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THE EFFECTIVENESS OF STRICT ADHERENCE TO ERGONOMIC PRINCIPLES ON INJURY PREVENTION AND WORK PERFORMANCE IN METAL INDUSTRY WORKERS

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ABSTRACT

Introduction: The primary strategy to prevent musculoskeletal trauma is the use of ergonomic principles to modify hand tools and to improve workstation design and work practices. To reduce the chance of injury, work tasks should be designed to limit exposure to ergonomic risk factors. ***Objective:*** To determine the effectiveness of strict adherence to ergonomic principles on injury prevention and work performance in metal industry workers by assessing musculoskeletal questionnaire and grip strength. ***Method:*** Total of 50 subjects were divided equally into 2 groups by random sampling after checking the criteria for selection. Group A experimental (n= 25) and group B control (n=25). The experimental group underwent 1month of strict ergonomic principles whereas the control group underwent normal working protocol. The pre and post measurements were measured by using grip strength and musculoskeletal health questionnaire (msk-hq). ***Result:*** The mean MSK-hq post score in Experimental Group was 53.24 with a standard deviation 2.50 and the mean MSK-hq post score in Control Group was 48.08 with a standard deviation 4.63 which was statistically significant (p value <0.00012). The mean Grip(kg)post score in Experimental Group was 45.83 with a standard deviation 0.55 and the mean Grip(kg) post score in Control Group was 45.08 with a standard deviation 1.39 which was statistically significant (p value <0.01546). Hence Experimental group was found to be better than the control group. ***Conclusion:*** Based the study's findings and review of supporting evidence, this study concludes that applying ergonomic principles has substantial evidence suggesting that ergonomics can help prevent musculoskeletal injuries and improve grip strength among metal industry workers.

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INTRODUCTION

The word ergonomics comes from the Greek language"ergo" which means "work" and "nomos" meaning law. So, ergonomics means laws of work. Ergonomics is used to fit the job to the worker.[1]Human factors is the terminology used with advancement in Industrial health and it focuses on human beings and their interaction with products, equipment, facilities, procedures, and environments used in work and everyday living. The emphasis is on human beings and how the design of things influences people. Human factors, then, seeks to change the things people use and the environments in which they use these things to better match the capabilities, limitations, and needs of people (Eklund, 1997). The ergonomic interventions include modifying existing equipment, making changes in work practices and purchasing new tools or other devices to assist in the production process. Making these changes has reduced physical demands, eliminated unnecessary movements, lowered injury rates and their associated workers' compensation costs, and reduced employee turnover. Simple, low-cost solutions are often available to solve problems. As an initiative in metal industries, a particular setup has been chosen and the employee attitudes has been studied for further research work (Bunning, 1998). To reduce the chance of injury, work tasks should be designed to limit exposure to ergonomic risk factors. Engineering controls are the most desirable, where possible. Administrative or work practice controls may be appropriate in some cases where engineering controls cannot be implemented or when different procedures are needed after implementation of the new engineering controls (Blondell, 1997). Ergonomics reduces costsby systematically reducing ergonomic risk factors, thereby preventing the costs of Musculoskeletal Disorders (MSDs). With approximately 1 out of every 3 in workers compensation costs attributed to MSDs, this represents an opportunity for significant cost savings. Also, don't forget that indirect expense can be up to twenty times the direct cost of an injury. The reduction of Musculoskeletal Disorders, reduction in incidence rate, reduction in lost workdays, reduction in restricted days, reduction in worker's compensation costs and reduction in cost per claim altogether result to 43% decrease in labor costs (Chang, 1999). Ergonomics improves productivity. The best ergonomic solutions often improve productivity by designing a job to allow for good posture, less exertion, fewer motions and better heights and reaches which make the workstation more efficient and results to around 25% increase in productivity. Ergonomics improves quality of the work as well. Poor ergonomics leads to frustrated and fatigued workers that don't do their best work. When the job task is too physically taxing on the worker, they may not perform their job like they were trained. For example, an employee might not fasten a screw tight enough due to a high force requirement which could create a product quality issue (Gite, 1990 and Hilton, 1997). Ergonomics improves employee engagement as well.Employees notice when the company is putting forth their best efforts to ensure their health and safety. If an employee does not experience fatigue and discomfort during their workday, it can improve turnover, decrease absenteeism, boost morale and increase employee involvement. Studies have shown that better ergonomics can lead up to 48% average increase in employee turnover and 58% average reduction in employee absenteeism (Meyers, 1995 and Miles, 1996). Manual material handling (MMH) work contributes to a large percentage of the over half a million cases of musculoskeletal disorders reported annually even in the developed countries. Musculoskeletal disorders often involve strains and sprains to the lower back, shoulders, and upper limbs. They can result in protracted pain, disability, medical treatment, and financial stress for those afflicted with them, and employers often find themselves paying the bill, either directly or through workers' compensation insurance all the while coping with the loss of the full capacity of their workers. Scientific evidence shows that effective ergonomic interventions can lower the physical demands of MMH work tasks, thereby lowering the incidence and severity of the musculoskeletal injuries they can cause. Their potential for reducing injuryrelated costs alone makes ergonomic interventions a useful tool for improving a company's productivity, product quality, and overall business competitiveness. But very often, the productivity gets an additional and solid shot in the arm when managers and workers take a fresh look at how best to use energy, equipment, and exertion to get the job done in the most efficient, effective, and effortless way possible. Planning that applies these principles can result in big wins for all concerned. Therefore, the aim of the present study is to assess the effect of strict adherence to ergonomic principles on injury prevention and work performance in metal industry workers (Oxenburgh, 1997 and Scott, 1996).

METHODS

An experimental study was conducted with data collected from Cooper corporation, Satara. Fifty male subjects were recruited randomly into two groups of twenty-five subjects each by convenience sampling. Consent was obtained from them prior to the study. Inclusion criteria comprised of male workers aged between 20 to 30 years and skilled labors with experience of at least 2 years. The uncooperative subjects with psycho-social issues; malnourished workers and any impairment or disability were excluded from the study (Stal, 1996).

The included subjects were then divided into two groups:

Group A- experimental: Twenty-five subjects who were treated with 1month of strict adherence to ergonomic principles.

Group B- control: Twenty-five who were treated with normal working protocol.

However, prior to commencement of the intervention, the pre-test of dependent variables were measured in all participants. The pre and post measurements were measured by using grip strength and musculoskeletal health questionnaire (msk-hq). The primary data of the sample population was recorded which included demographic data (age and duration of work). As per the study the ergonomic principles were brought into practice for samples under supervision for a period of 4 weeks and the results were analysed with appropriate statistical measures. Data analysis was performed by using SPSS (version 17) for windows. Alpha value was set as 0.05. Descriptive statistics was performed to find out mean, standard deviation for the demographic variable and outcome variables. Unpaired t test was used to find out significant differences among demographic variable such as age, BMI, duration and outcome variable such as grip strength at baseline. Unpaired t test was used to find out difference in scores between groups for Grip (kg). Paired t test was used to find out significant difference within the groups for Grip (kg). Mann Whitney U test was used to find out difference in scores between the groups for MSK-hq at baseline and post measurement. Wilcoxon signed rank sum test was used to find out significant difference within the groups for MSK-hq. Finally, Microsoft excel and word was used to generate graph and tables.

Procedure

Group A- Twenty-five subjects treated with 1month of strict adherence to ergonomic principles.

Ergonomic principles

Many potentially harmful situations that lead to back injury can be identified and avoided by following four basic rules of thumb:

1. Prolonged static posture is the enemy. The healthy body can only tolerate staying in one position for about 20 minutes. That is why sitting on an airplane, at a desk in an office chair, or at a movie theatre becomes uncomfortable after a short time. Standing in one place, such as standing on a concrete floor at an assembly line for extended periods of time tends to cause back pain. Holding the same position slowly diminishes elasticity in the soft tissues (muscles ligaments and tendons in the back). Then, stress builds up and causes back discomfort and/or leg discomfort. The solution is simple which is to change positions frequently. Stand or sit, stretch and take a short walk. After returning to the standing or sitting posture, use an alternate posture for just a few moments and some of the tissue elasticity needed to protect the joints will return.
2. Frequent or repetitive stretching to the end range of motion or awkward, angled postures can bind the joints. Unlike jobs that require long-term seating in an office chair, jobs that require frequent repetitive motion can cause great discomfort. Such jobs involve lifting from the floor, lifting overhead, moving bulky loads, or using rotational force or twisting while handling material and which signal back injuries might be on the way.
3. Heavy loads offer greater risk. If the job requires moving heavy or bulky objects, it is important to have the proper tools or get help.
4. Fatigue from sitting in an office chair for days, from work or from insomnia can make people move more awkwardly. If one is overtired or feels fatigued, it is advisable to avoid lifting heavy objects alone or quickly.

If following these ergonomic rules of thumb is a frequent problem, the worker is at risk of sustaining or aggravating a back injury. Any job that involves heavy labor or manual material handling may be in a high-risk category. Manual material handling entails lifting, but also usually includes climbing, pushing, pulling and pivoting, all of which pose the risk of injury to the back. Lifting from the floor places strain on the structures in the lumbar spine. Ergonomic lifting techniques involve the use of a diagonal foot position, and getting as close to the load as possible. The load should be kept as close to the body as possible when standing up. It is easier to move loads that are waist high than ones that are on the floor. Stacking pallets to raise the height of the load is one ergonomic solution. A scissors lift will mechanically raise the load to a comfortable lifting level. Repetitive lifting from the floor is particularly risky, so it is advised not to try to get the material off the floor. Keep all loads as close to one's center of gravity as possible. Carrying loads on one shoulder is safer for long and narrow material. This would include construction material or rolls of carpet. When lifting anything with a handle, place one hand on one knee to get additional leverage and use a diagonal foot position.

Safety guidelines for ergonomics: The use of stretching is appropriate as part of a comprehensive ergonomic program.

- Stretching must not be used in place of engineering and/or administrative improvements.
- Check for tags on loads.
- Before lifting, always test the load for stability and weight.
- For loads that are unstable and/or heavy, follow management guidelines for: Equipment use; Reducing the weight of the load; Repacking containers to increase stability.
- **Plan the lift:** Wear appropriate shoes to avoid slips, trips, or falls. If you wear gloves, choose the size that fits properly. Depending on the material the gloves are made of and the number of pairs worn at once, more force may be needed to grasp and hold objects. For example, wearing a single pair of heat-resistant gloves can reduce grip strength up to 40 percent. Wearing two or more pairs of gloves at once can reduce the grip strength up to 60 percent. Lift only as much as one can safely handle by oneself. Keep the lifts within the power zone (i.e., above the knees, below the shoulders, and close to the body), if possible. Use extra caution when lifting loads that may be unstable.
- ***When lifting:*** Get a secure grip. Use both hands whenever possible. Avoid jerking by using smooth, even motions. Keep the load as close to the body as possible. To the extent feasible, use the legs to push up and lift the load, not the upper body or back.Do not twist the body. Step to one side or the other to turn. Alternate heavy lifting or forceful exertion tasks with less physically demanding tasks. Take rest breaks.

A check list was provided to supervisor in the company to know whether selected employees were following strict guidelines of ergonomics and safety measures and investigator visited regularly to the workstation to know the status of employee's programand regular follow-up was performed.

RESULTS

Table 1. Baseline data for demographic variable

Sl.No:	Variable	Experimental	Control	Þ-Value
1	Age	26.36±2.18	26.96±1.54	>0.266
2	BMI	23.59±1.30	23.64±1.44	>0.902
3	Duration	8.24±0.66	8.24±0.66	=1

In the Experimental group, the mean age was 26.36 years with sd of 2.18 whereas in the Control group, the mean age was 26.96 and standard deviation(sd)was 1.54 which was not statistically significant (p value >0.266). The mean BMI was 23.59 with sd of 1.30 in the Experimental group whereas it was 23.64 with sd of 1.44 in the Control group, which was not statistically significant (p value >0.902). The mean duration was 8.24 with sd of 0.66 in the Experimental group whereas it was 8.24 with sd of 0.66 in the Control group,which was not statistically significant (p value =1). Data was homogenous among both groups for base line data of demographic variables.

Table 2. Baseline data for outcome variables

Sl.No:	Variable	Experimental	Control	Þ-Value
1	MSK-hq	47.20±5.28	47.00±3.71	>0.660
2	Grip(kg)	44.96±0.57	44.76±0.94	>0.368

In the Experimental group, the mean MSK-hq was 47.20 with sd of 5.28 and in the Control group, itwas 47.00 with sd of 3.71 which was not statistically significant (Þ-value>0.660). In the Experimental group, the mean Grip(kg) was 44.96 with sd of 0.57 and in the Control group, itwas 44.76 with standard deviation of 0.94 which was not statistically significant (Þ-value >0.368). In summary data were homogenous among both groups for baseline data. In the study, the pre mean MSK-hq score was 47.20 with sd of 5.28 which was improved to post mean MSK-hq score 53.24 with sd of 2.50, which was statistically significant (Þ-value <0.00016). Similarly, the pre mean Grip (kg) score 44.96 with sd of 0.57 was improved to post mean Grip (kg) score 45.83 with sd of 0.55 which was also found to be statistically significant (Þ-value <0.00001).

Table 3. Pre-Post in Experimental group

Sl.No:	Variable	Pre	Post	Þ-Value
1	MSK-hq	47.20±5.28	53.24±2.50	<0.00016
2	Grip(kg)	44.96±0.57	45.83±0.55	<0.00001

Table 4. Pre-Post in Control group

Sl.No:	Variable	Pre	Post	Þ-Value
1	MSK-hq	47.00±3.71	48.08±4.63	>0.234
2	Grip(kg)	44.76±0.94	45.08±1.39	>0.121

In the study, the pre mean MSK-hq score was 47.00 with sd of 3.71 which was improved to post mean MSK-hq score 48.08 with sd of 4.63, which was not statistically significant (Þ-value >0.234). Similarly, the pre mean Grip(kg)score 44.76 with sd of 0.94 was improved to post mean Grip(kg) score 45.08 with sd of 1.3, which was again statistically not significant (Þ-value >0.121).

Table 5 Difference between groups

Sl.No:	Variable	Experimental	Control	Þ-Value
1	MSK-hq	53.24±2.50	48.08±4.63	<0.00012
2	Grip(kg)	45.83±0.55	45.08±1.39	<0.01546

When comparing between the groups, the mean MSK-hqpost score in Experimental Group was 53.24 with a sd 2.50 and the mean MSK-hqpost score in Control Group was 48.08 with a sd 4.63, which was statistically significant (p value <0.00012). The mean Grip(kg)post score in Experimental Group was 45.83 with a sd 0.55 and it was 45.08 with a sd 1.39 in the Control group, which was again statistically significant (p value <0.01546). Hence, based on the result, it was found that the Experimental group showed better results when compared to the Control group.

DISCUSSION

Ergonomics has two distinct aspects: Firstly study, research, and experimentation, in which the main focus is to determine specific human traits and characteristics that are needed to know for engineering design. Secondly application and engineering, in which design tools, machines, shelter, environment, work tasks, and job procedures are assessed to fit and accommodate the human and equipment in the environment in order to find out the suitability of the designed human-machine system and to determine possible improvements. This study was conducted to find the effectiveness of strict adherence to ergonomic principles on injury prevention and work performance in metal industry workers by assessing physiological outcome of workers using physiological fatigue scale and to provide awareness related to injury rate and recurrence of health problems on industry workers. In the present study total of 50 subjects were divided equally in 2 groups where the Experimental group underwent ergonomic principles and the Control group followed a normal working protocol. All the included subjects received the allocated treatment for the complete study duration with no drop out. The outcome measures used in the study were musculoskeletal health questionnaire and grip strength.

Baseline and demographic data did not show any significant difference in both the groups. In this study, the pre mean MSK-hq score was 47.20 in the Experimental group which was improved to post mean score 53.24, which was statistically significant (Þ-value <0.00016). Similarly, he pre mean Grip (kg) score improved from 44.96 to post mean Grip (kg) score 45.83, which also statistically significant (Þ-value <0.00001). This significance in the result could be attributed to the ergonomic suggestions followed during the study. One of the main concepts used in ergonomics advice was use of three-point contact. When climbing with a load, "three-point" contact is important for safety. This means two hands and a foot or both feet and a hand must be in contact with the ladder or stairs at all times. If the load is bulky, it is advised to get another person or a mechanical device to assist. Manual material handling may require pushing or pulling. Pushing is generally easier on the back than pulling. It is important to use both the arms and legs to provide the leverage to start the push (Drinkaus, 2013 and McAtamney, 1993). In this study, the control group did not show any significant difference between pre and post data as they were continuing regular activity without any ergonomic advice or protocol. When comparing between the groups, the mean MSK-hqpost score in Experimental Group was 53.24 and it was 48.08in the Control Group, which was statistically significant (p value <0.00012). The mean Grip (kg) post score in Experimental Group was 45.83 and it was 45.08 in the Control Group, which was again significant (p value <0.01546). Therefore, it can be concluded that the Experimental group performed better than the Control group. This could be explained by a hypothesis where subject in the Experimental group were aware of their posture and how to take care of their back and how better they can perform without straining their joint and back. Lifting from the floor places great strain on the structures in the lumbar spine. Ergonomic lifting techniques involve the use of a diagonal foot position, and getting as close to the load as possible. The subjects were advised to keep the load as close to the body as possible when standing up (Colligan, 2004). Previous literatures have explained the use of ergonomics in workplaces like placing the handle ideally at waist high for ease of pushing. It is also suggested to avoid twisting the lower back if it is necessary to pull. Sometimes, for very large loads, turning around and using the back to push against an object allows the legs to provide maximum force while protecting the low back from strain or twisting. The opposite of twisting is pivoting. Pivoting means moving the shoulders, hips and feet with the load in front at all times. The lower back is not designed to torque or repetitive twisting. Whether using a shovel or moving material or products, always avoid twisting the back. Practicing these techniques, both at work and at home, will go a long way to help prevent back injury and protect the structures in the low back (Ford, 1994; Dannenberg, 1998). Even though the workers were skilled, they had pain and stiffness of back and many more musculoskeletal problems interfering with daily routine which was evident from pre-test data of musculoskeletal questionnaire. More than 30 percentage subjects had disturbed sleep due to musculoskeletal issues and pattern of sleeping postures. The overall impact was changed in post-test measurement where more than 70 percentage benefited with ergonomic advise.

This study has also brought about self-understanding and good emotional well being which was evident from the post test measurement. Employees were feeling free to report fatigue symptoms and minor incident of risk to the supervisors, which was evident from the strict adherent to ergonomic principles and improvement in grip strength. Major behavioral change was found as there was an improvement in confidence level among the employees evident from the administrative roll cell and reduced absenteeism. [18]

Based on the results, this study thus accepted the experimental hypothesis and rejected the null hypothesis concluding that there will be a significant positive difference on injury prevention and work performance if the strict adherence to ergonomic principles is followed among metal industry workers. However; there are few limitations as well of the study. The current study lasted for 30 days, and no follow-up was conducted. No comment can be made on the long-term effects of the ergonomic advice followed because no follow-up was done in this study. The severity of the complaints was not mentioned in the study that could have had an effect on the result of the study. The study time of the research was brief, which may have lowered the efficacy of ergonomic principle in allowing muscle to undergo neuromuscular and physiological changes related to pain reduction. In order to generalize the findings, the study did not compare the influence of quality of life on each group.

CONCLUSION

Based the study's findings and review of supporting evidence, the current study concluded that applying ergonomic principles has substantial evidence suggesting that ergonomics can prevent musculoskeletal injuries and improve grip strength among metal industry workers.

REFERENCES

Blondell, J. Epidemiology of pesticide poisonings in the United States, with special reference to occupational cases. *Occup. Med.,* 1997, 12, 209-220.

Bunning, T. Designing ergonomically sound assembly workstations, *Occupational Hazards,* 1998, Vol. 60, No. 8, 63–65.

Chaffin D. Biomechanical models in high exertion manual jobs. In: Violante F, Armstrong T, Kilbom A, ed. Occupational Ergonomics. Work Related Musculoskeletal Disorders of the Upper Limb and Back. London: Taylor & Francis, 2000; 157–177.

Chang S, Park. S, Freivalds A. Ergonomic evaluation of the effects of handle types on garden tools. *International Journal of Industrial Ergonomics,* 1999; 24, 99-105.

Colligan MJ, Cohen A. The role of training in promoting workplace safety and health. In: Barling J, Frone MR, eds. The Psychology of Workplace Safety. Washington, DC: American Psychological Association; 2004:223–248.

Dannenberg AL, Fowler CJ. Evaluation of interventions to prevent injuries: an overview. Inj Prev. 1998;4:141–147.

Drinkaus P, Sesek R, Bloswick D, Bernard T, Walton B, Joseph B, et al. Comparison of ergonomic risk assessment outputs from rapid upper limb assessment and the strain index for tasks in automotive assembly plants. Work. 2003;21(2):165–72.

Eklund, J. Ergonomics, quality and continuous improvement—conceptual and empirical relationships in an industrial context, *Ergonomics,* 1997, Vol. 40, 982–1001.

Ford JK, Fisher S. The transfer of safety training in work organizations: a systems perspective to continuous learning. *Occup Med.* 1994; 9:241–259.

Gite, L. Quality of work life of farm workers and ergonomics. *Agricultural Engineering Today,* 1990; 14, 5-17.

Hilton, W. (1997). Ergonomic job design in the hog industry. In J. Kohn (Ed.), The Ergonomic Casebook. NY: Lewis.

Lowe BD. Accuracy and validity of observational estimates of wrist and forearm posture. Ergonomics. 2004;47(5):527–54.

McAtamney L, Nigel Corlett E. RULA: a survey method for the investigation of work-related upper limb disorders. *Appl Ergon.* 1993;24(2):91–9.

Meyers J, Bloomberg. L., Faucett J, Janowitz I, Miles JA. (1995). Using ergonomics in the prevention of musculoskeletal cumulative trauma injuries in agriculture: learning from the mistakes of others. *Journal of Agromedicine,* 2(3), 11-24.

Miles J, Steinke. W. (1996). Citrus workers resist ergonomic modifications to picking ladder. *Journal of Agricultural Safety and Health,* 2(1), 7-15.

Oxenburgh, M. (1997). Cost-benefit analysis of ergonomics programs. *American Industrial Hygiene Association Journal*, 58, 150-156.

Scott GB, Lambe. N. (1996). Working practices in a percherysystem, using the OVAKO working posture analysing system (OWAS). Applied Ergonomics, 27(4), 281-284.

Stal M, Moritz., U, Gustafsson B, Johnsson B. (1996). Milking is a high risk job for young females. *Scand J Rehab Med,* 28, 95-104.

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