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Risks assessment at automotive manufacturing company and ergonomic working condition

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Abstract. Manufacturing sectors are the major industrial sector which contribute to the development of the country. The automotive manufacturing industry is a global industry which has high competition all over the world and contribute in large amount of revenue to the country. From the review, the management of automotive industries faced a few problems relates to the assembly line and the workers. The workers are exposed to hazard which resulting from unsuitable tasks or inappropriate workplace. The purpose of the study is to identify the occupational risks at automotive manufacturing company and recommend the ergonomic working condition at the workplace. This study is carried out through interview session, observation, videotaping and assessment method using Rapid Upper Limb Assessment (RULA). Based on the findings, it shows that the subjects are exposed to extremely high risks and the changes need to be done immediately. The occupational risks will lead to the presence of Work-Musculoskeletal Disorders (WMSDs) which cause absenteeism, employee turnover and the production drops. There are a few factors which causes the occurrence of WMSDs which are repetitive tasks, awkward postures and strenuous physical load or force exertion. The implementation of ergonomics in the workplace is important to avoid the presence of WMSDs.

1. Introduction

According to history, manufacturing sectors is a key pillar of economic growth and development and until nowadays it becomes positively moderate for the economy[1]. There are a few types of manufacturing industries which are textiles, food and beverages, aerospace and also automotive manufacturing. The automotive industry is a worldwide industry which has high competition all over the world. As the automotive sectors contribute high economic revenue for the country, the growth of the sectors should be intensified [2]. To boost up the sectors by incorporate strategies that help in increasing the production and quality, all issues that involve in the manufacturing should be solved.

Recent issues in the modern automotive manufacturing is the Musculoskeletal Disorder (MSDs) which causes large amount of absent due to inappropriate assembly system and human work related satisfaction [3]. Moreover, the automotive industrial workers are exposed to the hazards relates to the occupational risks factors which occur because of the repetitive work while doing different tasks [4]. In western European countries, WMSDs are the major cause of sick leaves [5]. There are a few factor leads to the occurrences of WMSDs including severe force, non-neutral posture, repetition, and vibration[6]. In the manufacturing sectors, Musculoskeletal disorder (MSDs) may occur because of continuous performing repetitive task, working in repeated and sustained or challenging postures, performing strenuous physical work, and using forceful exertion[7]. Likewise, the issues in the automotive sectors



where the operators are dealing with the awkward posture and repetitive work. WMSDs indicates a critical ergonomic problems specifically in automotive assembly line due to the risky tasks for instance tightening, picking up, material handling and lifting [8]. Hence, the risks assessment at the automotive manufacturing are important in order to point out the risky part at the automotive manufacturing company and implement the effective working postures or conditions.

Ergonomics is knowledge of designing of a healthy workplace which considering the capabilities and the limitations of human being called workers. The primary goal of ergonomic is to optimize the well-being and increasing productivity by developing and apply worker's compatible techniques to their tasks with efficient and secure. High degree execution of ergonomics practices enhances the achievement of the company concerning economic and social objectives [9]. The recent study of ergonomics centres around the risks assessment in other sector such as at the construction sites[10], agriculture[11] and healthcare [12]. However, there are few existing ergonomic study at the automotive plant which directly focused on job rotation [13] and cause factor for WMSDs [14]. Besides there are study targeting an under-car operation which the objects are located above the head of the subjects [15]. Therefore, the aim of this study is to identify the occupational risks at the welding workstation assembly line in automotive manufacturing plant. Yet, it is an initial study before proceeds for further steps which includes delphi method and validation with other company. There are few ergonomic analysis tools available to determine the occupational risks at the workplace which are used based on the requirement for the risks assessment. In this study, the ergonomic tool used to identify the occupational risks on the workers are Rapid Upper Limb Assessment (RULA).

2. Methodology

This study was conducted at one of the automotive component plant in Malaysia which activity are assembles the automotive part such as the doors and the body of the car. Figure 1 show the flow of the study. The flow is classified into four phases according to the stage which are the identification stage (Phase 1), empirical stage (Phase 2) and Analytic stage (Phase 3).

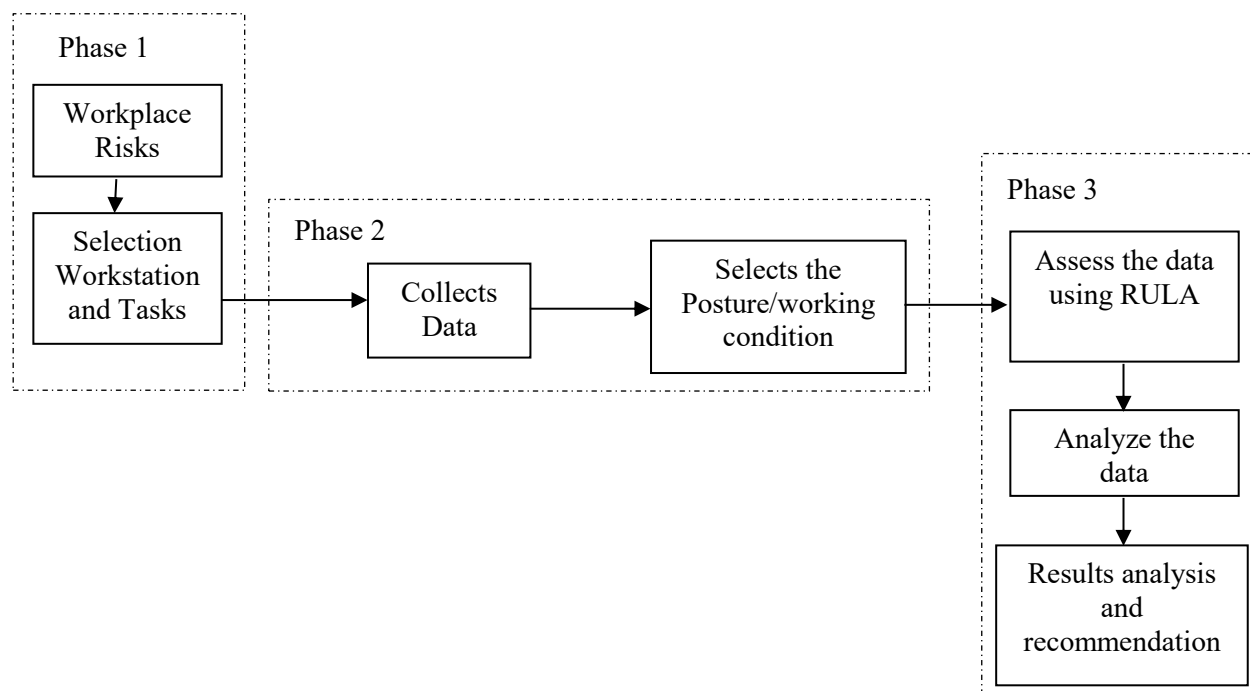


Figure 1. Flowchart of Study

2.1 Phase 1: Identification Stage

The initial stage which is the identification stage are involved the safety department and the engineers of the company who are in-charged the production floor. Interviewing the related person helps in identify the critical risks workplace which are exposed to high risks due to their work which using a manual handling machine. Besides interviewing, the whole production line is reviewed in order to study the working condition in the plant. The selected working area are at the welding spot-gun assembly line because based on the data from the interview, the selected area facing high turnover. From the reviewed, the tasks which are considered for the assessment are the task on the manual handling of the welding spot-gun.

2.2 Phase 2: empirical stage

In this stage, the data are collected using videotaping while the workers are doing the works. Besides, the anthropometric data of the workers are taken. The recording takes 2 hours continuously in order to tape all postures of the workers while doing works. In order to assess the risks levels, the number of the participants involved are nine operators at the welding spot-gun. The study is in a small sample size because of the operator that mastered the skills on handling the spot-gun are limited. Note that the weight of the component to be assembled are estimate to 10 kilogram (>22lbs).

After collecting the data, the videos are reviewed in order to selects the risky postures and the working condition. There are a few aspect are taken into account such as the repetition of the postures, the time range and the awkward condition.

From the videotaping reviews, there are three postures selected are shown as follows:

Table 1. Selected Postures

No.	Postures	Remarks
1		• Repetition >4 times per minute • Load >22 lbs • Arm working cross the midline • Trunk twisted
2		• Repetition >4 times per minute • Load >22 lbs • The arm raised exceed the ideal range. • Trunk side bending

3



- Repetition >4 times per minute
- Load >22 lbs
- Trunk twisted

2.3 Phase 3: Analytic stage

The assessment by using Rapid Upper Limb Assessment (RULA) are done on the selected postures in this phase. After the assessment, the data are analyze to determine the occupational risks that occurred. Figure 2 shows the RULA assessment method while Table 2 shows the score level of the risks in RULA assessment. In the assessment there are two different score which are score A and score B where score A assessing the arm and the wrists while score B assessing the neck, trunk and leg. The grand score is the results from both score adding with muscle score and force.

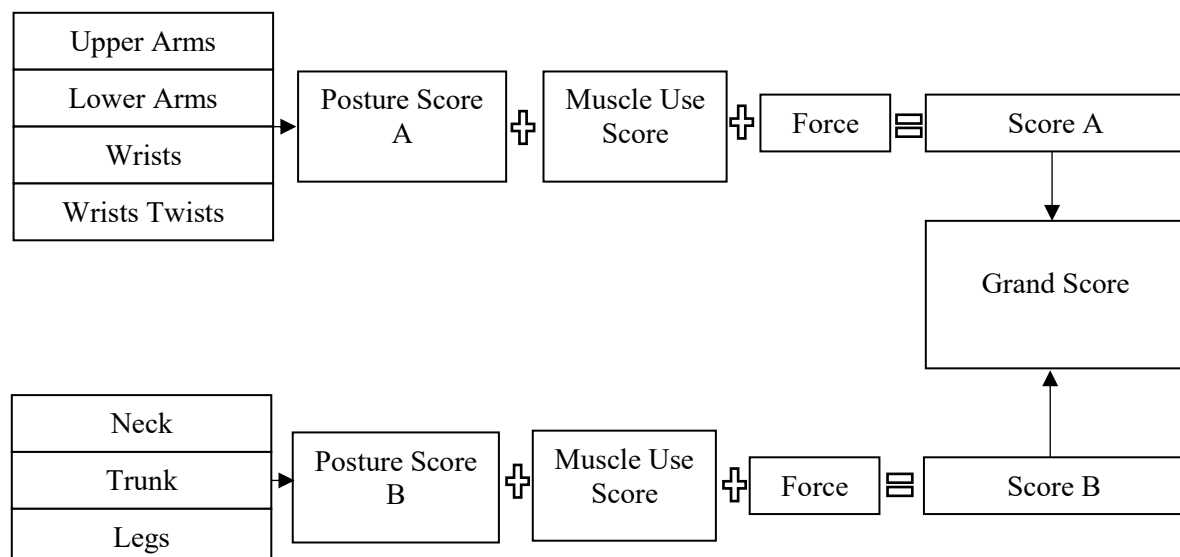


Figure 2. RULA Assessment Method

Table 2. Level of MSD Risk (RULA) [16]

Score	Level Of MSD Risk
1-2	Negligible risk, no action required
3-4	Low risk, change may be need
5-6	Medium risk, further investigation, change soon
6+	Very high risk, implement change now

3. Results and Discussions

From the data collected, it shown clearly that the workers are exposed to extremely high risks handling the spot-weld gun manually. Figure 3 shows the scores for posture 1 while Figure 4 and Figure 5 shows the results for posture 2 and posture 3. The overall score for the grand score of the subjects are shown

in Figure 6. The nine subjects involved are named as worker 1 (W1), worker 2 (W2), Worker 3 (W3), worker 4 (W4), worker 5 (W5), worker 6 (W6), worker 7 (W7), worker 8 (W8) and worker 9 (W9).

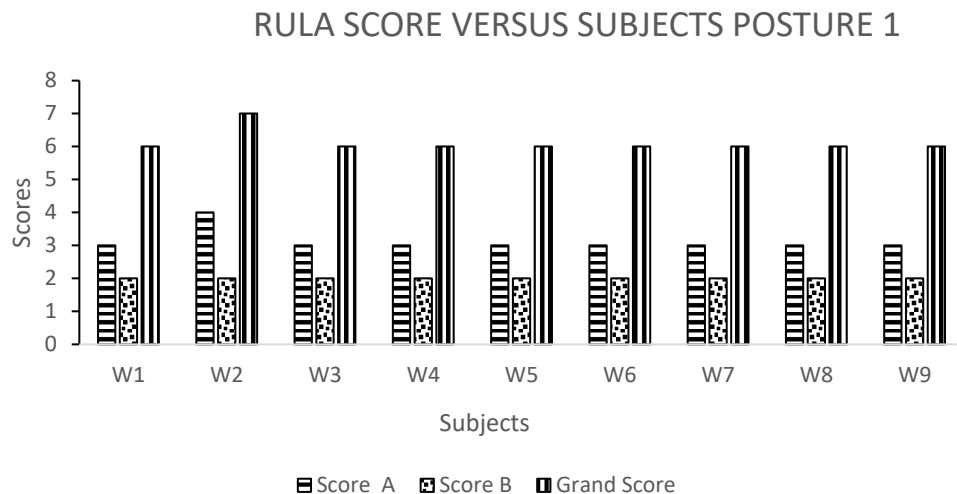


Figure 3. RULA Scores Posture 1

The RULA score for posture 1 as shown in Figure 3 shows that the subjects W2 are exposed to extremely high risks which needs to investigate and implement change. The posture score A that relate to the arm and the wrists of the for W2 contribute to the high grand score. By referring to the anthropometric data, the span size of W2 is the highest compared to other workers. Therefore, the changes should be made at that part. However, all subjects are need further investigation and changes as the grand scores are above the acceptable scores.

By referring to Table 1, the posture 1 are repeated for more than four times per minute and the loads are exceed 22 lbs while the arm working cross the midline and the trunk are twisted. Therefore, the posture exposed the subjects to high occupational risks because of the awkward postures and the repetitive job.

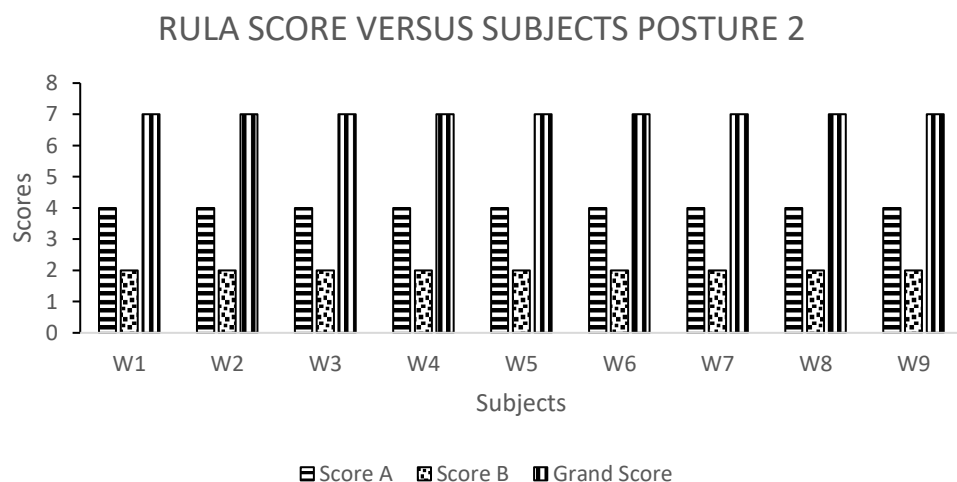


Figure 4. RULA Scores Posture 2

Based on the results for RULA score of posture 2, it indicates that the position is dangerous for all of the subjects as the score are higher than 2 which is the negligible risks. For this posture, the arm and wrists part causes the higher risks score because the arm raised exceed the ideal range and the trunk side is bending.

The other researcher also come out with the conclusion that the significant effect on mechanical loading at the shoulder and low back during pull or push exertions are the effect from the height handle[17]. Therefore, the arm and shoulder should be in resting condition to work neutrally.

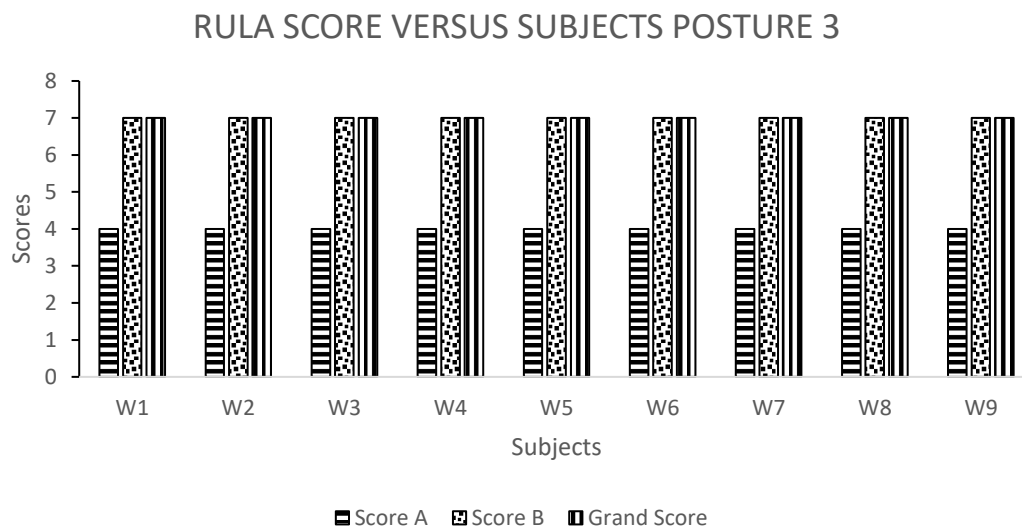


Figure 5 RULA Scores Posture 3

Figure 5 exhibit the score for posture 3 which indicates that score B contribute to the occupational hazards. Score B involves neck, trunk and leg. From Table 1, it pointed that the trunk of these subjects are twisted. The angle of the twist is exceeded the normal angle for ideal postures which is not crossing the middle line of body. Regarding the posture 3, although the score A is in low risks, the condition need to be changed since the grand score is 7.

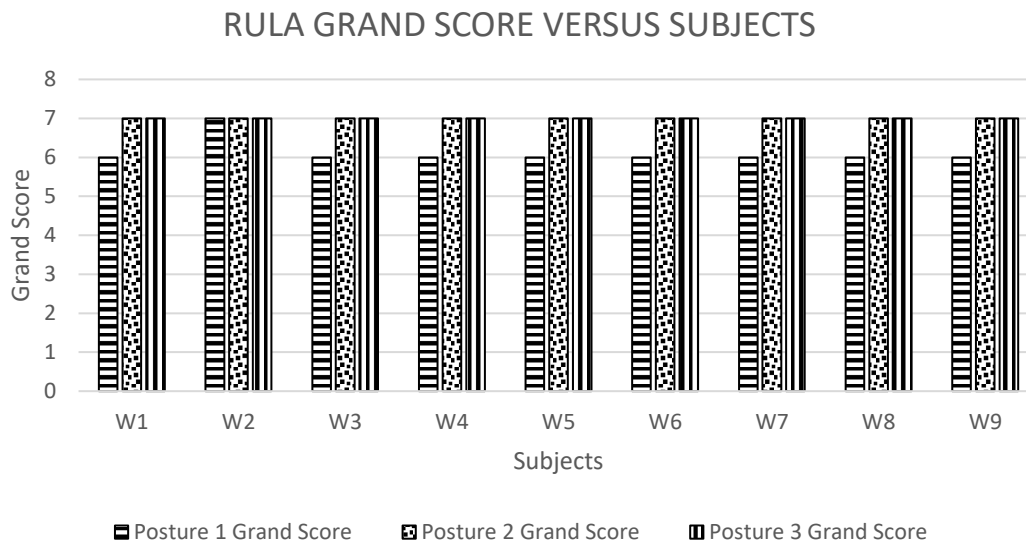


Figure 6. RULA Grand Scores

The graphical results from Figure 6 reveal that posture 2 and posture 3 are extremely high risks and need to change immediately. Despite that, posture 1 also need to be investigated and change soon as the subjects are exposed to medium risks. As mentioned in Table 1, posture 2 and 3 are exceeding the midline for normal posture where the lower arm and forearm are raised greater than 90 degree for posture 2 while for posture 3 the trunk bent is near to 60 degree plus twisted and side bend. In contrast with posture 2 and 3, posture 1 still in the medium range although the trunk is twisted.

The study proved that the workplace is not safe for the workers and the design should be changed immediately.

In ergonomic approaches, there are principles which act as a guide for a good practice. The principles are work in neutral postures, reduces excessive forces, keep everything in easy reach, work at proper height, reduce excessive motions, minimize fatigue and static load and minimize pressure points [18].

4. Recommendation

For this research, based on the selected postures in Table 1, the recommended ways are to work in neutral postures, reduces excessive forces, keep everything in easy reach and work at proper height.

Figure 7 shows the neutral postures means the well-balance of the muscle and joint of the body. It should not be too precise as the movement of the body are shift occasionally. The suggested way is by maintain S-curve of the spine, keep the neck in its proper alignment, keep elbows in with the shoulder relaxed and keep wrists straight.

As the body in neutral position, therefore the body is in comfortable condition where the structure of the body did not bear pain from imbalance joint or muscle. One of the WMSDs factor is the awkward postures [19] which creates strain on the joint and surrounding tissues. It will reduce strength and dexterity while doing works because of fatigue and other related discomfort pain.

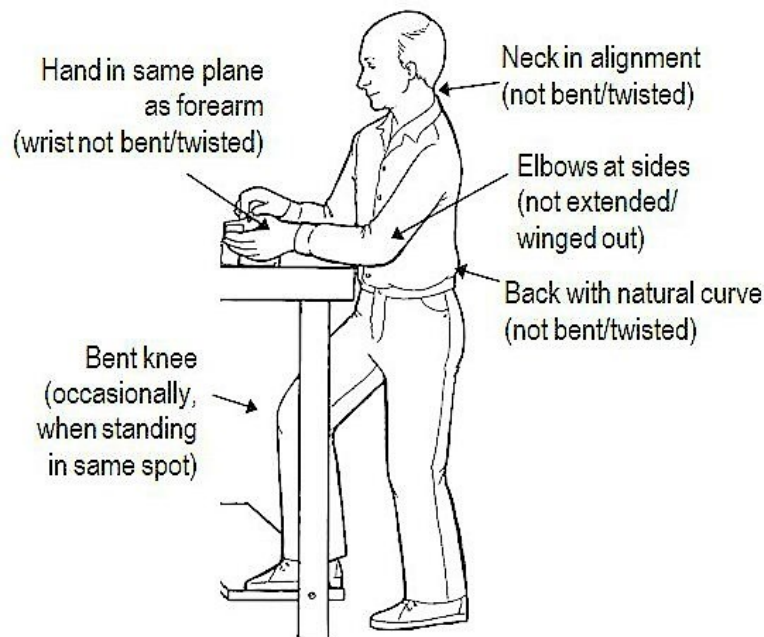


Figure 7. Neutral Position [18]

Moreover, the overload stress on the muscle by the excessive force will create fatigue and high potential of injuries. Force is one of the factor that lead to the occurrence of Work Musculoskeletal Disorders (WMSDs). There are study on the effects of handle height on hand force direction and quantified the changes in shoulder loads and low back resulting from the changes of in the direction of force[20]. In the research, the subjects pulled or pushed with various level of horizontal force on either moveable cart or stationary bar at different handle height. There are significant changes on the shoulder and low back torques due to the hand forces vector.

Furthermore, a basic aspect of the workplace design is by keeping the frequent needs such as products, parts and tools within the easy reach in order to prevent the workers from the awkward movement such as trunk bending or twisted. Easy reach of the tools will prevent the multiple strain on the shoulder and lower back while doing works therefore the rate of being exposed to WMSD will decrease.

Next, proper height during work are important in order to prevent the mismatch of the height between the workers and the tasks which are the common issues at the workplace. This condition will make the tasks become harder. Figure 8 shows the structure of body with the proper height while doing work. The back will be in natural curve as the body following the right posture in line with the height. Therefore, the body is free from the backache which is one of the WMSD symptoms. There are five types of the height mismatch which are out of reach for everyone, optimal individual height, accommodate individual differences, height of materials and height relationships within equipment. Thus, the anthropometry of the workers are taken into account while designing the workplace.

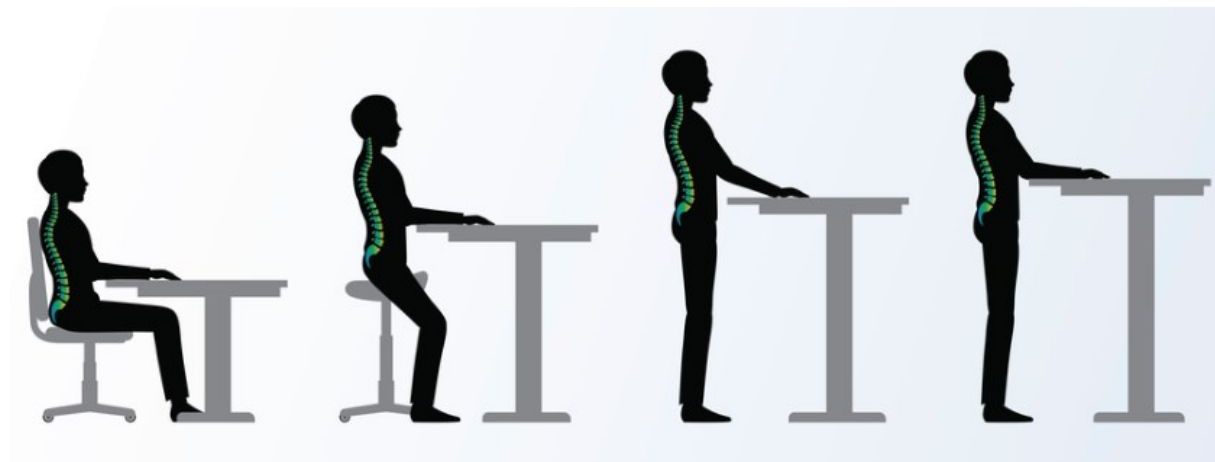


Figure 8. Proper Height During Work [21]

5. Conclusion

The occupational risks are exposed to the workers in automotive industry that involves in manual handling assembly parts especially the welding spot gun. The awkward posture while welding the assembly parts with the repetitive and high loads are the contributors for the WMSDs. Therefore, the risks assessment on the workers should be done periodically to avoid the presence of work-musculoskeletal disorders since it can effect the production of the company. Besides, the company should implement ergonomic workplace from the early design stage of the workplace to avoid risks to the workers.

Acknowledgments

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References

- [1] Szirmai, A. and B. Verspagen, *Manufacturing and economic growth in developing countries, 1950–2005*. Structural Change and Economic Dynamics 2015. **34** p. 46-59.
- [2] Saidani, M., et al., *Heavy vehicles on the road towards the circular economy: Analysis and comparison with the automotive industry*. Resources, Conservation & Recycling 2018. **135** p. 108-122.
- [3] Battini, D., et al., *Assembly line balancing with ergonomics paradigms: two alternative methods*. IFAC, 2015. **48**(3): p. 586-591.
- [4] Ferguson, S.A., et al., *Musculoskeletal disorder risk as a function of vehicle rotation angle during assembly tasks*. Applied Ergonomics, 2011. **42**: p. 699-709.
- [5] Bernal, D., et al., *Work-related psychosocial risk factors and musculoskeletal disorders in hospital nurses and nursing aides: A systematic review and meta-analysis*. International Journal of Nursing Studies, 2015. **52**: p. 635-648.
- [6] Charles, L.E., et al., *Vibration and Ergonomic Exposures Associated With Musculoskeletal Disorders of the Shoulder and Neck*. Safety and Health at Work 2018. **9**: p. 125-132.
- [7] Deros, B.M., et al., *RULA Analysis of Work-Related Disorder among Packaging Industry Worker Using Digital Human Modeling (DHM)*. Advanced Engineering Forum, 2013. **10**: p. 9-15.
- [8] Z.X, W., et al., *The epidemiological study of work-related musculoskeletal disorders and related factors among automobile assembly workers*. Journal of Industrial Hygiene and Occupational Diseases, 2011. **29**: p. 572-578.

- [9] Thun, J.H., C.B. Lehr, and M. Bierwirth, *Feel free to feel comfortable—An empirical analysis of ergonomics in the German automotive industry*. Int. J. Production Economics 2011. **133** p. 551-561.
- [10] Banares, J.R., et al., *A comprehension-based ergonomic redesign of Philippine road warning signs*. International Journal of Industrial Ergonomics 2018. **65** p. 17-25.
- [11] Houshyara, E. and I.-J. Kimb, *Understanding musculoskeletal disorders among Iranian apple harvesting laborers: Ergonomic and stop watch time studies*. International Journal of Industrial Ergonomics 2018. **67**: p. 32-40.
- [12] Garosia, E., et al., *Design and ergonomic assessment of an infusion set connector tool used in nursing work*. Applied Ergonomics 75 2019. **75**: p. 91-98.
- [13] Hochdörffer, J., M. Hedler, and G. Lanza, *Staff scheduling in job rotation environments considering ergonomic aspects and preservation of qualification*. Journal of Manufacturing Systems 2018. **46**: p. 103-114.
- [14] Anyfantis, I.D. and A. Biska, *Musculoskeletal Disorders Among Greek Physiotherapists: Traditional and Emerging Risk Factors*. Safety and Health at Work 9 2018. **9**: p. 314-318.
- [15] Sylla, N., et al., *Ergonomic contribution of ABLE exoskeleton in automotive industry*. International Journal of Industrial Ergonomics 2014. **44**: p. 475-481.
- [16] McAtamney, L. and E.N. Corlett, *RULA: a survey method for the investigation of work-related upper limb disorders*. Applied Ergonomics 1993. **24**(2): p. 91-99.
- [17] Hoozemans, M.J.M., et al., *Mechanical loading of the low back and shoulders during pushing and pulling activities*. Ergonomics, 2004. **47**(1): p. 1-18.
- [18] Macleod, D., *The Rules of Work: A Practical Engineering Guide to Ergonomics*. 2013: United States Of America CRC Press, Taylor & Francis Group.
- [19] Occhipinti, E. and D. Colombini, *A toolkit for the analysis of biomechanical overload and prevention of WMSDs: Criteria, procedures and tool selection in a step-by-step approach*. International Journal of Industrial Ergonomics 2016. **52** p. 18-28.
- [20] Looze, M.P.D., et al., *Force direction and physical load in dynamic pushing and pulling*. Ergonomics, 2000. **43**(3): p. 377-390.
- [21] Ergonomics, U., *Principles of Ergonomics in the Workplace*. 2017.