

Ergonomics evaluation of snowmobiles at yellowstone national park



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During the period of February 17 to February 25, 2000, the National Institute for Occupational Safety and Health conducted an ergonomics evaluation of all personnel at Yellowstone National Park (YNP) who frequently rides on snowmobiles. This was in relation to the request of the National Park Services (NPS) to the Senior Industrial Hygienist from the Occupational Safety and Health Administration (OSHA) to conduct a study based on the continued increase of costs due to work related injuries and illnesses of the Yellowstone National Park's employees, specifically maintenance and rangers, who utilized snowmobiles to patrol and maintain the park.

The YNP, like any other national parks in the United States, is under the jurisdiction of the NPS. During 1999, a large volume of snowmobiles entered the park from the West entrance since it is closer to many of the tourist spots on the park such as restaurants, hotels, and snowmobiles rental stores which consequently supports the winter activities at the park. This large volume of snowmobiles entering the park from the West to the Old Faithful transformed the surface of the road to "bumps" and "moguls" instead of a smooth layer.

This has created a serious concern on the rangers and maintenance personnel who patrol the park since they have developed related work injuries in the form of musculoskeletal disorder of the shoulder, hand, arms, and back. The snowmobile they are using are powered by a two-stroke gasoline type engine, with a banana type seat, a modifiable seat back, wiper, and a steering bar common to a typical motorcycle or bicycle. The gas control (throttle) is located at the right hand side with controlled by lever

type thumb-activated, which is 2.5 in. long and mounted on the grip 4.25 in. long, and 1.

0625 in. in diameter. The angle between the throttle lever and the grip is around 60 degrees. The brake is located at the left hand side with four fingers needed to activate it. The dimensions are the same as of the throttle. Ergonomics Involved Ergonomics is the systematic, interdisciplinary learning of persons and their physical association to their respective environment. It can be further defined as "the methodical design of the equipment, workplace, tool, machine, environment, product and system, taking into concern human's physiological, physical, psychological and biomechanical capabilities.

An Ergonomic design is the relative application of these principles to the proper design of machines, tools, tasks, systems, environments, and jobs for comfortable, safe, efficient human use. The word ergonomics is consequent from the ergos meaning "work", and nomos, which mean "study of" or "natural laws of". The term Human Factors Engineering is often used in the United States (Bridger 2003). The ergonomics involved is the study of the musculoskeletal disorder of the shoulder, arms, hand, and back in relation to the use of the snowmobiles of the employees of the Yellowstone National Park.

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Musculoskeletal disorder refers to the injuries obtained from the stress on the arms, hands, shoulder, and back. These can be associated with the type of work performed such as stereotyped or repetitive movement of the joints,

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lifting, exertions in a forceful and manual manner, work postures that are static or awkward, working in a cold environment, direct contact pressures on the soft tissues and nerves, and exposure to vibration. The risk injuries caused by these factors continuous to increase as the exposure and the intensity becomes prolonged.

Though the personal factors such as age, sex, height, or fitness can influence the effect on the person, proper ergonomic design is an indispensable method to prevent or eliminate further potential injuries. The criteria being used in the evaluation of the snowmobiles used by the employees of the YNP were the features of adjustability and joint angle with reference to the other snowmobiles being used in a Norwegian study to herd reindeer; the force necessary to depress the throttle and brake. The maximum acceleration levels in the study were used as a reference point for comparison for the levels being measured at YNP.

Research Involved The evaluation used involved the measure of the adjustability ranges and dimensions of the major components of the snowmobiles such as the throttle, steering bar, handle grip, and the measurement of the amount of force necessary to depress the part of the throttle. The measurements were eventually compared to those of the snowmobiles used by the Norwegian workers to herd reindeers. The study considered several snowmobiles' type and designed the necessary adjustments and dimensions that can be considered factors to decrease or eliminate the health associated risks in driving snowmobiles.

These are the following methods conducted to determine such: The measurement of the throttle forces was conducted at semi and entirely
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depressed positions using a push-pull force meter (Wagner Model FDV-50). These measurements were made on the three models of the snowmobile: The Trail Touring, Trail 10, and the WideTrak LX. Videotapes and photographs were taken on some of the rangers while positioned on their respective snowmobiles to be able to evaluate and measure the lower and upper extremity of the posture. The rangers, based on the different conditions they were exposed, described different postural adjustments.

Tremor and Coordination tests were also conducted using the CATSYS 6.0 system. These tests were chosen because the secure function of the snowmobiles requires the standard coordination aptitude. The test can measure fatigue depending on the test score on a normal working day, and was comprised of several tests: the rhythmic test (left and right hand pronation, fast and slow); the rhythmic test on the left and right index finger (slow and fast tapping); Hand pronation/ supination at maximum frequency; Finger tap also at maximum frequency; and simple reaction time.

The rhythmic test was conducted using a circular pad, and the participant will eventually "tap" the pad in unison with a metronome beat. The beat would gradually increase in frequency from 1.6 Hz up to 8.1 Hz. The simple reaction time utilized a hand-held switch, which required to be pressed by the thumb in unison again with the sound of the metronome. The tremor tests were used to measure the physical fatigue in relation with the tremor experienced by the forearm, the arms, and hands. The tremor was recorded using a micro accelerometer with two axes implanted in the tilt of a device called tremor pen.

The Vibrotactile Sensitivity Tests was used to eventually verify the effect of the arm-hand vibration being created by snowmobiles on a vibration sensitivity threshold. The consequent instability on the vibrotactile senses can indicate an early sign of vibration-caused injury on the nerves. The device used in measuring such was the Vibrometry system by Bruel and Kjaer Model 96-27. The Whole Body Vibration measured the vertical vibration that the workers felt while riding on the snowmobiles.

The device used to measure such vibration data was the Shock and Vibration Environmental Recorder that comprised of an accelerometer, data readout and storage, digital circuitry, and batteries. The units were securely fastened on a box made of metal and measures the different vibration levels while the employees used their snowmobiles. A medical evaluation was also conducted through interview of each participant on their job, age, years of work, job title, work and non-work related health problems and symptoms.

Findings, Recommendations and Other Significant Points

The results of the various tests administered indicated that 8 out of 18 interviewed maintenance personnel and rangers who currently using snowmobiles on their work have reported symptoms of pain and eventual numbness of the fingers. These indicate that there was an existence of adverse effect on the personnel riding on the snowmobiles. The coordination and tremor tests results indicated that the use of snowmobiles could cause hand fatigue. The vibrotactile tests indicated no signs of significant association between the lifetime use of snowmobiles and its effect on the sensory functions.

Furthermore, the following findings were established: The necessary force to be able to depress the throttle control was appreciable; the current snowmobiles being used features several adjustments mechanism to provide a comfortable seating posture; the snowmobiles does not contain the suspension components required to decrease the level of “jolting” while riding it; the result of the several tests performed were not conclusive but indicative that there were symptoms of muscle fatigue on the hands and arms.

Several conclusions were established with reference to the findings obtained: The YNP could provide a custom-made configured snowmobiles depending on the specifications of the user (height, weight, reach, etc); the throttle control should be re-designed so as to involved the other fingers to decrease the fatigue on the thumb; the diameter of the handle grip should be increased to about 1.5 in.

to lessen the grip forces exerted while riding the snowmobile; the road should be groomed from time to time to decrease jolts and shocks while riding; consider the suspension system of other snowmobile manufacturer so that excessive vibrations could be eliminated; the personnel should be acquainted or familiarized with the cause and symptoms of musculoskeletal disorder to avoid work related stress and injuries; the time the rangers and the maintenance used their snowmobiles should be optimized so that continuous hours of prolonged exposure would be lessened.

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