain is associated with the musculoskeletal symptoms that were reported.
4. Used to assess which areas of soreness are reported most frequently.
5. Used to determine how long the soreness from questions 4 and 7 typically last.
6. Used to assess how many participants report ongoing physical ailments associated with driving a snowmobile.
7. Used to assess the type of ongoing physical ailment(s) and the areas of the body they are reported to assess if participants report ongoing symptoms in the same areas.

The available responses for each question were chosen by the researcher as being appropriate selections for the study. The reasons for each selection are as follows:

1. The 5 years increments were used due to the fact that most snowmobile manufacturers have made changes to their products within the 5-year increment.
2. The length of the snowmobile tracks were divided into short, medium, and long. Short being 120"-137", Medium 141"-146", and Long 151" or more. Track Length: the longer the track the less likely the driver will be to hit every bump on rough riding terrain. However, increasing the length of the snowmobile from the manufacture length may not be as structurally sound as a snowmobile of the same length from the manufacturer. This could potentially increase the risk of injury if the lengthening of the snowmobile is not completed correctly.
3. Groomed Trail: groomed trails are state sanctioned trails within each states trail system. These trails are groomed on a regular basis during the winter season.

   Ungroomed Trail: ungroomed trails could be either a self cut trail or a trail that may be frequently used by other drivers but is not part of a state sanctioned trail system and is not groomed on a regular basis.

4. The shoulders, hands, arms, knees, hips, low back, feet, and neck were chosen as options due to the fact that these are the regions of the body that symptoms were reported in other studies.
5. Three day increments were given to determine how long soreness reported would last. The researcher chose to use 3 day increments to take into account the effects of delayed onset muscle soreness.
6. A yes or no answer is appropriate for this question.
7. Ongoing low back pain: low back pain has been associated with snowmobile driving.

    Loss of Grip Strength: has been associated with driving a snowmobile due to the driving being subjected to hand-arm vibration.

    Ongoing joint pain in the upper and/or lower body: These injuries are associated with any injury or overuse due to snowmobile driving.

Data Analysis Methods

Participants' data was summed across categories. This method was used in order to find the percentage and number of participants reporting specific symptoms for the three variables; snowmobile year, track length, and riding terrain.

Musculoskeletal pain in the neck/shoulders, arms, lower back, legs, and no soreness were reported for each snowmobile manufacture year category (1991-1995, 1996-2000, 2001-2005, 2006-2010). This was done in order to find how many snowmobile drivers within each manufacture year category (1991-1995, 1996-2000, 2001-2005, 2006-2010) reported specific pain symptoms.

Musculoskeletal pain symptoms in the neck/shoulders, arms, lower back, legs, and no soreness were reported for each snowmobile track length category (short – 120"-128", medium – 130"-146", long – 151"+). This was done in order to find how many snowmobile drivers within each category reported specific pain.

Musculoskeletal pain symptoms in the neck/shoulders, arms, lower back, legs, and no soreness were reported for each riding terrain category (groomed trail, ungroomed trail, equal riding on both, other). This was done in order to determine the number of snowmobile drivers within each category who reported specific pain symptoms.

CHAPTER 4

RESULTS

Participant Demographics

Participant demographics including; gender, age, snowmobile year, track length, riding terrain, the type of symptoms reported, how long the reported symptoms lasted, if drivers had any ongoing physical ailments, and the type of ongoing physical ailments reported are found in Table 1. The number of participants in each category and the percentage of participants reporting in each category are included in Table 1.

Results

The association among snowmobile year, track length and riding terrain and the presence of musculoskeletal symptoms in recreational snowmobile drivers was determined by comparing the snowmobile year, the track length of the snowmobile, and the riding terrain to the symptoms reported by the participants. A comparison was made between each variable separately (snowmobile year, track length, riding terrain) to the symptoms reported (soreness in the neck/shoulders, arms, lower back, legs, no soreness) to determine how the variables (snowmobile year, track length, and riding terrain) are associated with the musculoskeletal symptoms reported.

Table 1 Demographics of the participants

Total: n=243 Number (%)					
Gender	Male 186 (77)	Female 57 (23)			
Age	18-25 21 (9)	26-35 38 (16)	36-45 69 (28)	46-55 78 (32)	56 + 36 (15)
Snowmobile Year	1991-1995 9 (4)	1996-2000 33 (13)	2001-2005 67 (27)	2006-2010 133 (55)	
Track Length	Short (120"-128") 62 (26)	Medium (130"-146") 128 (52)	Long (151" +) 53 (22)		
Riding Terrain (Trail Type)	Groomed 73 (30)	Ungroomed 57 (23)	Both 94 (39)	Other 19 (8)	
Length of symptoms	1-3 days 193 (79)	3-5 days 7 (3)	5-7 days 3 (1)	7-10 days 0 (0)	Other 40 (16)
Reported ongoing symptoms	Yes 21 (9)	No 222 (91)			
Type of ongoing symptoms	Low back pain 31 (13)	Loss of grip strength 12 (5)	Joint pain in lower body 21 (8)	Joint pain in upper body 11 (4)	Other 28 (11)

Year of Manufacture

Musculoskeletal symptoms were reported by the year the snowmobile was manufactured (Table 2). Drivers of snowmobiles manufactured between 1991 and 1995 reported symptoms in the neck and shoulders as the most prevalent symptom followed by, Legs, multiple symptoms, Arms/Lower Back, and no soreness, respectively. Drivers of snowmobiles manufactured between 1996 and 2000 reported symptoms

in the lower back as the most prevalent symptom followed by symptoms in the arms, neck and shoulders/multiple symptoms, legs, and no soreness, respectively. Drivers of snowmobiles manufactured between 2001 and 2005 reported symptoms in the neck and shoulders as the most prevalent symptom followed by multiple symptoms, symptoms in the lower back, legs, arms, and no soreness, respectively. Drivers of snowmobiles manufactured between 2006 and 2010 reported symptoms in the neck and shoulders as the most prevalent symptom followed by multiple symptoms, symptoms in the lower back, arms, legs/no soreness, respectively.

Table 2 Comparison of Snowmobile Year to Reported Symptoms

Total: n=242				
Number (%)	1991-1995 (n=9)	1996-2000 (n=33)	2001-2005 (n=67)	2006-2010 (n=133)
Neck/Shoulders	5 (55)	9 (27)	34 (51)	62 (47)
Arms	2 (22)	10(30)	13 (19)	33 (25)
Lower Back	2 (22)	15 (45)	26 (39)	37 (28)
Legs	4 (44)	6 (18)	18 (27)	26 (19)
No soreness	1 (1)	4 (12)	10 (15)	26 (19)
Multiple Symptoms	3 (33)	9 (27)	28 (42)	41 (31)

Track Length

Musculoskeletal symptoms were also recorded based on the track length of the snowmobile (Table 3). Drivers who drive snowmobiles with a short length track (120"-128") reported symptoms in the neck and shoulders as the most prevalent symptom followed by the lower back, arms/no soreness/multiple symptoms, and legs, respectively. Drivers who drive snowmobiles with a medium length track (130"-146") reported symptoms in the neck and shoulders as the most prevalent symptom followed by multiple symptoms, symptoms in the lower back, arms/legs, and no soreness, respectively. Drivers who drive snowmobiles with a long length track (151" or more) reported symptoms in the neck and shoulders as the most prevalent symptom followed by multiple symptoms, symptoms in the lower back, legs, arms, and no soreness, respectively.

Table 3 Comparison of Track Length to Reported Symptoms

Total: n=243 Number (%)	Short – 120"-128" (n=62)	Medium – 130"-146" (n=128)	Long – 151" + (n=53)
Neck/Shoulders	23 (37)	62 (48)	25 (47)
Arms	14 (22)	30 (23)	14 (26)
Lower Back	21 (34)	40 (31)	20 (38)
Legs	9 (14)	30 (23)	15 (28)
No Soreness	14 (22)	22 (17)	5 (9)
Multiple Symptoms	14 (22)	44 (34)	23 (43)

Riding Terrain

Musculoskeletal symptoms were also reported based on the riding terrain (Table 4). Snowmobile drivers using groomed trails reported pain in the neck and shoulders as the most prevalent symptom followed by the lower back, multiple symptoms, no soreness, legs, and arms, respectively. Snowmobile drivers using ungroomed trails reported pain in the lower back as the most prevalent symptom followed by the neck and shoulders, multiple symptoms, arms, legs, and no soreness, respectively. Snowmobile drivers using both groomed and ungroomed trails reported pain in the neck and should as the most prevalent symptom followed by pain in multiple locations, pain in the arms, lower back, legs, and no soreness, respectively. Snowmobile drivers driving on other types of terrain reported pain in the neck and shoulders as the most prevalent symptom followed by pain in multiple locations, lower back/legs, arms, and no soreness, respectively.

Table 4 Comparison of Riding Terrain to Reported Symptoms

Total: n=243 Number (%)	Groomed Trail (n=73)	Ungroomed Trail (n=57)	Both (n=94)	Other (n=19)
Neck/Shoulders	31 (42)	22 (38)	45 (48)	12 (63)
Arms	12 (16)	12 (21)	31 (33)	3 (16)
Lower Back	22 (30)	28 (49)	23 (24)	8 (42)
Legs	13 (18)	11 (19)	22 (23)	8 (42)
No Soreness	17 (23)	8 (14)	15 (16)	1 (5)
Multiple Symptoms	19 (26)	21 (37)	32 (34)	9 (47)

Length of Symptoms

The symptoms reported were categorized by the reported length the symptoms persisted (Table 5).

Table 5 Comparison of Reported Symptoms to Number of Days Symptoms Persist

	Neck/Shoulders	Arms	Lower Back	Legs	No Soreness
Number (%)	(n=110)	(n=58)	(n=81)	(n=54)	(n=41)
1-3 days	101 (92)	53 (91)	77 (95)	47 (87)	8 (19)
3-5 days	6 (5)	2 (3)	2 (2)	3 (5)	0 (0)
5-7 days	1 (.9)	1 (2)	0 (0)	2 (4)	0 (0)
7-10 days	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Other	2 (2)	1 (2)	2 (2)	2 (4)	33 (80)

Type of Ongoing Physical Ailments

Ongoing physical ailments were compared to reported types of ongoing physical ailments were also recorded (Table 6).

Table 6 Comparison of Reported Ongoing Physical Ailments Related to Snowmobile Driving to Type of Ongoing Physical Ailments Reported

Total: n=243	Yes	No
Number (%)	(n=21)	(n=222)
Ongoing low back pain	7 (33)	24 (11)
Loss of grip strength	2 (9)	10 (5)
Ongoing joint pain in the lower body	5 (24)	16 (7)
Ongoing joint pain in the upper body	2 (9)	9 (4)
Other	9 (43)	19 (8)
Multiple Symptoms	4 (19)	7 (3)

CHAPTER 5

SUMMARY, CONCLUSIONS,

AND RECOMMENDATIONS

Discussion of Results

The occurrence of musculoskeletal pain symptoms has been shown to be related to snowmobile driving. This study looked at pain symptoms reported by snowmobile riders. The data was categorized by snowmobile manufacture year, track length, and riding terrain. Most participants reported pain in the neck and shoulders (110), followed by the low back (80 – snowmobile year, 81 – track length and riding terrain), multiple symptoms (81), the arms (58), the legs (54), and no reported soreness (41).

Snowmobile Year

Drivers of snowmobiles manufactured between the years of 1991-1995 and 2001-2010 reported pain in the neck and shoulders as the most prevalent symptom they experience after driving a snowmobile. The differences seen in the reported symptoms by each manufacture year may be due to the difference in design of the snowmobiles in each category. These design difference could affect the ergonomics of the riders, which would explain the difference in reported symptoms. The National Institute for Occupational Safety and Health (2001), Habes et al (2003), Rehn et al (2005a), Rehn et al (2005b), Tostrup (1994), all reported that the handle bars and the angle of the arms during

snowmobile driving influenced the occurrence of musculoskeletal pain in the neck and shoulders. Most participants experienced symptoms in the neck and shoulder despite the manufacture year of the snowmobile. This shows that the changes to snowmobile design has not met the needs of the driver in order to see a decrease in the pain symptoms of the neck and shoulders. In the study evaluating the ergonomics of snowmobiles used by the National Park Service by Habes et al (2003) it was reported that "Several rangers indicated that it would be beneficial if the steering bar could be moved closer to the body and lowered, without having to move the seat back closer. This feature would allow the arms to be used more effectively in stabilizing the body position on the seat as the snowmobile is driven, particularly under bumpy road conditions." The National Institute for Occupational Safety and Health (2001) reported that "the most important feature to adjust is the steering bar, which is moved closer to the body with grips oriented to provide for neutral wrist positions while in typical use, would reduce grip forces and improve shoulder and arm postures." These studies reinforce the fact that there continues to be room for improvement in the ergonomics of the snowmobile.

Track Length

Drivers of every track length reported pain in the neck and shoulders as the most prevalent followed by pain in the lower back. These findings show that track length may impact the occurrence of musculoskeletal

symptoms; however, as previously mentioned, the symptoms reported may be strongly related to ergonomics of the snowmobile, which is going to be related to the manufacturer's design. Pain in the neck and shoulders and lower back are the most commonly reported symptoms for snowmobile drivers according to the National Institute for Occupational Safety and Health (2001), Habes et al (2003), Nayha et al (1994), Rehn et al (2005a), Rehn et al (2005b), and Tostrup (1994), Astrom et al (2006), Daerga et al (2003), Rehn et al (2002), Rehn et al (2004). The reports of these two symptoms (neck and shoulders, and lower back) may account for the significant reports of multiple symptoms that occurred in the medium and long track length snowmobiles. Drivers of medium and long length track snowmobiles reported a greater occurrence of multiple symptoms while driving a snowmobile. This may be due to the track length, the driving behavior of participants on theses snowmobiles, or various other reasons.

Riding Terrain

The most frequently reported pain locations reported by individuals who use an ungroomed trail compared to those who use a groomed trail are in the neck and shoulders and lower back, respectively. This difference in reported symptoms may be due to the deteriorated terrain of an ungroomed trail in which drivers would be subjected to significantly more jolts and bumps. Drivers who use both groomed and ungroomed trails reported pain in the neck and shoulders as being most prevalent.

As reported by the National Institute of Occupational Safety and Health (2001), "The jolts sustained by NPS personnel while riding snowmobiles for long hours under conditions of severely deteriorated roads are extremely higher, may be associated with the musculoskeletal symptoms reported by the works, and amplify the effects of the design shortcomings of the snowmobiles used in the park." The National Park Service personnel in this study drove three models of snowmobiles manufactured by Polaris; the Trail 10, the Trail Touring, and the Widetrak LX. Driving on uneven terrain and deteriorated trails increase the risk of being subjected to jolts and bumps that the snowmobile may not be equipped to handle. As stated by Habes et al (2003), "The snowmobiles do not have the necessary features or adjustment in suspension components to significantly reduce the jolts and riders experience on the deteriorated trails." As snowmobiling grows in popularity more groomed trails and trail systems are available however ungroomed trails continue to be used by snowmobile drivers. "Trail development and improvement should be evaluated as a snowmobile injury control strategy." (Landen et al, 1999) By increasing the number of groomed trails available to snowmobile drivers, more drivers may use the provided trails instead of using ungroomed trails. This could potentially reduce some of the common musculoskeletal symptoms the occur during snowmobile driving.

Length of Symptoms

Almost all drivers reporting pain in the neck and shoulders (92%), arms (91%), lower back (95%), and legs (87%) reported that their symptoms lasted between 1 and 3 days. Those reporting no soreness reported the length of their symptoms as other, meaning they did not get sore. The length of the reported symptoms lasting only 1-3 days could be related to the drivers subjection to whole-body vibration. According to Rhea et al (2009), "Delayed-onset muscle soreness (DOMS) typically peaks within 24 to 48 hours after exercise and is resolved within 5-7 days. Enhanced local blood flow immediately after vibration training is one of the factors that would be expected to result in decreased DOMS." Snowmobile drivers are subjected to whole body vibration for the duration of the ride. Considering the majority of the snowmobile drivers reported symptoms only lasting 1-3 days, the subjection of vibration may be the reason for the soreness to diminish before the typical 5-7 days.

Types of Ongoing Physical Ailments

Drivers who confirmed having ongoing physical ailments reported that other ailments were the most prevalent followed by ongoing low back pain, ongoing joint pain in the lower body, and loss of grip strength/ongoing joint pain in the upper body. Nayha et al (1994) reported that "close to half (46%) of the subjects reported pain, aching or tenderness upon movement they had felt in at least one joint during the

current year, the most common location for such symptoms being the back (30%), shoulder (22%), neck (21%), and knees (20%)."

Conclusions

The results of the current study yield the following conclusions:

1. Ergonomics of the snowmobile, no matter what year the snowmobile was manufactured, seem to be associated with the occurrence of musculoskeletal pain symptoms. The potential to decrease the occurrence of musculoskeletal symptoms may be achieved by further developments in snowmobile design.
2. Drivers of snowmobiles with medium to long length track snowmobiles may have an increased risk of developing multiple musculoskeletal pain symptoms.
3. Riding terrain may be associated with the occurrence of musculoskeletal symptoms. Driving a snowmobile on an ungroomed surface may increase the risk of multiple musculoskeletal pain symptoms after driving.
4. Neck and Shoulder symptoms affect most snowmobile drivers. This may be due to the placement of the handle bars, and/or driving posture of the rider.
5. Musculoskeletal Symptoms that develop in snowmobile drivers last on average 1-3 days.

Recommendations

Based on the finding of the current study, the following recommendations are offered:

1. Designing a similar study in which symptoms are reported immediately post snowmobile driving.
2. Construct groups to ride on each type of terrain only. (Groomed and Ungroomed) This would be beneficial in order to determine which of the two produced more symptoms, and having the opportunity to report exactly what conditions the subjects are driving on.
3. An interesting area would be to test each track length by directly measuring the jolts sustained while driving each length of snowmobile on the same terrain. This would help us to better understand if track length affects the number of jolts sustained by snowmobile drivers and how that affects the occurrence of musculoskeletal symptoms.

REFERENCES

Allyson, J. (2010). The history of snowmobiles. *Helium*. Retrieved from http://www.helium.com/items/812556-the-history-of-snowmobiles

American Academy of Pediatrics. (2000). Snowmobiling Hazards. *Pediatrics 106(5)*, 1142-1144.

Anttonen, H., Niskanen, J. (1994a). Whole body vibration and the snowmobile. *Arctic Medical Research, 53(3)*, 24-28.

Antonnen,H., Virokannas, H. (1994b). Hand-arm vibration in snowmobile drivers. *Arctic Medical Research, 53(3)*, 19-23.

Anttonen, H., Virokannas, H., Niskanen, J. (1995). Hand-arm Vibration and Terrain Vehicles. *Central European Journal of Public Health, 3*, 123-125.

Astom, C., Rehn, B., Lundstrom, R., Nilsson, T., Burstrom, L., Sundelin, G. (2006). Hand-arm vibration syndrome (HAVS) and musculoskeletal symptoms in the neck and the upper limbs in professional driver of terrain vehicles – A cross sectional study. *Applied Ergonomics 37*, 793-799.

Bassett, J. (1989). *Polaris Pioneers: a star is born: 35th Anniversary Commemorative Ed.* St. Paul, MN: Recreational Publications, Inc.

Bassett, J. (1994). *Polaris Partners: 40th Anniversary Commemorative Ed.* St. Paul, MN: Recreational Publications, Inc.

Bauer, M., Hemborg, H. (1979). Snowmobile accidents in Northern Sweden. *Injury: the British Journal of Accident Surgery, 10(3)*, 178-182.

Beilman, G., Brasel, K., Dittrich, K., Seatter, S., Jacobs, D., Croston, J. (1999). Risk factors and patters of injury in snowmobile crashes. *Wilderness and Environmental Medicine, 10(4)*, 226-232.

Bjornstig, U., Eriksson, A., Mellbring, G. (1984). Snowmobiling injuries: types and consequences. *Acta chirurgica Scandinavica, 150*, 619-624.

Bovenzi, M., Hulshof, C.T.J. (1999). An updated review of epidemiologic studies on the relationship between exposure to whole-body vibration and low back pain (1986-1997). *International Archives of Occupational and Environmental Health, 72*, 351-365.

Braun, B., Meyers, B., Dulebohn, S., Eyer, S. (1998). Severe Brachial Plexus Injury as a Result of Snowmobiling: A Case Study. *The Journal of Trauma: Injury, Infection, and Critical Care, 44(4)*, 726-730.

Campbell, S. (2006). History of Snowmobiling. *Northern Timber Cruisers Snowmobile Club, Inc.*

Canadian Paediatric Society. (2004). Recommendations for snowmobile safety. *Paediatrics & Child Health, 9(9)*, 639-646.

Centers for Disease Control and Prevention. (1995). Injuries Associated With Use of Snowmobiles – New Hampshire, 1989-1992. *The Journal of the American Medical Association, 273(6)*, 448-449.

Centers for Disease Control and Prevention. (1997). Injuries and Deaths Associated with use of Snowmobiles – Maine, 1991-1996. *Morbidity & Mortality Weekly Report, 46(1)*, 1-4.

Daergo,L., Edin-Liljegren, A., Sjolander, P. (2003). Work-related musculoskeletal pain among reindeer herding Sami in Sweden – a pilot study on causes and prevention. *Circumpolar Health*, 343-348.

Daniel, R., Midgley, R., (1972). Facial Fractures in Snowmobile Injuries. *Plastic and reconstructive surgery, 49(1)*, 38-40.

DeCou, J., Fagerman, L., Ropele, D., Uitvlugt, N., Schlatter, M., Connors, R. (2003). Snowmobile Injuries and Fatalities in Children. *Journal of Pediatric Surgery, 38(5)*, 784-787.

Eriksson, K., Tjarner, D., Marqvardsen, I., Jarvholm B. (2003). Exposure to benzene, toluene, xylenes and total hydrocarbons among snowmobile drivers in Sweden. *Chemosphere, 50*, 1343-1347.

Farley, D., Orchard, T., Bannon, M., Zietlow, S. (1996). The Care and Cost of Snowmobile-related Injuries. *Minnesota Medicine, 79*, 21-25.

Fioranelli, D., Lee, C. (2008). The Influence of Bar Diameter on Neuromuscular Strength and Activation: Inferences from an Isometric Unilateral Bench Press. *Journal of Strength and Conditioning Research, 22(3)*, 661-666.

Fonseca, A., Ochsner, M., Bromberg W., Gantt, D. (2005). All-Terrain Vehicle Injuries: Are They Dangerous? A 6-Year Experience at a Level I Trauma Center After Legislative Regulations Expired. *The American Surgeon, 71(11)*, 937-941.

Furness, T., Maschette, W. (2009). Influence of Whole Body Vibration Platform Frequency on Neuromuscular Performance of Community-

Dwelling Older Adults. *Journal of Strength and Conditioning Research, 23(5)*, 1508-1513.

Gorski, T., Gorski, Y., McLeon, G., Suh, D., Cordero R., Essien, F., Berry, D., Dada, F. (2003). Patterns of Injury and Outcomes Associated with Motocross Accidents. *The American Surgeon, 69*, 895-898.

Habes, D., Dick, R., Tubbs, R., Biggs, F., Burt, S. (2003). An Ergonomic Evaluation of Snowmobiles. *Applied Occupational and Environmental Hygiene, 18(4)*, 213-225.

Hoey, J. (2003). Snowmobile Injuries. *Canadian Medical Association Journal, 168(6)*, 739.

Ingram, L.A. (2000). *As the snow flies: A history of snowmobile development in North America.* Lanigan, Saskatchewan, CA: Snowmobile Research Publishing.

James, E., Lenz, J., Swenson, W., Cooley A., Gomez, Y., Antonenko D. (1991). Snowmobile Trauma: An Eleven-Year Experience. *The American surgeon, 57(6)*, 349-353.

Karleen, C. (1973). Snowmobiling with Associated Maxillofacial Injuries. *Minnesota Medicine, 56(11)*, 975-979.

Karlstad, R., Trousdale, R. (2003). Orthopedic Injuries Related to Snowmobile Use. *Journal of Orthopaedic Trauma, 17(1)*, 48-52.

Keske, J., Blough, J., Dilworth, B. (2006). Subjective Characterization of Snowmobile and ATV Vibration. *Sound and Vibration. November 2006*, 16-19.

Kjellberg, A., Wikstrom, B. (1985). Whole-body vibration: exposure time and acute effects – a review. *Ergonomics, 28(3)*, 535-544.

Konttinen, T., Hakkinen, K., Kyrolainen, H. (2007). Cardiopulmonary loading in motocross riding. *Journal of Sports Sciences, 25(9)*, 995-999.

Konttinen T., Kyrolainen, H., Hakkinen, K. (2008). Cardiorespiratory and Neuromuscular Responses to Motocross Riding. *Journal of Strength and Conditioning Research, 22(1)*, 202-209.

Koskinen, K. (1994). Snowmobile traumas in Finnish Lapland: Injuries to head, face and neck. Possible effects of speed and the use of helmet. *Arctic Medical Research, 53(3)*, 5-7.

Landen, M., Middaugh, J., Dannenberg, A. (1999). Injuries Associated with Snowmobiles, Alaska, 1993-1994. *Scientifica Contributions, Public Health Reports, 114*, 48-52.

Marin P., Bunker, D., Rhea, M., Ayllon F. (2009). Neuromuscular Activity During Whole-Body Vibration of Different Amplitudes and Footwear conditions: Implications for Prescription of Vibratory Stimulation. *Journal of Strength and Conditioning Research, 23(8)*, 2311-2316.

McLay, R. (1971). A survey of snowmobile injuries and hazards. *Medicine and Science in Sports, 3(2)*, 97-99.

National Institute for Occupational Safety and Health. (2001, August). Ergonomics Evaluation of Snowmobiles at Yellowstone National Park. *Health Hazard Evaluation Report 99-0283-2855*.

Nayci A., Stavlo, P., Zarroug, A., Zietlow, S., Moir, C., Rodeberg, D. (2006). Snowmobile Injuries in Children and Adolescents. *Mayo Clinic Proceedings, 81(1)*, 39-44.

Nayha, S., Antonnen, H., Hassi, J. (1994). Snowmobile driving and symptoms of the locomotive organs. *Arctic Medical Research, 53(3)*, 41-44.

Ostrom, M., Eriksson, A. (2002). Snowmobile fatalities Aspects on preventive measures form a 25-year review. *Accident Analysis and Prevention, 34*, 563-568.

Parmar, M. (2003). Snowmobiler's hematuria. *Canadian Medical Association Journal, 168(6)*, 672.

Pierz, J. (2003). Snowmobile injuries in North America. *Clinical Orthopaedics and Related Research, 409*, 29-36.

Rabideau, G. (1974). Human, Machine, and Environment Aspects of Snowmobile Design and Utilization. *Human Factors, 16(5)*, 481-494.

Ramstad, C.J. (1987). *Arctic Cat's First Quarter Century (1st ed.)*. Deephaven, MN: PPM Books.

Ramstad, C.J. (1999). *Arctic Cat's First Four Decades (2nd ed.).* Deephaven, MN: PPM Books.

Rehn, B., Bergdahl, C., Ahlegran, C., From, C., Jarvholm, B., Lundstrom, R., Nilsson, T., Sundelin, G. (2002). Musculoskeletal Symptoms among Drivers of All-Terrain Vehicles. *Journal of Sound and Vibration 253(1)*, 21-29.

Rehn, B., Lundstrom, R., Nilsson, T., Bergdahl, I.A., Ahlgren,C., From,C., Sundelin, G., Jarvholm,B. (2005a). Symptoms of musculoskeletal disorders among drivers of all-terrain vehicles in northern Sweden. *Noise & vibration worldwide, 36(1)*, 13-18.

Rehn, B., Nilsson, T., Olofsson, B., Lundstrom, R. (2005b). Whole-Body Vibration Exposure and Non-neutral Neck Postures During Occupational Use of All-terrain Vehicles. *Annals of Occupational Hygiene, 49(3)*, 267-275.

Rehn,B., Nilsson, T., Jarvholm, B. (2004). Neuromusculoskeletal disorders in the neck and upper extremities among drivers of all-terrain vehicles – a case series. *BMC Musculoskeletal Disorders, 5:1*.

Rhea, M., Bunker, D., Marin, P., Lunt, K. (2009). Effect of iTonic Whole-Body Vibration on Delayed-Onset Muscle Soreness Among Untrained Individuals. *Journal of Strength and Conditioning Research, 23(6)*. 1677-1682.

Roberts V., Noyes, F., Hubbard R., McCabe, J. (1971). Biomechanics of Snowmobile Spine Injuries. *Journal of Biomechanics, 4*, 569-577.

Rodengen, J.L., Hubbard, R.F. (2003). *The Legend of Polaris*. Ft. Lauderdale, FL: Write Stuff Enterprises.

Sanfilippo, J., Winegar, C., Harrop, J., Albert, T., Vaccaro, A. (2008). All-Terrain Vehicles and Associated Spinal Injuries. *Spine, 33(18)*, 1982-1985.

Silva-Grigoletto, M., Vaamonde, D., Castillo, E., Poblador, M., Garcia-Manso, J., Lancho, J. (2009). Acute and Cumulative Effect of Different Times of Recovery From Whole Body Vibration Exposure on Muscle Performance. *Journal of Strength and Conditioning Research, 23(7)*, 2073-2082.

Skokan, E., Olson, L., Cook, L., Corneli, H. (2001). Snowmobile Injuries in Utah. *Academic Emergency Medicine, 8(12)*, 1173-1177.

Soininen, L., Hantula, L. (1992). Snowmobile Accidents in Lapland. *Arctic Medical Research, 51(7)*, 64-70.

Sundstrom I., Zetterqvist, H., Bjornstig, U. (1994). Snowmobile Injuries in Kiruna, Northern Sweden. *Arctic Medical Research, 53*, 189-195.

Sy, M., Corden, T. (2005). The Perils of Snowmobiling. *Wisconsin Medical Journal, 104(2)*, 32-34.

Testerman, G. (2009). Increased All-Terrain Vehicle Crash Accidents in Older Riders. *Southern Medical Journal, 102(5)*. 461-464.

Torvinen, S., Kannus, P., Sievanen, H., Jarvinen, T., Pasanen, M., Kontulainen, S., Jarvinen, T., Jarvinen, M., Oja, P., Vuori, I. (2002). Effect of a vibration exposure on muscular performance and body balance. Randomized cross-over study. *Clinical Physiology and Functional Imaging, 22(2)*, 145-152.

Tostrup, B. (1994). Ergonomic aspects on snowmobile driving. *Arctic Medical Research, 53(3)*, 45-54.

Virokannas, H., Ant6onnen, H. (1993). Risk of Frostbite in Vibration-induced White Finger Cases. *Arctic Medical Research, 52*, 69-72.

Virokannas, H., Anttonen, H. (1994a). Combined effects of cold, vibration and smoking, particularly in snowmobile users. *Arctic Medical Research, 53(3)*, 29-34.

Virokannas, H., Anttonen H. (1994b). Thermal responses in the body during snowmobile driving. *Arctic Medical Research, 53(3)*, 12-18.

Waller, J., Lamborn, K. (1975). Snowmobiling: Characteristics of owners, patterns of use and injuries. *Accident Analysis and Prevention, 7*, 213-223.

Warren, J. (Monday, October 1, 2007). Adirondack Snowmobile History, Part One. *Adirondack Almanack*. Retrieved from http://www.adirondackalmanack.com/2007/10/adirondack-snowmobile-history-part-one.html

Warren, J. (Wednesday, October 3, 2007). Adirondack Snowmobile History, Part Two. *Adirondack Almanack.* Retrieved from http://www.adirondackalmanack.com/2007/10/adirondack-snowmobile-history-part-two.html

Warren, J. (Friday, October 5, 2007). Adirondack Snowmobile History, Part Three. *Adirondack Almanack.* Retrieved from http://www.adirondackalmanack.com/2007/10/adirondack-snowmobile-history-part.html

Warren, J. (Monday, October 8, 2007). Adirondack Snowmobile History, Part Four. *Adirondack Almanack*. Retrieved from http://www.adirondackalmanack.com/2007/10/adirondack-snowmobile-history-part-four.html

Warren, J. (Wednesday, October 10, 2007). Adirondack Snowmobile History, Part Five. *Adirondack Almanack*. Retrieved from http://www.adirondackalmanack.com/search/label/Adirondack%20Snowmobiling%20History

APPENDIX I

INFORMED CONSENT

Informed Consent

Please Read and Sign the following before completing the Survey

You are invited to participate in a research study by completing a survey. The purpose of this study is to understand which factors are related to injuries during snowmobiling.

If you want to participate in the study, please provide answers to the questions in the survey.

In this survey, you will be asked about things like injuries you may have, how long you have been riding snowmobiles, and what type of snowmobile you use, for example.

If you have questions about the research, please contact the student investigator, Erica Heisler (heislere@unlv.nevada.edu) or the principal investigator, Dr. John Young (john.young@unlv.edu).

If you have questions about the rights of subjects, any complaints/concerns regarding the study, you may contact the UNLV Research Integrity – Human Subjects Division at (702)895-2794, toll free at (877)895-2794, or via email at IRB@unlv.edu.

If you mail the survey back, we will use your answers as part of the research.

Thank you for your consideration and time in completing the survey if you decide to.

Participant Signature _____

Date _____

APPENDIX II

SURVEY

Male	Female	Age Group:	18-25 ____	36-45 _____
			26-35 ____	46-55 _____
			56+_____	

1. What year is the snowmobile you typically ride?
   a. Older than 1980
   b. 1980-1985
   c. 1985-1990
   d. 1991-1995
   e. 1996-2000
   f. 2001-2005
   g. 2006-2010

2. How long is the track length on the snowmobile you most often ride?
   a. Short (120"-128") b. Medium (130"-146") c. Long (151" +)

3. What type of trail do you typically ride snowmobile on?
   a. A groomed trail
   b. An un-groomed trail
   c. Equal riding on both
   d. Other _____

4. While riding a snowmobile do you have any soreness or fatigue in the following areas? (check all that apply)
   a. Shoulders
   b. Hands
   c. Arms
   d. Knees
   e. Hips
   f. Low back
   g. Feet
   h. Neck
   i. Other _____

5. How long does the soreness last?
   a. 1-3 days
   b. 3-5 days
   c. 5-7 days
   d. 7-10 days
   e. Other_____

6. Do you have any ongoing physical ailments originating from snowmobile riding or a snowmobile injury accident last longer than 6 months?
   a. Yes b. No

7. What type of ongoing physical ailments do you have? (check all that apply)
   a. Ongoing low back pain
   b. Loss of grip strength _
   c. Ongoing joint pain in the lower body
   d. Ongoing joint pain in the upper body
   e. Other _____

APPENDIX III

PARTICIPANT SURVEY DATA

Participant	Please specify your gender		Select your appropriate age range.				
	Female	Male	18-25	26-35	36-45	46-55	56 & older
1		Male				46-55	
2		Male				46-55	
3	Female					46-55	
4	Female				36-45		
5		Male				46-55	
6		Male					56 & older
7		Male			36-45		
8		Male				46-55	
9		Male				46-55	
10		Male					56 & older
11		Male			36-45		
12	Female					46-55	
13		Male				46-55	
14		Male			36-45		
15		Male			36-45		
16		Male				46-55	
17	Female					46-55	
18		Male	18-25				
19		Male			36-45		
20		Male		26-35			
21		Male				46-55	
22		Male	18-25				
23		Male	18-25				
24		Male				46-55	
25		Male				46-55	
26	Female					46-55	
27		Male				46-55	
28		Male	18-25				
29		Male				46-55	
30		Male			36-45		
31		Male			36-45		
32		Male			36-45		
33		Male					56 & older
34	Female						56 & older
35		Male			36-45		
36		Male			36-45		
37	Female					46-55	
38	Female						56 & older
39		Male					56 & older

40		Male				36-45		
41		Male			26-35			
42		Male			26-35			
43		Male			26-35			
44		Male				36-45		
45		Male					46-55	
46		Male				36-45		
47		Male		18-25				
48	Female						46-55	
49		Male					46-55	
50		Male					46-55	
51		Male			26-35			
52		Male		18-25				
53		Male				36-45		
54	Female			18-25				
55		Male					46-55	
56		Male					46-55	
57		Male					46-55	
58		Male		18-25				
59		Male						56 & older
60		Male				36-45		
61		Male				36-45		
62		Male					46-55	
63	Female				26-35			
64		Male					46-55	
65		Male				36-45		
66		Male			26-35			
67		Male			26-35			
68		Male					46-55	
69	Female					36-45		
70		Male		18-25				
71		Male				36-45		
72		Male		18-25				
73		Male				36-45		
74		Male					46-55	
75		Male				36-45		
76		Male						56 & older
77		Male						56 & older
78		Male						56 & older
79		Male		18-25				
80		Male		18-25				
81		Male				36-45		
82		Male				36-45		

83		Male					46-55	
84		Male			26-35			
85		Male				36-45		
86		Male					46-55	
87		Male					46-55	
88		Male				36-45		
89		Male					46-55	
90		Male				36-45		
91		Male				36-45		
92		Male						56 & older
93		Male		18-25				
94		Male			26-35			
95		Male				36-45		
96		Male					46-55	
97		Male					46-55	
98		Male						56 & older
99	Female					36-45		
100		Male				36-45		
101	Female			18-25				
102		Male				36-45		
103	Female							56 & older
104		Male					46-55	
105		Male			26-35			
106		Male					46-55	
107		Male			26-35			
108		Male			26-35			
109		Male				36-45		
110		Male				36-45		
111	Female				26-35			
112		Male		18-25				
113		Male				36-45		
114		Male			26-35			
115		Male					46-55	
116		Male				36-45		
117		Male						56 & older
118	Female			18-25				
119		Male					46-55	
120	Female						46-55	
121	Female						46-55	
122	Female							56 & older
123	Female						46-55	

124	Female						46-55	
125	Female						46-55	
126		Male					46-55	
127		Male					46-55	
128		Male				36-45		
129	Female						46-55	
130		Male				36-45		
131		Male				36-45		
132		Male				36-45		
133		Male		26-35				
134		Male					46-55	
135		Male						56 & older
136	Female							56 & older
137		Male					46-55	
138		Male					46-55	
139	Female							56 & older
140		Male						56 & older
141		Male						56 & older
142		Male						56 & older
143	Female						46-55	
144	Female						46-55	
145		Male				36-45		
146		Male	18-25					
147		Male				36-45		
148	Female			26-35				
149		Male					46-55	
150	Female			26-35				
151		Male				36-45		
152		Male		26-35				
153	Female			26-35				
154		Male		26-35				
155	Female					36-45		
156		Male						56 & older
157		Male				36-45		
158		Male						56 & older
159		Male		26-35				
160		Male					46-55	
161		Male					46-55	
162		Male		26-35				
163	Female		18-25					

164	Female				36-45			
165	Female				36-45			
166		Male	18-25					
167	Female			26-35				
168		Male						56 & older
169	Female					46-55		
170	Female							56 & older
171		Male						56 & older
172		Male			36-45			
173	Female							56 & older
174		Male						56 & older
175		Male				46-55		
176		Male				46-55		
177		Male			36-45			
178		Male						56 & older
179	Female			26-35				
180		Male				46-55		
181		Male			36-45			
182		Male			36-45			
183	Female				36-45			
184		Male						56 & older
185	Female			26-35				
186		Male				46-55		
187		Male		26-35				
188	Female				36-45			
189	Female				36-45			
190		Male		26-35				
191		Male			36-45			
192	Female				36-45			
193	Female				36-45			
194		Male						56 & older
195	Female			26-35				
196		Male				46-55		
197		Male				46-55		
198		Male		26-35				
199		Male				46-55		
200		Male		26-35				
201		Male						56 & older
202	Female				36-45			
203		Male						56 & older

204	Female				36-45			
205		Male			36-45			
206		Male				46-55		
207		Male			36-45			
208	Female					46-55		
209		Male		26-35				
210		Male		26-35				
211		Male					56 & older	
212		Male		26-35				
213		Male				46-55		
214		Male					56 & older	
215		Male				46-55		
216		Male			36-45			
217		Male		26-35				
218		Male			36-45			
219		Male		26-35				
220		Male					56 & older	
221		Male				46-55		
222	Female				36-45			
223	Female			26-35				
224		Male				46-55		
225		Male	18-25					
226		Male				46-55		
227		Male			36-45			
228		Male				46-55		
229		Male				46-55		
230		Male				46-55		
231		Male			36-45			
232	Female					46-55		
233	Female				36-45			
234	Female					46-55		
235	Female					46-55		
236		Male				46-55		
237		Male				46-55		
238		Male			36-45			
239		Male				46-55		
240		Male			36-45			
241		Male	18-25					
242	Female				36-45			
243		Male		26-35				

		Question #1			
		What year is the snowmobile you typically ride?			
Participant		1991-1995	1996-2000	2001-2005	2006-2010
1		1991-1995			
2					2006-2010
3				2001-2005	
4			1996-2000		
5			1996-2000		
6			1996-2000		
7				2001-2005	
8					2006-2010
9					2006-2010
10					2006-2010
11					2006-2010
12				2001-2005	
13					2006-2010
14			1996-2000		
15					2006-2010
16				2001-2005	
17					2006-2010
18					2006-2010
19			1996-2000		
20					2006-2010
21					2006-2010
22					2006-2010
23				2001-2005	
24					2006-2010
25					2006-2010
26				2001-2005	
27				2001-2005	
28				2001-2005	
29					2006-2010
30					2006-2010
31				2001-2005	
32					2006-2010
33					2006-2010
34			1996-2000		
35				2001-2005	
36					2006-2010
37				2001-2005	

38					2006-2010
39					2006-2010
40			1996-2000		
41					2006-2010
42					2006-2010
43				2001-2005	
44			1996-2000		
45			1996-2000		
46					2006-2010
47			1996-2000		
48				2001-2005	
49			1996-2000		
50			1996-2000		
51			1996-2000		
52					2006-2010
53					2006-2010
54			1996-2000		
55				2001-2005	
56					2006-2010
57					2006-2010
58				2001-2005	
59				2001-2005	
60				2001-2005	
61				2001-2005	
62			1996-2000		
63					2006-2010
64			1996-2000		
65				2001-2005	
66					2006-2010
67					2006-2010
68					2006-2010
69					2006-2010
70					2006-2010
71				2001-2005	
72					2006-2010
73					2006-2010
74				2001-2005	
75		1991-1995			
76				2001-2005	
77					2006-2010
78					2006-2010
79			1996-2000		
80					2006-2010

81				2001-2005	
82					2006-2010
83					2006-2010
84					2006-2010
85					2006-2010
86					2006-2010
87					2006-2010
88				2001-2005	
89					2006-2010
90					2006-2010
91				2001-2005	
92				2001-2005	
93				2001-2005	
94					2006-2010
95					2006-2010
96			1996-2000		
97					2006-2010
98					2006-2010
99			1996-2000		
100					2006-2010
101					2006-2010
102					2006-2010
103					2006-2010
104					2006-2010
105					2006-2010
106		1991-1995			
107			1996-2000		
108					2006-2010
109			1996-2000		
110					2006-2010
111					2006-2010
112					2006-2010
113				2001-2005	
114					2006-2010
115					2006-2010
116					2006-2010
117					2006-2010
118					2006-2010
119				2001-2005	
120				2001-2005	

121				2001-2005	
122		1991-1995			
123				2001-2005	
124					2006-2010
125					2006-2010
126					2006-2010
127					2006-2010
128				2001-2005	
129					2006-2010
130					2006-2010
131					2006-2010
132				2001-2005	
133					2006-2010
134					2006-2010
135			1996-2000		
136				2001-2005	
137					2006-2010
138				2001-2005	
139		1991-1995			
140					2006-2010
141					2006-2010
142					2006-2010
143					2006-2010
144					2006-2010
145			1996-2000		
146					2006-2010
147					2006-2010
148					2006-2010
149					2006-2010
150					2006-2010
151					2006-2010
152					2006-2010
153					2006-2010
154				2001-2005	
155				2001-2005	
156					2006-2010
157					2006-2010
158					2006-2010
159				2001-2005	
160					2006-2010

161					2006-2010
162					2006-2010
163					2006-2010
164				2001-2005	
165					2006-2010
166				2001-2005	
167					2006-2010
168				2001-2005	
169					2006-2010
170				2001-2005	
171					2006-2010
172				2001-2005	
173				2001-2005	
174			1996-2000		
175					2006-2010
176				2001-2005	
177		1991-1995			
178					2006-2010
179			1996-2000		
180					2006-2010
181				2001-2005	
182					2006-2010
183					2006-2010
184			1996-2000		
185					2006-2010
186				2001-2005	
187			1996-2000		
188				2001-2005	
189			1996-2000		
190					2006-2010
191				2001-2005	
192				2001-2005	
193					2006-2010
194				2001-2005	
195					2006-2010
196					2006-2010
197				2001-2005	
198					2006-2010
199					2006-2010
200					2006-2010

201			1996-2000		
202					2006-2010
203		1991-1995			
204					2006-2010
205					2006-2010
206					2006-2010
207					2006-2010
208		1991-1995			
209		1991-1995			
210				2001-2005	
211				2001-2005	
212				2001-2005	
213					2006-2010
214					2006-2010
215				2001-2005	
216					2006-2010
217					2006-2010
218					2006-2010
219					2006-2010
220			1996-2000		
221					2006-2010
222					2006-2010
223					2006-2010
224					2006-2010
225				2001-2005	
226				2001-2005	
227				2001-2005	
228				2001-2005	
229					2006-2010
230			1996-2000		
231					2006-2010
232				2001-2005	
233				2001-2005	
234				2001-2005	
235			1996-2000		
236				2001-2005	
237			1996-2000		
238				2001-2005	
239				2001-2005	
240					2006-2010

241				2006-2010
242		1996-2000		
243				2006-2010

	Question #2		
	How long is the track length on the snowmobile you most often ride?		
Participant	short	medium	long
1	short		
2			long
3		medium	
4		medium	
5		medium	
6	short		
7	short		
8	short		
9	short		
10			long
11	short		
12	short		
13		medium	
14	short		
15		medium	
16		medium	
17		medium	
18		medium	
19	short		
20			long
21			long
22			long
23			long
24			long
25			long
26	short		
27	short		
28	short		
29			long
30			long
31	short		
32	short		

33	short		
34	short		
35		medium	
36			long
37	short		
38	short		
39	short		
40	short		
41		medium	
42	short		
43	short		
44		medium	
45	short		
46	short		
47	short		
48	short		
49	short		
50	short		
51	short		
52			long
53			long
54		medium	
55	short		
56		medium	
57		medium	
58	short		
59			long
60	short		
61	short		
62	short		
63		medium	
64	short		
65			long
66			long
67		medium	
68		medium	
69	short		
70	short		
71		medium	
72			long

73			long
74	short		
75	short		
76	short		
77			long
78		medium	
79	short		
80	short		
81	short		
82		medium	
83		medium	
84			long
85		medium	
86	short		
87			long
88		medium	
89			long
90		medium	
91	short		
92			long
93			long
94			long
95	short		
96	short		
97		medium	
98	short		
99	short		
100			long
101	short		
102			long
103		medium	
104	short		
105	short		
106	short		
107	short		
108			long
109	short		
110	short		
111	short		
112	short		

113			medium	
114			medium	
115		short		
116		short		
117				long
118		short		
119			medium	
120		short		
121				long
122			medium	
123		short		
124			medium	
125		short		
126				long
127			medium	
128			medium	
129		short		
130				long
131				long
132			medium	
133				long
134				long
135		short		
136			medium	
137		short		
138				long
139		short		
140		short		
141				long
142			medium	
143			medium	
144			medium	
145		short		
146			medium	
147			medium	
148			medium	
149				long
150		short		
151				long
152		short		

153		short		
154		short		
155			medium	
156		short		
157		short		
158			medium	
159		short		
160			medium	
161		short		
162			medium	
163		short		
164		short		
165		short		
166			medium	
167			medium	
168		short		
169			medium	
170			medium	
171		short		
172			medium	
173		short		
174		short		
175				long
176		short		
177		short		
178			medium	
179			medium	
180		short		
181			medium	
182				long
183		short		
184			medium	
185				long
186		short		
187		short		
188		short		
189		short		
190			medium	
191			medium	
192		short		

193	short		
194	short		
195	short		
196	short		
197	short		
198	short		
199	short		
200			long
201		medium	
202		medium	
203		medium	
204		medium	
205		medium	
206	short		
207			long
208	short		
209		medium	
210		medium	
211	short		
212		medium	
213	short		
214		medium	
215	short		
216	short		
217			long
218	short		
219			long
220	short		
221			long
222		medium	
223		medium	
224			long
225	short		
226			long
227	short		
228		medium	
229		medium	
230	short		
231	short		
232	short		

233	short		
234	short		
235	short		
236		medium	
237	short		
238			long
239	short		
240	short		
241			long
242		medium	
243			long

	Question #3			
	What type of trail do you typically ride snowmobile on?			
Participant	**A groomed trail**	**An un-groomed trail**	**Equal riding on both**	**Other**
1		An un-groomed trail		
2			Equal riding on both	
3	A groomed trail			
4			Equal riding on both	
5	A groomed trail			
6			Equal riding on both	
7	A groomed trail			
8	A groomed trail			
9	A groomed trail			
10	A groomed trail			
11	A groomed trail			
12	A groomed trail			
13			Equal riding on both	
14			Equal riding on both	
15			Equal riding on both	
16			Equal riding on both	
17	A groomed trail			
18		An un-groomed trail		
19			Equal riding on both	
20			Equal riding on both	
21			Equal riding on both	
22		An un-groomed trail		

23			An un-groomed trail		
24			An un-groomed trail		
25				Equal riding on both	
26			An un-groomed trail		
27				Equal riding on both	
28				Equal riding on both	
29				Equal riding on both	
30				Equal riding on both	
31		A groomed trail			
32		A groomed trail			
33		A groomed trail			
34		A groomed trail			
35		A groomed trail			
36			An un-groomed trail		
37		A groomed trail			
38		A groomed trail			
39		A groomed trail			
40				Equal riding on both	
41				Equal riding on both	
42				Equal riding on both	
43				Equal riding on both	
44				Equal riding on both	
45				Equal riding on both	
46				Equal riding on both	
47				Equal riding on both	
48				Equal riding on both	
49		A groomed trail			
50				Equal riding on both	
51				Equal riding on both	
52			An un-groomed trail		
53			An un-groomed trail		
54			An un-groomed trail		
55		A groomed trail			
56			An un-groomed trail		
57				Equal riding on both	
58				Equal riding on both	
59			An un-groomed trail		
60				Equal riding on both	
61		A groomed trail			
62				Equal riding on both	
63					Other

64				Equal riding on both	
65			An un-groomed trail		
66					Other
67			An un-groomed trail		
68			An un-groomed trail		
69				Equal riding on both	
70				Equal riding on both	
71					Other
72			An un-groomed trail		
73			An un-groomed trail		
74		A groomed trail			
75			An un-groomed trail		
76			An un-groomed trail		
77				Equal riding on both	
78		A groomed trail			
79			An un-groomed trail		
80			An un-groomed trail		
81		A groomed trail			
82				Equal riding on both	
83				Equal riding on both	
84					Other
85		A groomed trail			
86		A groomed trail			
87				Equal riding on both	
88			An un-groomed trail		
89			An un-groomed trail		
90					Other
91		A groomed trail			
92					Other
93				Equal riding on both	
94		A groomed trail			
95					Other
96		A groomed trail			
97				Equal riding on both	
98				Equal riding on both	
99		A groomed trail			
100			An un-groomed trail		
101			An un-groomed trail		
102			An un-groomed trail		
103				Equal riding on both	

104			An un-groomed trail		
105			An un-groomed trail		
106				Equal riding on both	
107				Equal riding on both	
108		A groomed trail			
109			An un-groomed trail		
110			An un-groomed trail		
111				Equal riding on both	
112				Equal riding on both	
113		A groomed trail			
114			An un-groomed trail		
115				Equal riding on both	
116				Equal riding on both	
117				Equal riding on both	
118			An un-groomed trail		
119			An un-groomed trail		
120		A groomed trail			
121				Equal riding on both	
122		A groomed trail			
123				Equal riding on both	
124		A groomed trail			
125		A groomed trail			
126					Other
127				Equal riding on both	
128		A groomed trail			
129		A groomed trail			
130				Equal riding on both	
131			An un-groomed trail		
132					Other
133			An un-groomed trail		
134			An un-groomed trail		
135				Equal riding on both	
136		A groomed trail			
137				Equal riding on both	
138					Other
139				Equal riding on both	
140				Equal riding on both	
141			An un-groomed trail		
142				Equal riding on both	
143			An un-groomed trail		

144					Other
145		A groomed trail			
146		A groomed trail			
147			An un-groomed trail		
148			An un-groomed trail		
149		A groomed trail			
150		A groomed trail			
151			An un-groomed trail		
152					Other
153		A groomed trail			
154					Other
155			An un-groomed trail		
156		A groomed trail			
157				Equal riding on both	
158		A groomed trail			
159				Equal riding on both	
160				Equal riding on both	
161		A groomed trail			
162		A groomed trail			
163		A groomed trail			
164		A groomed trail			
165				Equal riding on both	
166					Other
167				Equal riding on both	
168		A groomed trail			
169		A groomed trail			
170				Equal riding on both	
171				Equal riding on both	
172				Equal riding on both	
173		A groomed trail			
174				Equal riding on both	
175			An un-groomed trail		
176		A groomed trail			
177				Equal riding on both	
178				Equal riding on both	
179		A groomed trail			
180				Equal riding on both	
181			An un-groomed trail		
182			An un-groomed trail		
183				Equal riding on both	

184			An un-groomed trail		
185				Equal riding on both	
186		A groomed trail			
187				Equal riding on both	
188				Equal riding on both	
189		A groomed trail			
190			An un-groomed trail		
191				Equal riding on both	
192		A groomed trail			
193		A groomed trail			
194		A groomed trail			
195		A groomed trail			
196				Equal riding on both	
197		A groomed trail			
198				Equal riding on both	
199		A groomed trail			
200				Equal riding on both	
201		A groomed trail			
202				Equal riding on both	
203				Equal riding on both	
204				Equal riding on both	
205				Equal riding on both	
206		A groomed trail			
207		A groomed trail			
208				Equal riding on both	
209			An un-groomed trail		
210				Equal riding on both	
211		A groomed trail			
212				Equal riding on both	
213		A groomed trail			
214		A groomed trail			
215		A groomed trail			
216				Equal riding on both	
217					Other
218		A groomed trail			
219					Other
220				Equal riding on both	
221			An un-groomed trail		
222		A groomed trail			
223				Equal riding on both	

224					Other
225			An un-groomed trail		
226					Other
227		A groomed trail			
228			An un-groomed trail		
229				Equal riding on both	
230			An un-groomed trail		
231				Equal riding on both	
232				Equal riding on both	
233			An un-groomed trail		
234				Equal riding on both	
235		A groomed trail			
236				Equal riding on both	
237				Equal riding on both	
238					Other
239			An un-groomed trail		
240				Equal riding on both	
241			An un-groomed trail		
242			An un-groomed trail		
243			An un-groomed trail		

		Question #4				
		If you get sore from riding, where do you usually get sore? (check all that appy)				
Participant		**Neck/shoulders**	**Arms**	**Lower back**	**Legs**	**I do not get sore**
1					Legs	
2			Arms		Legs	
3		Neck/shoulders	Arms			
4			Arms	Lower back		
5				Lower back		
6						I do not get sore
7						I do not get sore
8				Lower back		
9				Lower back		
10		Neck/shoulders		Lower back		
11		Neck/shoulders				
12		Neck/shoulders		Lower back		
13		Neck/shoulders		Lower back		
14		Neck/shoulders				
15		Neck/shoulders				

16			Arms			
17		Neck/shoulders	Arms			
18				Lower back		
19					Legs	
20				Lower back		
21		Neck/shoulders	Arms			
22				Lower back		
23			Arms	Lower back		
24		Neck/shoulders				
25		Neck/shoulders		Lower back		
26						I do not get sore
27		Neck/shoulders		Lower back	Legs	
28						I do not get sore
29		Neck/shoulders	Arms			
30			Arms			
31					Legs	
32			Arms			
33						I do not get sore
34				Lower back		
35				Lower back		
36			Arms		Legs	
37		Neck/shoulders				
38						I do not get sore
39		Neck/shoulders				
40			Arms			
41		Neck/shoulders				
42						I do not get sore
43		Neck/shoulders				
44					Legs	
45		Neck/shoulders		Lower back		
46		Neck/shoulders				
47						I do not get sore
48		Neck/shoulders				
49				Lower back		
50		Neck/shoulders		Lower back		
51				Lower back		
52		Neck/shoulders		Lower back		
53		Neck/shoulders		Lower back		
54					Legs	
55		Neck/shoulders			Legs	

56		Neck/shoulders				
57			Arms		Legs	
58		Neck/shoulders		Lower back		
59			Arms		Legs	
60				Lower back		
61					Legs	
62		Neck/shoulders	Arms	Lower back		
63			Arms	Lower back		
64			Arms			
65				Lower back		
66		Neck/shoulders			Legs	
67		Neck/shoulders		Lower back		
68		Neck/shoulders		Lower back		
69		Neck/shoulders				
70		Neck/shoulders		Lower back		
71		Neck/shoulders				
72		Neck/shoulders				
73		Neck/shoulders				
74				Lower back		
75			Arms	Lower back	Legs	
76				Lower back		
77						I do not get sore
78			Arms			
79				Lower back		
80				Lower back		
81		Neck/shoulders				
82		Neck/shoulders				
83			Arms		Legs	
84		Neck/shoulders	Arms	Lower back	Legs	
85				Lower back		
86				Lower back		
87		Neck/shoulders			Legs	
88		Neck/shoulders	Arms	Lower back	Legs	
89			Arms			
90					Legs	
91				Lower back		
92		Neck/shoulders			Legs	
93				Lower back		
94		Neck/shoulders		Lower back		
95		Neck/shoulders				

96				Lower back		
97		Neck/shoulders				
98						I do not get sore
99						I do not get sore
100						I do not get sore
101		Neck/shoulders		Lower back		
102			Arms			
103		Neck/shoulders	Arms			
104						I do not get sore
105		Neck/shoulders				
106		Neck/shoulders	Arms		Legs	
107			Arms			
108					Legs	
109			Arms	Lower back		
110		Neck/shoulders		Lower back		
111			Arms			
112		Neck/shoulders	Arms	Lower back	Legs	
113						I do not get sore
114		Neck/shoulders	Arms			
115		Neck/shoulders				
116			Arms			
117					Legs	
118		Neck/shoulders		Lower back		
119		Neck/shoulders			Legs	
120		Neck/shoulders				
121		Neck/shoulders				
122					Legs	
123			Arms		Legs	
124		Neck/shoulders	Arms	Lower back	Legs	
125						I do not get sore
126				Lower back	Legs	
127					Legs	
128		Neck/shoulders		Lower back		
129		Neck/shoulders				
130		Neck/shoulders				
131					Legs	
132		Neck/shoulders				
133						I do not get sore
134		Neck/shoulders				
135						I do not get sore

136		Neck/shoulders		Lower back		
137		Neck/shoulders				
138		Neck/shoulders		Lower back		
139		Neck/shoulders				
140		Neck/shoulders				
141			Arms			
142						I do not get sore
143			Arms			
144		Neck/shoulders				
145				Lower back		
146		Neck/shoulders				
147						I do not get sore
148				Lower back		
149			Arms		Legs	
150		Neck/shoulders	Arms			
151		Neck/shoulders				
152						I do not get sore
153		Neck/shoulders	Arms	Lower back		
154		Neck/shoulders		Lower back		
155				Lower back		
156		Neck/shoulders			Legs	
157			Arms			
158						I do not get sore
159		Neck/shoulders		Lower back		
160						I do not get sore
161						I do not get sore
162						I do not get sore
163		Neck/shoulders				
164			Arms			
165						I do not get sore
166		Neck/shoulders		Lower back	Legs	
167		Neck/shoulders	Arms	Lower back	Legs	
168						I do not get sore
169		Neck/shoulders				
170					Legs	
171				Lower back		
172		Neck/shoulders	Arms		Legs	
173		Neck/shoulders		Lower back		
174			Arms			
175						I do not get sore

176		Neck/shoulders				
177		Neck/shoulders				
178			Arms			
179		Neck/shoulders				
180						I do not get sore
181		Neck/shoulders			Legs	
182		Neck/shoulders		Lower back		
183			Arms			
184				Lower back		
185						I do not get sore
186				Lower back		
187			Arms	Lower back	Legs	
188					Legs	
189			Arms			
190			Arms		Legs	
191		Neck/shoulders	Arms			
192						I do not get sore
193						I do not get sore
194						I do not get sore
195		Neck/shoulders				
196						I do not get sore
197					Legs	
198				Lower back		I do not get sore
199						I do not get sore
200		Neck/shoulders		Lower back		
201		Neck/shoulders			Legs	
202		Neck/shoulders	Arms			
203		Neck/shoulders		Lower back		
204		Neck/shoulders				
205					Legs	
206						I do not get sore
207		Neck/shoulders	Arms			
208		Neck/shoulders				
209						I do not get sore
210			Arms	Lower back		
211						I do not get sore
212		Neck/shoulders				
213					Legs	
214		Neck/shoulders		Lower back		
215						I do not get sore

216				Legs	
217				Legs	
218	Neck/shoulders				
219			Lower back		
220	Neck/shoulders				
221				Legs	
222				Legs	
223	Neck/shoulders				
224	Neck/shoulders				
225			Lower back		
226	Neck/shoulders				
227	Neck/shoulders			Legs	
228	Neck/shoulders		Lower back		
229					I do not get sore
230			Lower back		
231			Lower back	Legs	
232		Arms		Legs	
233					I do not get sore
234	Neck/shoulders	Arms			
235	Neck/shoulders	Arms			
236	Neck/shoulders				
237	Neck/shoulders			Legs	
238		Arms	Lower back	Legs	
239	Neck/shoulders		Lower back		
240		Arms			
241	Neck/shoulders		Lower back		
242			Lower back		
243			Lower back		

	Question #5				
	How long does the soreness last?				
	1-3 days	3-5 days	5-7 days	7-10 days	Other
1	1-3 days				
2	1-3 days				
3	1-3 days				
4	1-3 days				
5	1-3 days				
6					Other
7	1-3 days				
8	1-3 days				
9	1-3 days				
10	1-3 days				

11		1-3 days				
12		1-3 days				
13		1-3 days				
14				5-7 days		
15		1-3 days				
16		1-3 days				
17		1-3 days				
18		1-3 days				
19			3-5 days			
20		1-3 days				
21			3-5 days			
22		1-3 days				
23		1-3 days				
24		1-3 days				
25		1-3 days				
26						Other
27		1-3 days				
28						Other
29		1-3 days				
30		1-3 days				
31		1-3 days				
32		1-3 days				
33						Other
34		1-3 days				
35		1-3 days				
36				5-7 days		
37		1-3 days				
38						Other
39		1-3 days				
40		1-3 days				
41		1-3 days				
42						Other
43		1-3 days				
44		1-3 days				
45		1-3 days				
46		1-3 days				
47						Other
48		1-3 days				
49		1-3 days				
50		1-3 days				

51		1-3 days				
52		1-3 days				
53		1-3 days				
54		1-3 days				
55		1-3 days				
56		1-3 days				
57		1-3 days				
58		1-3 days				
59		1-3 days				
60		1-3 days				
61		1-3 days				
62		1-3 days				
63		1-3 days				
64		1-3 days				
65		1-3 days				
66		1-3 days				
67			3-5 days			
68		1-3 days				
69		1-3 days				
70		1-3 days				
71		1-3 days				
72		1-3 days				
73		1-3 days				
74						Other
75		1-3 days				
76		1-3 days				
77		1-3 days				
78		1-3 days				
79		1-3 days				
80		1-3 days				
81		1-3 days				
82		1-3 days				
83		1-3 days				
84		1-3 days				
85		1-3 days				
86		1-3 days				
87		1-3 days				
88		1-3 days				
89		1-3 days				
90		1-3 days				

91						Other
92		1-3 days				
93		1-3 days				
94		1-3 days				
95		1-3 days				
96		1-3 days				
97		1-3 days				
98						Other
99						Other
100						Other
101		1-3 days				
102		1-3 days				
103		1-3 days				
104						Other
105		1-3 days				
106		1-3 days				
107		1-3 days				
108						Other
109		1-3 days				
110		1-3 days				
111		1-3 days				
112		1-3 days				
113						Other
114		1-3 days				
115		1-3 days				
116		1-3 days				
117						Other
118		1-3 days				
119			3-5 days			
120		1-3 days				
121						Other
122		1-3 days				
123		1-3 days				
124			3-5 days			
125						Other
126		1-3 days				
127		1-3 days				
128		1-3 days				
129		1-3 days				
130		1-3 days				

131		1-3 days				
132		1-3 days				
133						Other
134		1-3 days				
135						Other
136		1-3 days				
137		1-3 days				
138		1-3 days				
139		1-3 days				
140		1-3 days				
141		1-3 days				
142						Other
143		1-3 days				
144		1-3 days				
145		1-3 days				
146		1-3 days				
147						Other
148		1-3 days				
149		1-3 days				
150		1-3 days				
151		1-3 days				
152		1-3 days				
153		1-3 days				
154		1-3 days				
155		1-3 days				
156		1-3 days				
157		1-3 days				
158						Other
159		1-3 days				
160						Other
161						Other
162						Other
163		1-3 days				
164		1-3 days				
165						Other
166		1-3 days				
167		1-3 days				
168		1-3 days				
169		1-3 days				
170				5-7 days		

171		1-3 days				
172		1-3 days				
173		1-3 days				
174		1-3 days				
175						Other
176		1-3 days				
177			3-5 days			
178		1-3 days				
179		1-3 days				
180						Other
181		1-3 days				
182		1-3 days				
183		1-3 days				
184		1-3 days				
185						Other
186		1-3 days				
187		1-3 days				
188		1-3 days				
189		1-3 days				
190		1-3 days				
191		1-3 days				
192						Other
193						Other
194		1-3 days				
195		1-3 days				
196		1-3 days				
197		1-3 days				
198		1-3 days				
199		1-3 days				
200		1-3 days				
201		1-3 days				
202		1-3 days				
203		1-3 days				
204		1-3 days				
205		1-3 days				
206						Other
207		1-3 days				
208		1-3 days				
209						Other
210		1-3 days				

211						Other
212		1-3 days				
213		1-3 days				
214		1-3 days				
215						Other
216		1-3 days				
217		1-3 days				
218		1-3 days				
219		1-3 days				
220		1-3 days				
221		1-3 days				
222		1-3 days				
223		1-3 days				
224						Other
225		1-3 days				
226		1-3 days				
227		1-3 days				
228		1-3 days				
229						Other
230		1-3 days				
231		1-3 days				
232		1-3 days				
233						Other
234			3-5 days			
235		1-3 days				
236		1-3 days				
237		1-3 days				
238		1-3 days				
239		1-3 days				
240						Other
241		1-3 days				
242		1-3 days				
243		1-3 days				

	Question #6	
	Do you have any ongoing physical ailments originating from snowmobile riding or a snowmobile injury accident last longer than 6 months?	
	Yes	**No**
1		No
2		No
3		No
4		No
5		No
6		No
7		No
8		No
9	Yes	
10		No
11		No
12	Yes	
13		No
14		No
15		No
16		No
17		No
18		No
19		No
20		No
21		No
22		No
23		No
24		No
25		No
26		No
27		No
28		No
29		No
30		No
31	Yes	
32		No
33		No
34		No
35		No
36		No

37			No
38			No
39			No
40		Yes	
41			No
42			No
43			No
44			No
45			No
46			No
47			No
48			No
49		Yes	
50			No
51			No
52			No
53			No
54			No
55			No
56			No
57			No
58			No
59			No
60			No
61			No
62			No
63			No
64			No
65			No
66			No
67			No
68			No
69			No
70			No
71		Yes	
72			No
73			No
74			No
75		Yes	
76			No

77			No
78			No
79			No
80			No
81		Yes	
82			No
83			No
84			No
85			No
86			No
87			No
88			No
89			No
90			No
91			No
92			No
93			No
94		Yes	
95		Yes	
96			No
97			No
98			No
99			No
100			No
101		Yes	
102			No
103			No
104			No
105			No
106			No
107			No
108		Yes	
109			No
110			No
111			No
112			No
113		Yes	
114			No
115			No
116			No

117			No
118			No
119			No
120			No
121			No
122			No
123			No
124			No
125			No
126			No
127			No
128			No
129			No
130			No
131			No
132			No
133			No
134			No
135			No
136			No
137			No
138			No
139			No
140			No
141			No
142			No
143			No
144			No
145			No
146			No
147			No
148			No
149			No
150			No
151			No
152			No
153			No
154		Yes	
155			No
156			No

157			No
158			No
159			No
160			No
161			No
162			No
163			No
164			No
165			No
166			No
167			No
168			No
169			No
170			No
171			No
172			No
173			No
174			No
175			No
176			No
177		Yes	
178			No
179			No
180			No
181			No
182			No
183			No
184			No
185			No
186			No
187			No
188			No
189			No
190			No
191			No
192			No
193			No
194			No
195			No
196			No

197			No
198			No
199			No
200			No
201			No
202			No
203		Yes	
204			No
205			No
206			No
207			No
208			No
209			No
210			No
211			No
212			No
213			No
214			No
215			No
216			No
217			No
218			No
219			No
220			No
221			No
222			No
223			No
224		Yes	
225		Yes	
226			No
227		Yes	
228			No
229			No
230			No
231			No
232			No
233			No
234			No
235		Yes	
236			No

237		No
238		No
239	Yes	
240		No
241		No
242		No
243		No

	Question #7				
	What type of ongoing physical ailments do you have? (check all that apply)				
	Ongoing low back pain	**Loss of grip strength**	**Ongoing joint pain in the lower body**	**Ongoing joint pain in the upper body**	**Other**
1					Other
2					
3					
4					
5	Ongoing low back pain		Ongoing joint pain in the lower body	Ongoing joint pain in the upper body	
6					
7					Other
8					
9	Ongoing low back pain				
10	Ongoing low back pain	Loss of grip strength	Ongoing joint pain in the lower body	Ongoing joint pain in the upper body	
11	Ongoing low back pain				
12		Loss of grip strength		Ongoing joint pain in the upper body	
13	Ongoing low back pain				
14		Loss of grip strength			
15					
16					
17					
18					
19					
20					
21					
22			Ongoing joint pain in the lower body		

23						
24						
25						
26						
27				Ongoing joint pain in the lower body		
28						
29						
30						Other
31						Other
32						
33						
34						
35		Ongoing low back pain				
36					Ongoing joint pain in the upper body	
37						
38			Loss of grip strength			
39						
40			Loss of grip strength			
41						
42						
43						
44						
45		Ongoing low back pain				
46						
47						
48						
49				Ongoing joint pain in the lower body		
50						
51						
52						
53						
54						
55						
56						
57				Ongoing joint pain in the lower body		
58						Other
59		Ongoing low back pain		Ongoing joint pain in the lower body		
60						Other

61					
62	Ongoing low back pain	Loss of grip strength	Ongoing joint pain in the lower body		
63					
64					
65	Ongoing low back pain				
66					
67					Other
68					
69	Ongoing low back pain				
70					
71					Other
72					
73					
74					
75					Other
76					
77	Ongoing low back pain				
78					
79	Ongoing low back pain				
80					
81	Ongoing low back pain				
82					
83					
84					
85					
86	Ongoing low back pain				
87					
88			Ongoing joint pain in the lower body		
89					
90					
91					
92					
93					
94	Ongoing low back pain		Ongoing joint pain in the lower body		
95	Ongoing low back pain				

96						Other
97					Ongoing joint pain in the upper body	
98						
99						
100						
101		Ongoing low back pain				
102						
103			Loss of grip strength			
104						
105						
106						Other
107						Other
108						Other
109						Other
110						
111						
112						
113		Ongoing low back pain				
114		Ongoing low back pain				
115						
116						
117						
118						
119						
120						
121		Ongoing low back pain				
122			Loss of grip strength			
123						
124		Ongoing low back pain	Loss of grip strength	Ongoing joint pain in the lower body	Ongoing joint pain in the upper body	
125						
126						
127						
128		Ongoing low back pain				
129						
130						
131						
132						
133						

134						Other
135						Other
136						
137						
138						
139						Other
140				Ongoing joint pain in the lower body	Ongoing joint pain in the upper body	
141						
142						
143						
144						
145						
146		Ongoing low back pain				
147						
148		Ongoing low back pain				
149						
150						
151						Other
152						
153						
154		Ongoing low back pain				
155				Ongoing joint pain in the lower body		
156						
157						
158						
159		Ongoing low back pain				
160						
161		Ongoing low back pain				
162						
163						
164						
165						
166						
167						
168						
169						
170						Other
171						

172		Ongoing low back pain		Ongoing joint pain in the lower body		
173			Loss of grip strength			
174						
175						
176						
177						Other
178						
179						
180						Other
181						
182						
183						
184						
185						
186						
187						
188						
189						
190						
191						
192						Other
193						
194				Ongoing joint pain in the lower body		
195						
196						Other
197						
198						
199						
200						
201						
202						
203				Ongoing joint pain in the lower body		Other
204						
205				Ongoing joint pain in the lower body		
206						
207						
208						
209						
210					Ongoing joint pain in the upper body	

211						
212						
213						
214				Ongoing joint pain in the lower body		
215			Loss of grip strength			
216						
217						
218						
219						
220			Loss of grip strength			
221		Ongoing low back pain				
222						
223						
224						Other
225					Ongoing joint pain in the upper body	Other
226						
227				Ongoing joint pain in the lower body		
228						
229						
230		Ongoing low back pain				
231						
232						
233						
234					Ongoing joint pain in the upper body	
235				Ongoing joint pain in the lower body		
236					Ongoing joint pain in the upper body	
237				Ongoing joint pain in the lower body		
238						
239						Other
240						
241						
242						
243						Other

VITA

Graduate College
University of Nevada, Las Vegas

Erica Lynn Heisler

Degrees:

Bachelor of Science, Exercise Science, 2007
Cum Laude
University of North Dakota, Grand Forks

Thesis Title: The Relationship of Snowmobile Year, Track Length, and Riding Terrain to the Occurrence of Musculoskeletal Symptoms in Recreational Snowmobile Drivers.

Thesis Examination Committee:
Chairperson, Dr. Jack Young, Ph.D.
Committee Member, Dr. Richard Tandy, Ph.D.
Committee Member, Dr. Lawrence Golding, Ph.D.
Graduate College Representative, Dr. Daniel McLean, Ph.D.