January 2012

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in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
December, 2012

DEDICATION

This thesis is dedicated to my parents Edward and Dolores Klimkowsky for their unwavering support throughout my educational path. They have always provided support to further my education and sometime a helpful push forward.

ACKNOWLEDGEMENTS

I would like to thank my major professor, Dr. Scotty Dunlap for his guidance and patience throughout this writing process. I would also like to thank my thesis committee members Paul English and William Hicks for their patience and support over this past year in writing and preparing my thesis. Thank you to Rocky Mountain Motorsports for your help in this process. I would like to express my thanks to Dr. Mark Carrico for never giving up on his students and always believing greatness for them. I would like to extend a thank you to my brother, Brett, and all of my friends for the support they have given me while pursuing my educational goals.

ABSTRACT

Throughout the workday many of us feel uncomfortable whether our muscles hurt, or there is a chronic pain from our jobs, and at that point we can ask for ergonomic help. Are there companies in the workplace that do not have the aid of ergonomics? Within the study below, an attempt is made to answer the question, "Can ergonomics be utilized within the power sports repair profession at Rocky Mountain Motorsports?" As a whole, the mechanical repair industry appears to be lacking in ergonomic support. Many of the injuries to the employees could be prevented with the use or intervention of ergonomics.

This study is to evaluate the postures while employees of Rocky Mountain Motorsports perform their daily jobs. This evaluation will identify ergonomics in the areas of lifting, body mechanics, tool design, and the environmental conditions of the work being performed. The employees would also be asked to participate in answering some questions to further evaluate the use of ergonomics.

A couple of the classic methods of ergonomic evaluation will be utilized. These include the NIOSH lifting equation and the NIOSH guide to non-powered hand tools. Humantech® designed a methodology for ergonomic postures and scoring them. A risk associated with the job performed will be done using a Baseline Risk Identification of Ergonomic Factor (BRIEF™), and then scored using the BRIEF Exposure Scoring Technique (BEST™). A score of thirty or more on the BEST will determine that there is at least a high risk of ergonomic related injury, and there is room for ergonomic improvement within the job. Please note that the NIOSH evaluation tools work independently of the Humantech evaluation tools.

The cost of ergonomic related injuries is not just the injury itself, but the cost includes lost talent in which a company may have to obtain a new employee. The new employee cannot perform as proficiently as the injured employee therefore cycle time is increased and production yields diminish. The true cost is higher than originally estimated. However, with the use of ergonomics, these injuries can be avoided, and the cost will be eliminated. The general industry rule regarding ergonomics is that for every one dollar spent on ergonomic related repair, a five dollar return can be realized in the future. How can this rule be possibly? Ergonomics fits the work to the worker instead of making the worker fit to the work. This simple concept will reduce the likelihood of injury and improves cycle time, which means higher production.

Thus, is it possible for ergonomics to be utilized within the power sports repair profession and at Rocky Mountain Motorsports? Will the implementation of ergonomics within the power sports repair profession at Rocky Mountain Motorsports reduce the risk of injury, lower costs related to injury, and benefit this area of the workforce?

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Chapter I

Introduction

With rising insurance and medical costs, companies like Boeing, Goodyear, and Toyota have adopted the use of ergonomics in their workplaces as a way to minimize these costs and decrease lost production time. Injuries occur in all places of employment and many of these injuries have root causes from repetitive motion, poor postures, and other body motions. Ergonomics is the study of how work is performed. Ergonomics can be used at a design stage to reduce injury or can be implemented as a reaction tool to prevent further injuries from occurring (Kohn, 1999). For this research study, an evaluation was performed at Rocky Mountain Motorsports, in Loveland, Colorado.

The question is. Has the use of ergonomics been established within the power sports repair profession? The risk of ergonomic related injury was evaluated using the Humantech®, Baseline Risk Identification of Ergonomic Factor (BRIEF™), and then scored using the BRIEF Exposure Scoring Technique (BEST™) (Appendices B & C). The National Institute of Occupational Safety and Health (NIOSH), lifting equation (Appendix D), and the Guide for Selecting Non-Powered Hand Tools checklist (Appendix E) was used for evaluating lifting, tool design, and use. The ergonomic risks that a power sport repair professional would encounter would be lifting of heavy parts, twisting of the back and neck, ulnar and radial deviation of the hand and wrist. There are many other problematic postures that will be defined in the study. The purpose of the study is to determine if ergonomics can be utilized in the power sports repair profession at Rocky Mountain Motorsports.

Rocky Mountain Motorsports is a power sports retailer. It specializes in the sale, service, and repair of power sport vehicles such as motorcycles, all-terrain vehicles (ATV's), snowmobiles, and personal watercrafts. The repair shop employs four full time repair professionals and has two repair bays which include two motorcycle racks. The repairs that are performed on these vehicles, at Rocky Mountain Motorsports include tire changes, oil changes, engine rebuilding, and service inspections.

One of the devices that is used to aid repairs is a motorcycle rack. It is a lift on which the motorcycle is supported and holds the motorcycle in a vertical position. The racks can elevate the motorcycle to the desire position for the repair professional.

The limitation of this study is that only Rocky Mountain Motorsports and its employees will be providing the research data, therefore, the research will not encompass all of the power sports repair professionals. However, many of the employees have worked at other shops and can provide some additional information about the power sports repair profession. Employees were asked to participate in an interview. The questions asked can be seen in (Appendix A). The content of this study will be published. Also, the data, findings, and recommendations will be provided to the owner of Rocky Mountain Motorsports. The recommendations are not required to be implemented, and no changes to the current process will be required. Can the use of ergonomics be utilized in the power sports repair profession at Rocky Mountain Motorsports?

Chapter II

Literature Review

Ergonomics is the science of fitting workplace conditions and job demands to the capabilities of the employees. Common examples of ergonomic risk factors are found in jobs that require repetitive motions, heavy lifting, awkward postures of the wrists, hands, back, neck, and shoulders. Vibrations, impact stress, and cold temperatures may add to the risk of ergonomic related injury (Health and Safety Topics, Ergonomics, n.d.). Overall, there is a lack of information as it pertains to ergonomic related injury within the power sports repair industry. A reason for this is that there are not a lot of power sports repair professionals in the workplace. From the National Employment Matrix as of 2008, there are only 18,800 motorcycle mechanics nationwide. It is predicted that this number will increase to 20,500 by the year of 2018, an increase of nine percent (U.S. Bureau of Labor Statistics, n.d.). With more power sports repair professionals emerging into the workforce, this will create more ergonomic related injuries occurring in the workplace.

A typical environment for power sports repair professional is a small well lit shop with a concrete floor. The work environment is at times often noisy, and the repair professionals work in cramped and awkward positions (U.S. Bureau of Labor Statistics, n.d.). The awkward positioning occurs more often when the repair professional cannot utilize the motorcycle rack to perform the repair; this would be the case if a repair is being done on a personal watercraft, all terrain vehicle or side by side vehicle. In these instances the repair is generally preformed on the concrete floor increasing the risk of ergonomic related injury.

The reason why there is a lack of information with respect to this industry is that there is a small number of power sports repair professionals. This may be the reason why there is a lack of information as it pertains to their occupation, the study of ergonomics, and injuries. For this reason, sources from like occupations have been utilized for this assessment. Automobile repair professionals use the same tools to repair automobiles as do power sports repair professionals. The two repair professionals perform many of the same repairs; however, the automobile repair is on a larger scale, which is not always a benefit. Automotive repair work consists of long days. Moving around the vehicle and reaching into a cramped engine or electrical compartments may require awkward positions that can lead to ergonomic related sprains and strains. Automobile parts may be heavy, therefore the practice of using proper lifting methods to reduce the likelihood of a back related injury is required (Automobile Repair Services, n.d.).

The ergonomic risk factors that are associated with automobile and power sports repair professionals would include: back and neck related injuries, wrists, hands and upper limb related injuries, legs, knees and feet related injuries. Many times these areas of the human body may not be injured but there may be chronic pain associated with these body parts. From the vibrations of working with pneumatic tools, Raynaud's phenomenon may develop. It is defined as a condition causing numbness, blanching of the fingers, loss of muscular strength, and finger control. Raynaud's phenomenon will occur when vibrations between frequencies 40 and 124 Hertz are encountered. Environments with colder temperatures and chemical presence may aggravate this phenomenon. From the use of tools that are used by automobile and power sports repair professionals, De Quervain's tendinitis and/or trigger finger may also be a result in this profession. De Quervain's tendinitis is the inflammation of the short extensor and long abductor tendons in the thumb. Trigger finger is the inflammation of the tendon sheaths in the finger tendons (Kohn, 1999). One way to minimize the effects of Raynaud's syndrome is the implementation and use of impact gloves or the purchase of new low vibration tools (Small Business Ergonomic Case Studies, n.d.). Hand tools are usually owned by the repair employee. These tools are used every day and are essential to the repair professional. Improvements can be made to these hand tools following the NIOSH guide to non-powered hand tools (U.S. Bureau of Labor Statistics, n.d.).

Low back pain is one of the most recognized ergonomic related injuries associated with repair professionals. This is the result of long hours that the repair professionals stand on concrete floors, lean over into engine compartments, and stoop. Using electromyography (EMG), which is the study of muscular activity, this tool can be used to measure muscle activity. Readings are compared to a participant's actual maximum efforts. While stooping, a muscular activity of twenty eight percent was determined to be the workers maximum low back efforts and up to fifty percent was used when there was no upper body support (Small Business Ergonomic Case Studies, n.d.).

Work related injuries in the vehicle repair field are quite common; most repair professionals will suffer from a low back injury. Most of these lower back injuries are a result from lifting of heavy objects such as wheel and tire assemblies, or five gallon container of oil or other fluids. Repair professionals also have an increased risk of ergonomic related injuries from the repetitiveness of their profession; this repetitiveness is from oil changes or tire replacements for the entire work day (Cadena, 2009). At Rocky Mountain Motorsports, on a typical day, a repair professional will change approximately ten tires. Larger repair shops may perform even more tire changes per day. A typical motorcycle wheel and tire assembly of a front tire weighs twenty five pounds, and a rear tire and wheel assembly weighs thirty five pounds. The wheel and tire assemblies of some manufacturers, for example Harley Davidson, weigh up to seventy pounds. How many people are injured performing this activity? Since there are only approximately 20,000 motorcycle repair professionals, the actual number of injuries maybe unknown? A study of injuries occurring over a one year period among Army light-wheel vehicle mechanics at Fort Bragg, North Carolina was performed. From the medical records of five hundred eighteen males and forty three females the injuries sustained were examined. Males incurred an injury rate of 124 cases per 100 people, and the female injury rate was slightly higher at 156 injuries per 100 people (Knapik, et al., 2006). In males, thirty four percent of these injuries were upper body related; nineteen percent were in the lower back region, and forty six percent were in lower body regions (Knapik, et al., 2006). In the females, twenty four percent of the sustained injuries occurred in the upper body regions; only ten percent of the injuries were to low back region, and sixty two percent of injuries occurred in the lower body regions (Knapik, et al., 2006). Overuse or repetitive motions injuries accounted for forty eight percent of injuries to males and sixty eight percent of injuries to females (Knapik, et al., 2006). With injuries occurring from overuse and repetitive motions, there is room to improve ergonomic conditions for the power sports repair professionals. How much do these injuries cost the companies per year?

All of these injuries come with a cost to the companies and the employees who sustain these injuries. A back, neck, or other related spinal injury will most definitely cost the most to repair or cure. A musculoskeletal disorder (MSD), is an injury that occurs from a repetitive motion of poor ergonomics used during work that is taking place. Over the last ten years, the United States has reported a dramatic increase in MSD's. In 1999, MSD's accounted for sixty six percent of all work related injuries (Marcus, et al., 2002). In 1995, ergonomic related injuries cost the U.S. industry approximately twenty six billion dollars (Lackey & Chambers, 1999). Injuries within the automotive workshops have the highest claim rates in the trade sector. In the 2001-2002 financial year, some four hundred thirty claims were recorded. The injured employee was absent from work for at least ten days, or the occupational medical costs exceeded $466 (Automotive Workshop Safety, 2004). One of the largest factors to ergonomic injury in the repair profession is awkward posture or repetitive strain while using tools. As stated previously, the tools used in the power sport repair profession are identical to those used in the automotive repair profession. Repair professionals will have a good chance of ergonomic body stressing injury over the duration of their forty year career. On average, one in every fourteen claims is a serious injury with each of these claims costing an average of $40,500 (Automotive Workshop Safety, 2004). An injury to an employee's back will cost $64,000 before the repair professional can return to work (Automotive Workshop Safety, 2004). The average cost for ergonomic related sprains and strains is over $50,000 (Automotive Workshop Safety, 2004). Injury claims of this size would be large enough to put some companies out of business. In the case of Rocky Mountain Motorsports, just two claims of $64,000 would be quite harmful to the business, and could be enough to put other small companies out of business. The owner of Rocky Mountain Motorsports claims, that for every day he misses work do to an injury, he loses five hundred dollars worth of profit. This figure does not include the occupational medical costs, the cost of recovery time, which is defined as performing his job at less than one hundred percent capacity. The implementation of ergonomics can reduce the costs that a company pays for occupational medicine and insurance.

The implementation of ergonomic practices can do more than just reduce ergonomic related injuries and the costs of these injuries. Ergonomics can increase production and save money in other places. Humantech is a company that works with other companies to incorporate ergonomic designs into their processes. They have also developed methodologies to identify and evaluate ergonomic risks. Humantech provided an ergonomic process re-design of a motorcycle fender finishing operation at the Honda motorcycle plant in Marysville, Ohio. Before the re-design, the operator would have to reach forward twenty eight inches creating awkward upper body posture. There was an average of twenty four lifts of a twelve pound part per cycle time; the cycle time was thirty minutes. After the re-design the operator would only have to reach fifteen inches, and the lifting was eliminated. Thus the cycle time was reduced to fifteen minutes. Honda estimates that with this one ergonomic re-design, the company saves $500,000 per year for reduced cycle time, and an eighty three percent reduction in material that went to scrap along with the avoidance of occupational injury (Honda Case Study, n.d.).

From the information and examples above, Rocky Mountain Motorsports would be a prime company to evaluate ergonomics as it pertains to power sports repair professionals. Many of the same postures are identified as ergonomic risks in the similar automotive repair professions. These postures may result in MSD's over time. An ergonomic evaluation for Rocky Mountain Motorsports would include evaluating ergonomic postures, lifting and carrying parts such as wheel and tire assemblies, and an evaluation of the tools used in this profession. As a general rule, in the ergonomics profession, every one dollar spent on ergonomics can result in a five dollar return. The use of ergonomics not only can prevent occupational injuries from occurring, but can create a better process and allow the business to be more profitable.

Chapter III

Theoretical Framework

Using the data presented in the literature review section, an estimate can be made regarding ergonomic related injuries that occur in the power sport repair profession. As a baseline, in 2008, there were only 18,800 motorcycle mechanics. By 2018, the quantity is projected to be 20,500 motorcycle mechanics, which is an increase of 1,600 mechanics into the repair profession. Therefore, the projected number of motorcycle mechanics in the current day would be close to 19,440 (U.S. Bureau of Labor Statistics, n.d.). This is an increase of one hundred sixty motorcycle mechanics per year. This data and the injury data from the survey performed in Fort Bragg, North Carolina, ergonomics related injuries can be estimated.

In light wheeled vehicle mechanics, approximately 2.7 percent of the population sustained muscular skeletal injuries while performing repair work (Knapik, et al., 2006). Therefore, using and applying this data to the power sports repair professionals, of the 19,440 there will be approximately 525 ergonomic related injuries that may occur in 2012. Of the 525 injuries that are projected to occur in the power sports repair profession, 78.8 employees may develop lower back related injuries; 152.3 employees may develop upper body related injuries; 283.5 employees may develop lower body related injuries, and the remaining 10.4 employees may develop injuries in other areas. These projected injuries can be viewed in Figure 1.

These injuries that may occur in the power sports repair profession because there is a lack of ergonomics used in the repair industry as the literature review demonstrates. Another area in which power sports repair professionals may sustain injuries is from lifting objects such as wheel and tire assemblies and other heavy parts. As seen in Figure 1, below. Fifteen percent of the injuries occur in the lower back. Twenty nine percent of the injuries occur in the upper body regions which includes shoulder, hands, wrists, and neck in which all of the injuries could occur from lifting tasks. The lower body regions are responsible for the majority of injuries, weighing in at fifty four percent. One area of concern with this high percentage of injuries may be that the repair work is performed on concrete floors for a long duration of the workday for repair professionals. Simple ergonomic equipment could be implemented to potentially reduce this large amount of injuries to the lower body regions.

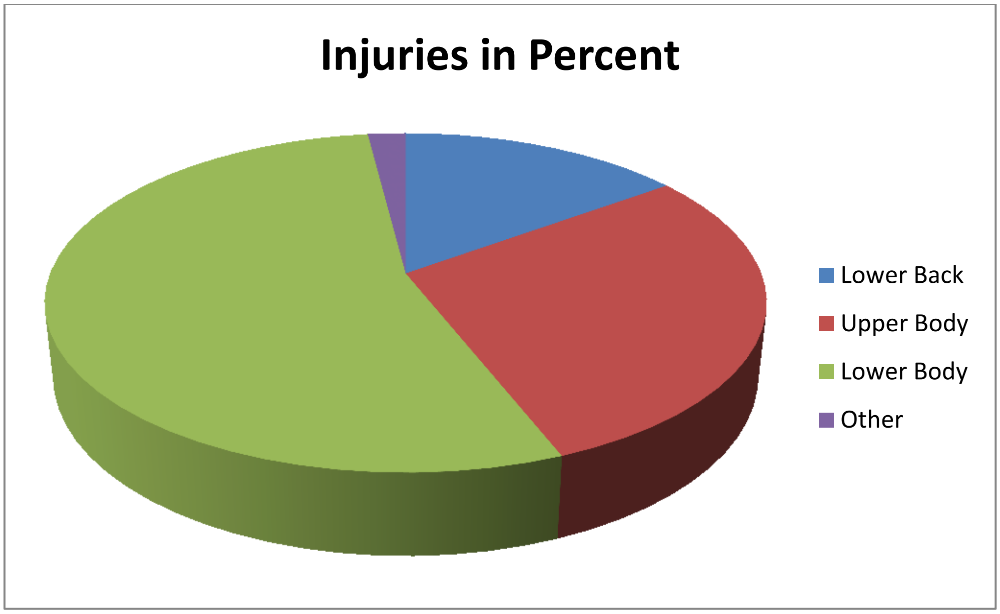

Figure 1, Projected Injuries: Includes the projected injuries that will occur in power sports repair professionals in 2012, these injuries are displayed by percentage of injuries.

The lifting of a Harley Davidson wheel and tire assembly that weighs seventy pounds and is above the NIOSH recommended weight for any one person lift. The NIOSH lifting equations weight is limited to fifty one pounds at a maximum in optimal lifting postures. Therefore, at Rocky Mountain Motorsports, if a person is lifting this wheel and tire assembly there is a demonstrated risk of ergonomic related injury. The NIOSH lifting equation will be able to examine how the metric wheel and tire assembly lifts, rate as they pertain to ergonomics of lifting within Rocky Mountain Motorsports. The power sports repair professional lifts wheel and tire assemblies that weigh twenty five and thirty five pounds. For a twenty five pound wheel and tire assembly, each of these lifts, when considered as just one lift, is being above the NIOSH lifting equation limits, scoring 1.11 on the single task lifting index (STLI). Using a thirty five pounds wheel and tire assembly the STLI is 1.59, seen in Table 1. Since Rocky Mountain Motorsports performs approximately ten tire changes per day, a composite lifting index (CLI) might score a 1.74. The NIOSH lifting equation considers any lift index score above one to have injury potential (NIOSH Lifting Equation, n.d.).

From the speculated lifting index of just the tire changes at Rocky Mountain Motorsports it can be seen there is room for improvement in lifting applications. For any CLI calculated to be above one,

Table 1, Wheel and Tire Lifting Index: STLI scores for the front and rear wheel and tire assemblies of a metric motorcycle, a metric motorcycle is a non American produced motorcycle i.e. Honda and or Yamaha.

Wheel & Tire Assemblies	**Weight**	**Single Task Lifting Index**
Front Wheel (metric)	**25 Pounds**	**1.11**
Rear Wheel (metric)	**35 Pounds**	**1.59**

NIOSH recommends that either engineering or administrative controls be utilized to reduce the potential for injury. An ergonomic assessment of Rocky Mountain Motorsports would be able to identify areas that could be improved through the use of ergonomics. The implementation of ergonomics will reduce the likelihood of an employee sustaining an injury from lifting or repetitive motion.

The data in Table 1 and Figure 1 demonstrates that the power sports repair profession may be one area of the workforce that could benefit from the use of ergonomics to reduce injuries. In Figure 2, the injuries sustained to the back and the upper body regions are linked to the lifting performed by power sport repair professionals. This link will provide the root cause of back and upper body related injuries. Performing an ergonomic assessment at Rocky Mountain Motorsports has allowed for the examination of the processes used by power sports repair professionals.

Beside the use of the BRIEF evaluation, the BEST scoring technique, and the NIOSH lifting equation, there are other identifiers of poor ergonomics that could be used in assessing ergonomics at Rocky Mountain Motorsports. These include the NIOSH guide to selecting non-powered hand tools; this guide will provide a guideline for tools that power sport repair professionals use on a daily basis. The diameter of the tools handles and the lengths of the handles have the potential for causing injury to employees. The Snook push pull and carry tables examine and score the amount of force used to push a motorcycle or ATV and how much weight can be carried from one point to another point to reduce injury (Snook & Ciriello, n.d.). Ultimately injuries reduce the profit margins at Rocky Mountain Motorsports. The evaluation and implementation of ergonomics and ergonomic design will reduce the potential of injuries sustained within the power sport repair profession at Rocky Mountain Motorsports.

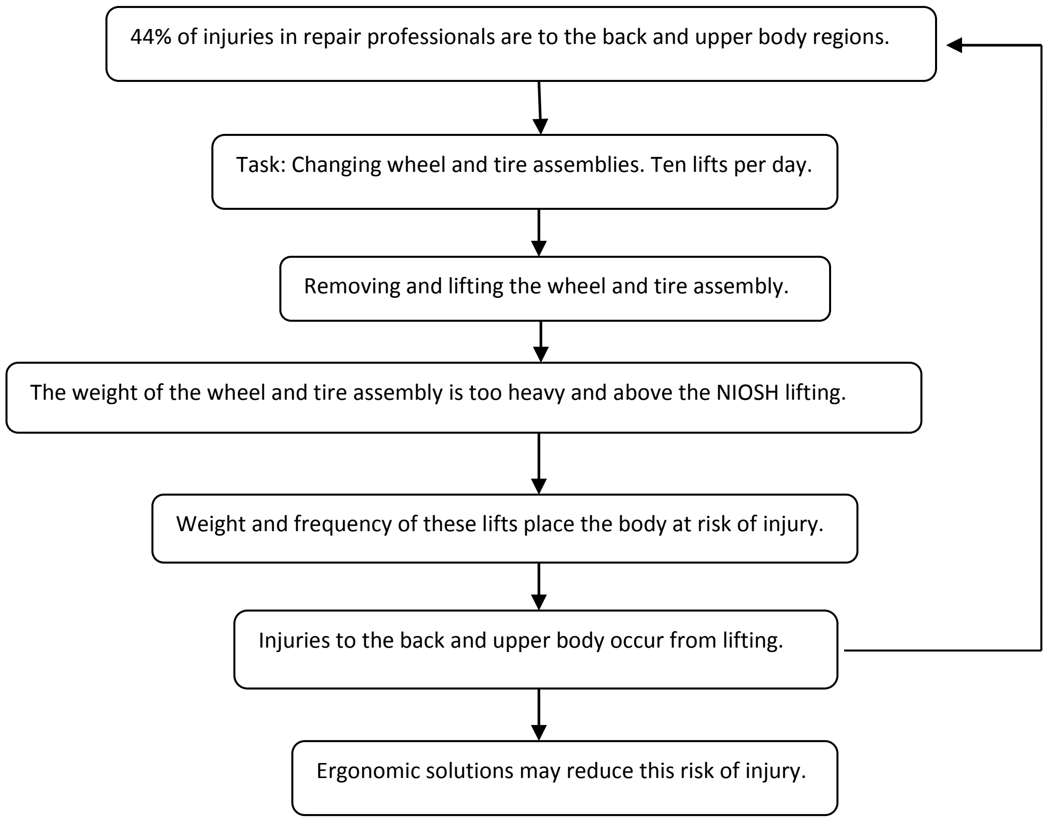

Figure 2, Injury Flowchart: In the table below the flow of tasks as they relate to injuries that occur linking Table 1 and Figure 1 together.

Chapter IV

Research Design

In order to evaluate the need for ergonomics at Rocky Mountain Motorsports, the evaluator had spent one day viewing how the power sports repair professionals perform their work. The evaluation examined the postures, the lifts, and the tools used by the employees at Rocky Mountain Motorsports to perform their daily jobs. Three of the four employees were asked to participate in answering some interview questions while the evaluation is being conducted. The evaluator interacted with the employees. The evaluation tools can be viewed in the appendices located at the end of this document.

The questions the evaluator used can be found in (Appendix A). The answers to these questions have remained anonymous. To develop a need for ergonomics there is no need to indentify who needs ergonomics, but whether the power sports repair profession can utilize ergonomics. In order for responses provided to remain anonymous, the evaluator did not require a name and will be the only one to view the answers provided. Once the data has been obtained from the interview questions, the original interview surveys were destroyed. The questions used have provided a baseline to the evaluator, as if there are injuries or fatigue from work being performed. Are there lifting operations that may result in ergonomic related injury? How many hours worked will be used to determine the BEST score and provide an ergonomic risk. The evaluator will determine tool use and vibration from the questions asked. The answers will be also be used later in the evaluation. Question fourteen, asks for the input of the employees and is one of the most important questions. This allows for the repair employee to add their ideas, suggestion and improvements. This is important because nobody knows the job better than the employees performing the job.

During the observation of the power sports repair professionals, the BRIEF survey shall be used to identify how employees perform their job. This has defined where negative ergonomic postures are used, the frequency, the duration, and the force used while applying these postures. Once all of the postures are observed, the BRIEF has been marked where postures, durations, and frequencies have been identified. Scores are then applied to each area of the body to determining the risk. Physical stressors are also identified in the BRIEF survey; these include vibration, low temperatures, soft tissue compression, impact stress, and glove issues (Applied Industrial Ergonomics, 2008). Please view the BRIEF survey located in (Appendix B) for details of what postures, frequencies, durations, and forces are recorded.

The BRIEF Exposure Scoring Technique or (BEST), which can be seen in (Appendix C) is then used to calculate the BRIEF score into a job hazard rating. The BEST coverts the BRIEF score, adds physical stressors, and a time exposure multiplier to ultimately create an ergonomic job hazard score. A score found to be thirty or above has been identified to pose a high ergonomic related risk, and solutions need to be implemented to lower this risk. The time exposure multiplier is not exactly how many hours the power sports repair professional works, but rather the amount of time the repair professional is performing tasks that could place him or her at risk of injury. For example, taking an ATV out for a test drive would not apply to the time multiplier. The scores are then converted to priorities; these priorities are developed bases on scores. A very high risk would have a score of fifty or above. A high risk would have a score of thirty or above. A medium risk would have a score of ten or above, and a low risk would have a score of less than ten. Thus, a very high score is the worst and a low score is the best priority (Applied Industrial Ergonomics, 2008). Furthermore these scores are color coded, very high is maroon, high is red, medium is yellow and low is green.

As stated above the power sports repair professional will have to lift wheels and tire assemblies. While observing their workday, the evaluator may witness lifts of engines and other heavy objects. Many places have a set weight restriction on lifting, however, no one weight limit will ensure injuries will not occur. The NIOSH lifting equation is a process that measures postures, distances, and the weight of an object. The use of multipliers provides a recommended weight that can be safely lifted (NIOSH Lifting Equation, n.d.). The NIOSH lifting equation as with other ergonomic tools will examine the duration and frequency of the lifts being performed. In cases where multiple lifts of differing weights may occur, NIOSH has a Composite Lifting Index (CLI) which will account for all the different weights and create a CLI score. Additional multipliers include asymmetry angle which is the twisting of back or spinal column while lifting, and the coupling which is defined as the lifting point where the human hands initiate the lift. The limit for the NIOSH lifting equation is fifty one pounds. At a weight of fifty one pounds, all multipliers must be at the lowest risk rating. The score will be calculated as a Lifting Index (LI). Any score of one and above will allow room for ergonomic improvements. The Recommended Weight Limit

(RWL) will define the weight in pounds that can be safely lifted with all of the multipliers used in the equation. An example of this NIOSH lifting equation can be seen in (Appendix D).

In order to perform the repairs to power sport vehicles, many common tools such as wrenches, pliers, sockets, and screwdrivers are utilized. The design of the tools used is another area in which ergonomics may have been overlooked in the power sports repair profession. NIOSH has developed a guide to aid in the selection of non-powered hand tools; this can be performed by the simple use of a checklist seen in (Appendix E). The NIOSH guide to selecting non-powered hand tools can be utilized to aid power sports repair professionals in the purchase of new tools by providing a baseline of what to look for (Hight et al., 2004). For example, the use of a standard set of box end wrenches has a small area where force is applied to loosen or tighten nuts and bolts, placing contact pressure on the fingers which may lead to ergonomic related injuries. A 7/8 inch box end wrench is ¼" X ¾" X 12 inches long. The area of the wrench where the force is applied is only ¼ inch wide. Following the checklist in (Appendix E), the 7/8 inch wrench would be categorized under section one as a single task tool used for a power task in which the handle design should be between one and one quarter inches and two inches in diameter (Hight et al., 2004). Pneumatic tools and other power tools such as impact hammers and impact drivers have been evaluated using the physical stressors section of the BRIEF survey looking for vibration and impact stress.

The evaluator used these methodologies as described above to determine the risk of ergonomic injury. However, it must be noted that all of the evaluation methods used above, with the exception of the BRIEF and BEST are independent of each other. If the lifting of an object is found to potentially to cause injury, and this lift has now been corrected, this correction will not necessarily lower the risk score of the BEST. Once a score of high or very high has been developed, it is recommended that ergonomic solution be implemented to correct ergonomic risk.

Chapter V

Research and Findings

On October 6, 2012, I met with the employees of Rocky Mountain Motorsports to perform the proposed research. Upon starting the research, I provided employees with an overview of what I was doing and the reason for the research. On this particular day, four employees were working. There was one employee working the sales counter and three were power sports repair professionals. The power sports repair professionals are the employees on which I based the ergonomics assessment.

Both motorcycle racks were being utilized during the time I performed the evaluation. One of the employees was being trained in power sports repair during this time. He was teamed up with another repair professional. I observed all three repair professionals while they performed repairs and services to motorcycles throughout the day. The postures identified were added to the same BRIEF and then converted to one BEST score to place ergonomic risk to the profession of power sports repair. The NIOSH lifting equation and guide to non-powered hand tools are separate from the Humantech BRIEF and BEST surveys.

The ergonomic postures observed during the repair and service work that took place on the day of the research were found to be a high risk of ergonomic injury according the BEST score of thirty seven, seen in (Appendix F). A BEST score of a thirty seven is just slightly high but does leave room for ergonomic improvement. The BRIEF methodology works like this: once negative postures are identified they are marked at times the posture can be right or left or both. Once the posture is marked, the force, frequency, and/or duration can be marked, creating a potential total score for each posture of four. A score of three to four is a high BRIEF risk. A score of two is a medium BRIEF risk, and a zero to one is a low BRIEF risk. Later these BRIEF scores are converted using the BEST to provide the ergonomic risk. The posture of the wrists and hands observed were ulnar and radial deviation with extensions greater than forty five degrees on both the left and right. A force of two pounds either from a pinch grip or finger press was observed on both the left and right as well. These postures of the wrist and hands were held for more than ten seconds adding the duration to be marked. This wrist and hand posture for the left and the right side was found to have a high BRIEF risk. The observations came from twisting and threading fasteners.

The posture of the elbows was observed as being rotated and extended fully open on both the left and right arms. The rotated arm was derived from the use of screwdrivers and other tools. The full extension of the elbow happens when the repair professional reached to access parts of the motorcycle. A force of greater than ten pounds was noted to applying force to be marked. The BRIEF risk for the right and left elbows was found to be medium. Also scoring in the medium risk was the posture of the shoulders. Observed on the left and the right side was the arm raised more than forty five degrees from the bodies core. While the shoulders were in this position a force of greater than ten pounds was observed. This posture came for lifting wheel and tire assembles.

The neck posture was observed being flexed forward at an angle of thirty degrees or more and for a duration of more than ten seconds. While a force of greater than two pounds was not observed, the neck posture was the only posture marked for frequency. The frequency is marked when the posture is observed more than two times per minute. This occurred when looking down at items that needed inspection, searching for tools on a lower shelf, and working with the wheel and tire changes. The neck posture received a BRIEF score of a three, placing this posture at a high ergonomic risk. Also, in this high risk position, the postures of the back were identified as being flexed forward at an angle of twenty degrees or greater and a sideway posture. The sideways twisting of the back was identified when the repair professional was securing the motorcycle to the rack. These postures were observed for greater than ten seconds in duration, therefore marking the duration. Do to the weight being handled while the posture was observed, a force of greater than twenty five pounds was marked creating a BRIEF score of three. The high ergonomic risk of the back postures was derived from performing wheel and tire changes. In Figure 3, below, the posture of a repair professional can be seen. Note the back is flexed forward at an angle greater than twenty degrees; the arms are more than forty five degree away from the body core, and the soft tissue compression occurs where the repair professional is manipulating the tire with his elbows.

The last posture observed was the legs. Squatting at more than a forty five degree angle and kneeling was observed. However force, frequency, and duration were not seen in these postures creating a BRIEF score of one which carries a low ergonomic risk. The physical stressors observed were soft tissue compression and impact stress. Soft tissue compression is when part of the body is compressed against a stationary object for a period of time. While repairs were being performed, the repair professional would

Figure 3, Tire Machine Posture: A repair professional is replacing a tube on a metric motorcycle wheel and tire assembly.

leverage their arm on the motorcycle rack creating this compression. The impact stress was observed when the repair professional used his hand like a hammer to hit the end of a wrench to break the bolts loose. Each of these physical stressors will be marked and added in the BEST survey. The completed BRIEF can be seen in (Appendix G). This will contain detailed information described in the above text as to the postures that were identified on the day of the research.

While applying the NIOSH lifting equation, I observed two American wheel and tire assemblies being changed. These weigh around seventy pounds and it exceeds the recommended lift for one person. However, the carry has been eliminated because the repair professional roll the entire wheel and tire assemblies across the shop to the tire machine. Throughout the rest of the day, two metric front tire changes and one metric rear tire change was performed. The front metric wheel and tire assemblies weigh approximately twenty five pounds and the rear wheel and tire assembly weighs thirty five pounds. Using the composite lifting equation seen in (Appendix H), six entries are noted. This is because wheel and tire assembly had two lifts associated with it, one from the motorcycle onto the tire machine, and one from the tire machine back onto the motorcycle. Any lifting index (LI) found to be over one does contain potential risk of injury. The composite lift index (CLI) for the three wheel and tire assemblies changes that were observed had a CLI of 1.13; just slightly elevated. Lifts 1, 3, and 5 were from the motorcycle to the tire machine. All of these lift were under the lifting index of 1. Lifts, 2, 4, and 6 were from the tire machine back to the motorcycle, and a problem was noted here. A fifteen degree angle of asymmetry of the back was observed while transitioning the wheel and tire assembly back to the motorcycle. The elimination of this asymmetry angle would reduce the CLI to 1.08 still a bit high, but this would create a LI for independent lifts all under one.

The NIOSH guide to selecting non-powered hand tools was used to evaluate the tools used by the power sport repair professionals while they performed the work tasks. Tools observed were box ends wrenches, hammers, ratchets, pliers, and pry bars. The tools that I viewed seem to be for the most part in compliance with the NIOSH guide to selecting non-powered hand tools, however there were some exception. The box end wrenches all seemed to have a small area where force is applied to loosen or tighten nuts and bolts, thus placing contact pressure on the fingers which may lead to trigger finger. For example, a 7/8" inch box end wrench measures ¼" X ¾" X 12 inches long. The area of the wrench where the force is applied is only ¼ inch wide. An example of these wrenches can be seen below in Figure 4.

Pry bars are located on the tire machine. The repair professionals use this pry bar to pry the tire bead off the rim of the wheel. The pry bar was made of steel and was 1-1/4"X ¼"X14 inches long. The repair professionals did not use pneumatic or powered tools because of the delicate items they repair most of the time. However, on occasion, powered tools are used and therefore no vibration was observed or noted.

Performing the interviews provided some insight into other areas of concern. One area that creates

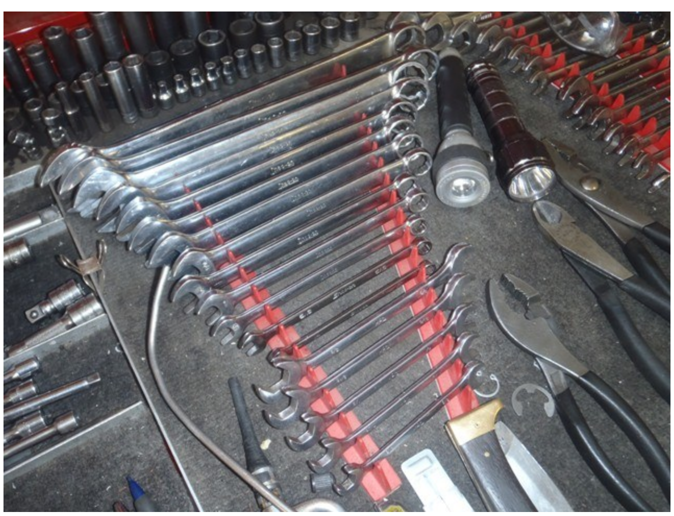

Figure 4, Tools: Standard box end wrenches used on a daily bases where force is applied on the narrow part of the wrench, placing soft tissue compression onto the palm and or fingers of the hand.

ergonomic concerns in the vibration put out by powered tools. At Rocky Mountain Motorsports power tools that create vibrations are rarely used. The reason given was that power tools tend to break things. Previous injuries from the job are varied. However, in most cases a smashed finger or something less severe has occurred. The major complaint was sore or tired feet at the end of the day. All of the repair professionals said the worst part of the job is when they have to work on the ground. However, overall the morale seemed high as everyone liked the profession they have chosen.

The information from the literature review and findings from the observations alludes that there are ergonomic related risks associated in the profession of power sports repair. As workers in any industry age, the risk of ergonomic problems becomes more likely to occur. Additionally the environment in which work is performed may add to the risk of ergonomic injury. The cold of winter or the heat of summer creates other concerns that may add to risk of injury.

Chapter VI

Discussion

As an outcome of the research performed within the above study, it has been determined that there is a risk of ergonomic injury within the power sports repair profession as well as at Rocky Mountain Motorsports. Can ergonomics be utilized in the power sports repair profession at Rocky Mountain Motorsports? Yes, ergonomics can be utilized within the power sport repair profession at Rocky Mountain Motorsports. While the BRIEF survey identified there was a high risk for injury, the lifting of motorcycle tire and wheel assemblies confirms the risk associated with performing this job. I have identified some areas of improvement that will in fact reduce the likelihood of ergonomic related injury.

One of the main factors in ergonomic risk was the height of the equipment. The tire machine, the tire balancer, drawers of tools boxes, and the motorcycle racks were all too low. The motorcycle lift rack could reach a maximum height of 31.5 inches. For a person sitting this would be a workable height. However, for work being performed in a standing position, this creates a flexed back and neck or requires the repair professional to kneel or squat to perform work. This exact scenario was observed in Figure 5 below. Additionally the low machine height can be seen in Figure 1, creating the flexed back to almost a ninety degree angle.

Tool boxes are designed with larger drawers on the bottom of the box. This is where larger and heavier items are stored. This creates a long vertical travel distance when lifting these tools out of the tool box. Many of the tool box drawers are too low. When one of the repair professionals opened the wrench drawer, he had to bend his back also creating a flexed neck position greater than thirty degrees in order to look for the correct size wrench. If the tool boxes were taller this would eliminate the flexed position of the back and neck.

A tool box that could have adjustable height legs would allow for repair professional of all heights to comfortably retrieve tools from their tool boxes. Instead of stamping the size of wrench on the tool, color codes could be added to the wrenches to create a high visibility which may reduce the bending of the back and neck for a closer view. The manufacturers of these tool boxes could make shelves interchangeable. This would allow the drawers to be relocated, therefore, heavier items such as hammers and pullers could be stored at higher level, thus reducing the vertical travel distances when performing

Figure 5, Kneeling Posture: The low height of the motorcycle rack forces the repair professional to kneel to perform the necessary work.

lifts. If the motorcycle racks, tire machine, and tire balancer could be adjusted to a height of forty five inches, this would eliminate the squatting and kneeling, and also reducing the flexed back posture. This would create an optimal working height while standing and performing the work.

The lifting of the American wheel and tire assemblies must be considered a two man lift. If the asymmetry angle of the wheel and tire assembly lifts is reduce to zero, the CLI could then be reduced to 1.08. If a better coupling design was introduced, the CLI would be further reduced to 1.02. If there were a way to raise the tire machine four inches, it would also reduce the flexed posture of the back, and would reduce the vertical travel distance to eight inches from twelve inches, creating a CLI of .99 creating a safe composite lift throughout the day.

Following the NIOSH guide to selecting non-powered hand tools the majority of the tools were within guidelines; however, the box end wrenches create soft tissue compression when the force applied is placed on the narrow edge of the wrench. Tool companies are including ergonomic design into their wrenches. Matco has a reversible wrench that locates the opposite end of the wrench at ninety degrees. This allows the applied force to be placed on the wide part of the wrench as seen in Figure 6 below. Alternatively the use of an impact glove would eliminate this soft tissue compression, and would also reduce or eliminate the impact stress indentified when the repair professional used his fist like a hammer to break a fastener loose. Notably the best way to reduce impact stress is to refrain from the practice of using your hand as a hammer. The use of grips on tools will do two things. First, the diameter of the tools would be within the specifications of the NIOSH guide to selecting non-powered hand tools, and second, these grips would reduce soft tissue compression. A product called My Grips™ is a grip that can be added to any tool and is molded to the user's hand. The grip can be remolded over again. The grip can be molded with gloves on as well.

Figure 6, Matco Wrenches: The applied force will now be applied to wider part of the wrench.

Working on the ground and on concrete was one of the largest complaint areas noted during the observation and interview. Due to the nature of the business, the implementation of an anti fatigue mat might create more risk than it solves. However, this compression on the feet needs to be addressed. In place of an anti-fatigue mat I believe a system called Ergomates™ could be utilized. Ergomates are essentially anti-fatigue mats that straps over your shoes, seen in Figure 7 below. This will allow the user to reduce the compression on their feet, legs and back. They can be worn when test driving power sport vehicles in addition to the everyday work. If the solution ideas that are mentioned above were to be implemented, the BEST could possibly be reduced by nine points, thus placing the repair of power sports at Rocky Mountain Motorsport at a medium risk of ergonomic related injury. The follow up analysis is speculated to have a BEST score of twenty eight. Raising the height of the machines and

Figure 7, Ergomates: Ergomates attach to the users shoe and provides an anti-fatigue mat with every step.

motorcycle racks contributed to the largest point reduction, thus reducing the BEST score by seven points. The elevated height will eliminate the need to kneel or squat, eliminate the shoulder being raised greater than a forty five degree angle, and the force identified with the shoulders. While the postures of the neck and back will still be identified, the duration of the posture may be decreased or be eliminated. The frequency of the neck posture will also be eliminated by raising the machines and tool boxes. If the fist is not used as a hammer, another two points will be deducted from the assessment, and the risk of ergonomic related injury will be reduced. Therefore, the use of ergonomics within the profession of power sports repair can be utilized and can also reduce the potential for injury. It can also create higher employee morale. With fewer injuries, lower insurance costs and reduce worker compensation costs.

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Appendix A

Interview Questionnaire

Rocky Mountain Motorsports Repair Interview Questions

The reason for this interview is to examine if there are ergonomic related injuries that occur within the power sports repair industry. Can the use of ergonomic related solutions be implemented into the power sports repair industry? The answers that you provide within the interview will remain confidential.

1. Do you enjoy the power sports repair profession, please explain?
2. How long have you worked in this profession?
3. What is your current age?
4. How many hours per week do you typically work?
5. Have you ever had an injury occur as a result of working in the power sports repair profession?
6. If yes to question 5, please explain; if no, please move to question 7.
7. Is there ever pain and or fatigue associated with your work, please explain?
8. Do you find that you have less aches and pains at the beginning of the work week rather than at the end of the work week?
9. Do you use any power tools to perform repair work, and how often?
10. Do you use hand tools to perform repair work, and how often?
11. Do you lift items that are above 20 pounds throughout the day?
12. How many times do you lift items over 20 pounds in the average work day?
13. Is the temperature in the repair shop ever too cold?
14. Do you have an ideas or suggestions that would improve your work day?
15. Do you think ergonomics can be implemented within the power sports repair profession, please explain?

Additional comments, notes or questions?

Appendix B

BRIEF Survey

BRIEF™ Survey – Baseline Risk Identification of Ergonomic Factors

Version 3.0

Step 1
Complete Job Information

Job Name: ______ Site: ______ Station: ______
Date: ______ Dept: ______ Shift: ______ Product: ______

Step 2
Identify Risks

2a. Mark Posture and Force boxes when risk factors are observed.

2b. For body parts with Posture or Force marked, mark Duration and/or Frequency box(es) when limits are exceeded.

	Hands and Wrists		Elbows		Shoulders		Neck	Back	Legs
	Flexed ≥ 45°, Ulnar Deviation, Extended ≥ 45°, Radial Deviation		Rotated Forearm, Fully Extended ≥135°		Arm Behind Body, Arm Raised ≥ 45°, Shoulders Shrugged		Flexed ≥ 30°, Sideways, Extended, Twisted ≥ 20°	Flexed ≥ 20°, Sideways, Extended, Twisted, Unsupported	Squat ≤ 45°, Kneel, Unsupported
	Left	Right	Left	Right	Left	Right			
2a. Posture	☐	☐	☐	☐	☐	☐	☐	☐	☐
Force	Pinch Grip or Finger Press ≥ 2 lb (0.9 kg), or Power Grip ≥ 10 lb (4.5 kg) ☐	☐	≥ 10 lb (4.5 kg) ☐	≥ 10 lb (4.5 kg) ☐	≥ 10 lb (4.5 kg) ☐	≥ 10 lb (4.5 kg) ☐	≥ 2 lb (0.9 kg) ☐	≥ 25 lb (11.3 kg) ☐	Foot Pedal ≥ 10 lb (4.5 kg) ☐
2b. Duration	≥ 10 sec. ☐	≥ 10 sec. ☐	≥ 10 sec. ☐	≥ 10 sec. ☐	≥ 10 sec. ☐	≥ 10 sec. ☐	≥ 10 sec. ☐	≥ 10 sec. ☐	≥ 30% of day ☐
Frequency	≥ 30/min. ☐	≥ 30/min. ☐	≥ 2/min. ☐	≥ 2/min. ☐	≥ 2/min. ☐	≥ 2/min. ☐	≥ 2/min. ☐	≥ 2/min. ☐	≥ 2/min. ☐
Score									
Risk Rating	H M L	H M L	H M L	H M L	H M L	H M L	H M L	H M L	H M L

Step 3
Determine Risk Rating

In the Score box, write the number of risk factor categories (0-4) checked for each body part. Using the table at right, circle the corresponding Risk Rating for each body part. ▶

Score	Risk Rating
3 or 4	= High (H)
2	= Medium (M)
0 or 1	= Low (L)

Step 4
Identify Physical Stressors

Mark physical stressors observed:

- ☐ Vibration (V)
- ☐ Low Temperatures (L)
- ☐ Soft Tissue Compression (S)
- ☐ Impact Stress (I)
- ☐ Glove Issues (G)

▶ Use the corresponding letters to show location of stressors. ▶

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Appendix C

BEST Survey

BEST™ — BRIEF™ Exposure Scoring Technique

Version 1.0

Step 1

Complete Job Information

Job Name: ______ Site: ______ Station: ______

Date: ______ Dept: ______ Shift: ______ Product: ______

Step 2

Transfer BRIEF Scores

Transfer scores (0-4) from a completed BRIEF Survey.

Hands and Wrists		Elbows		Shoulders		Neck	Back	Legs
Left	Right	Left	Right	Left	Right			

Step 3

Determine Conversion Factors

Find each BRIEF Score in the table at right and determine the conversion factor for each body part.

BRIEF Score	Conv. Factor
4	10
3	5
2	3
1	1
0	0

Step 4

Add Conversion Factors

\+

Step 5

Summarize Physical Stressors

Place a 2 in the box for each physical stressor marked on the BRIEF, and a 0 for each physical stressor not marked.

Vibration	Low Temperatures	Soft Tissue Compression	Impact Stress	Glove Issues

Step 6

Add Physical Stressor Scores

=

Step 7

Calculate Job Risk Factor Score

(Conversion Factors + Physical Stressor Scores)

X

Step 8

Determine Time Exposure Multiplier

Use the table at left to determine the appropriate multiplier.

Time on Task Per Week	Multiplier
> 40 hours	1.25
20 - 40 hours	1.0
4 - 19 hours	0.8
< 4 hours	0.4

=

Step 9

Calculate Job Hazard Score

(Job Risk Factor Score x Time Exposure Multiplier)

Job Hazard Score	Priority
0 - 9	Low
10 - 29	Medium
30 - 49	High
50+	Very High

Comments:

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Appendix D

NIOSH Lifting Equation

NIOSH Lifting Guidelines

Job Title

Model Inputs:	Enter Data	Multipliers:
Horizontal Location (H) (min 10", max 25")	in (10" is best)	HM =
Vertical Location (V) (min 0", max 70")	in (30" is best)	VM =
Travel Distance (D) (min 10", max 70")	in (10" is best)	DM =
Angle of Asymmetry (A) (min 0°, max 135°)	deg (0° is best)	AM =
Coupling (1=good, 2=fair, 3=poor)	(1 is best)	CM =
Duration (Enter 1, 2 or 8 hrs. only)	hr(s) (1 hour is best)	Dur =
Frequency (min 0.2, max 15 lifts/min)	l/min (0.2 lifts/min is best)	FM =
Average Load Weight	lb	
Maximum Load Weight	lb	

Model Outputs:

Recommended Weight Limit (RWL): lb

Lifting Index (LI = Load/RWL): 0.00

Frequency Independent RWL: lb

Frequency Independent LI: 0.00

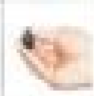
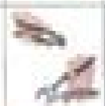
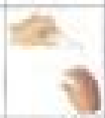
Recommendations:

Appendix E

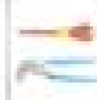
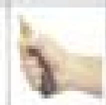
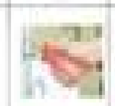
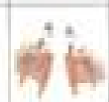
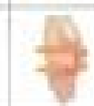
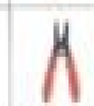
NIOSH Guide to Selecting Non-Powered Hand Tools

Use **BOTH** sides of the **checklist** to compare similar tools. For example, if you have two pliers and want to select the best of the two, compare each tool against the features on the checklist. The more "Yes" answers the tool has, the better the tool.

Refer to Section D, **Tips for Selecting Hand Tools**, for more details.

	Checklist for Hand Tool Selection Select the tool that has the most "YES" answers	Examples	Check if "YES": Single handle tools, Tool 1	Single handle tools, Tool 2	Double handle tools, Tool 1	Double handle tools, Tool 2
1	For single-handle tools used for power tasks: Does the tool have comfortable and has a handle diameter between 1 1/4 inches and 2 inches? (pg 8)					
2	For single-handle tools used for precision tasks: Is the handle diameter between 1/4 inch and 1/2 inch? (pg 8)					
3	For double-handle tools used for power tasks: Is the grip span at least 2 inches when closed and no more than 3 1/2 inches when open? (pg 8)					
4	For double-handle tools used for precision tasks: Is the grip span no less than 1 inch when closed and no more than 3 inches when open? (pg 9)					
5	For double-handle tools: Is the handle spring-loaded? (pg 9)					

COMPLETE BOTH SIDES

	Checklist for Hand Tool Selection Select the tool that has the most "YES" answers	Examples	Check if "YES" for all tools: Tool 1	Tool 2
6	Is the tool handle without sharp edges or finger grooves? (pg 9)			
7	Is the tool handle coated with soft material? (pg 9)			
8	Can the tool be used while keeping your wrist straight? (pg 10)			
9	Can the tool be used with your dominant hand or with either hand? (pg 10)			
10	For high-force tasks: Is the handle longer than the widest part of your hand (usually 4 inches to 6 inches)? (pg 11)			
11	Does the tool handle have a non-slip surface? (pg 11)			

COMPLETE BOTH SIDES

[illegible]

Appendix F

Rocky Mountain Motorsports BEST Survey

BEST™ – BRIEF™ Exposure Scoring Technique

Version 1.0

Step 1 Complete Job Information

Job Name: Rocky Mountain MotorsPorts Site: ______ Station: Shop
Date: 10-6-12 Dept: ______ Shift: 1st Product: Powersports Repair

Step 2 Transfer BRIEF Scores
Transfer scores (0–4) from a completed BRIEF Survey.

Step 3 Determine Conversion Factors
Find each BRIEF Score in the table at right and determine the conversion factor for each body part.

	Hands and Wrists		Elbows		Shoulders		Neck	Back	Legs
	Left	Right	Left	Right	Left	Right			
Step 2: BRIEF Scores	3	3	2	2	2	2	3	3	1
Step 3: Conversion Factors	5	5	3	3	3	3	5	5	1

BRIEF Score	Conv. Factor
4	10
3	5
2	3
1	1
0	0

Step 4 Add Conversion Factors: 33

+

Step 5 Summarize Physical Stressors
Place a 2 in the box for each physical stressor marked on the BRIEF, and a 0 for each physical stressor not marked.

Vibration	Low Temperatures	Soft Tissue Compression	Impact Stress	Glove Issues
		2	2	

Step 6 Add Physical Stressor Scores: 4

=

Step 7 Calculate Job Risk Factor Score (Conversion Factors + Physical Stressor Scores): 37

x

Time on Task Per Week	Multiplier
> 40 hours	1.25
20 - 40 hours	1.0
4 - 19 hours	0.8
< 4 hours	0.4

Step 8 Determine Time Exposure Multiplier
Use the table at left to determine the appropriate multiplier: 1

=

Job Hazard Score	Priority
0 - 9	Low
10 - 29	Medium
30 - 49	High
50+	Very High

Step 9 Calculate Job Hazard Score (Job Risk Factor Score x Time Exposure Multiplier): 37 High

Comments:

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Appendix G

Rocky Mountain Motorsports BRIEF Survey

BRIEF™ Survey – Baseline Risk Identification of Ergonomic Factors

Version 3.0

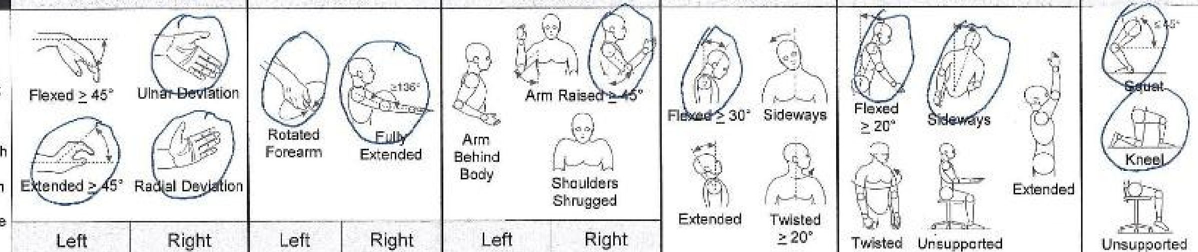
Step 1
Complete Job Information

Job Name: Rocky Mountain Motor Site: ____________ Station: Shop
Date: 10-6-12 Dept: ____________ Shift: 1st Product: Powersports Repair

Step 2
Identify Risks

2a. Mark Posture and Force boxes when risk factors are observed.

2b. For body parts with Posture or Force marked, mark Duration and/or Frequency box(es) when limits are exceeded.



	Hands and Wrists – Left	Hands and Wrists – Right	Elbows – Left	Elbows – Right	Shoulders – Left	Shoulders – Right	Neck	Back	Legs
2a. Posture	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]
Force	Pinch Grip or Finger Press ≥ 2 lb (0.9 kg), or Power Grip ≥ 10 lb (4.5 kg) [X]	[X]	≥ 10 lb (4.5 kg) [X]	≥ 10 lb (4.5 kg) [X]	≥ 10 lb (4.5 kg) [X]	≥ 10 lb (4.5 kg) [X]	≥ 2 lb (0.9 kg) [X]	≥ 25 lb (11.3 kg) [X]	Foot Pedal ≥ 10 lb (4.5 kg) [ ]
2b. Duration	≥ 10 sec. [X]	≥ 10 sec. [X]	≥ 10 sec. [ ]	≥ 10 sec. [ ]	≥ 10 sec. [ ]	≥ 10 sec. [ ]	≥ 10 sec. [ ]	≥ 10 sec. [X]	≥ 30% of day [ ]
Frequency	≥ 30/min. [ ]	≥ 30/min. [ ]	≥ 2/min. [ ]	≥ 2/min. [ ]	≥ 2/min. [ ]	≥ 2/min. [ ]	≥ 2/min. [X]	≥ 2/min. [ ]	≥ 2/min. [ ]
Score	3	3	2	2	2	2	3	3	1
Risk Rating	(H) M L	(H) M L	H (M) L	H (M) L	H (M) L	H (M) L	(H) M L	(H) M L	H M (L)

Step 3
Determine Risk Rating

In the Score box, write the number of risk factor categories (0-4) checked for each body part. Using the table at right, circle the corresponding Risk Rating for each body part. ▶

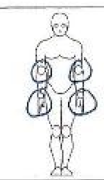
Score	Risk Rating
3 or 4	= High (H)
2	= Medium (M)
0 or 1	= Low (L)

Step 4
Identify Physical Stressors

Mark physical stressors observed:

- [ ] Vibration (V)
- [ ] Low Temperatures (L)
- [X] Soft Tissue Compression (S)
- [X] Impact Stress (I)
- [ ] Glove Issues (G)

▶ Use the corresponding letters to show location of stressors. ▶



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Appendix H

Rocky Mountain Motorsports Composite Lifting Index humantech®

PRINT | SCREEN CAPTURE

NIOSH Composite Lifting Guidelines

(scroll down to view results)

Job Title RMMS Lifting

Model Inputs:	Tasks 1	2	3	4	5	6	7	8	9	10
Average Load Weight	25 lb	25 lb	25 lb	25 lb	35 lb	35 lb	lb	lb	lb	lb
Max Load Weight	25 lb	25 lb	25 lb	25 lb	35 lb	35 lb	lb	lb	lb	lb
Horizontal Location (H) (min 10", max 25")	12 in	12 in	12 in	12 in	12 in	12 in	in	in	in	in
Vertical Location (V) (min 0", max 70")	30 in	18 in	30 in	18 in	30 in	18 in	in	in	in	in
Travel Distance (D) (min 10", max 70")	12 in	12 in	12 in	12 in	12 in	12 in	in	in	in	in
Angle of Asymmetry (A) (min 0°, max 135°)	0 deg	15 deg	0 deg	15 deg	0 deg	15 deg	deg	deg	deg	deg
Frequency (min 0.2, max 15 lifts/min)	0.2 l/m	0.2 l/m	0.2 l/m	0.2 l/m	0.2 l/m	0.2 l/m	l/m	l/m	l/m	l/m
Duration (1 hr., 2 hrs., 8 hrs.)	2 hr(s)	2 hr(s)	2 hr(s)	2 hr(s)	2 hr(s)	2 hr(s)	hr(s)	hr(s)	hr(s)	hr(s)
Coupling (1=good, 2=fair, 3=poor)	2	2	2	2	2	2				

Model Results:	Tasks 1	2	3	4	5	6	7	8	9	10
STRWL	39.16	32.23	39.16	32.23	39.16	32.23	0.00	0.00	0.00	0.00
FIRWL	41.23	33.93	41.23	33.93	41.23	33.93	0.00	0.00	0.00	0.00
STLI	0.64	0.78	0.64	0.78	0.89	1.09	0.00	0.00	0.00	0.00
FILI	0.61	0.74	0.61	0.74	0.85	1.03	0.00	0.00	0.00	0.00

CLI = 1.13

Appendix I

Humantech Agreement

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The 30-Inch View®

June 22, 2012

Mr. Todd Klimkowsky
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James D. Good
President

Agreed Todd Klimkowsky

Date: 6-25-12