# The ergonomics body posture on repetitive and heavy lifting activities of workers in aerospace manufacturing warehouse

IOP Conf. Series: Materials Science and Engineering **210** (2017) 012079 doi:10.1088/1757-899X/210/1/012079

# The ergonomics body posture on repetitive and heavy lifting activities of workers in aerospace manufacturing warehouse

**S. R. Kamat[1], N. E. N. Md Zula[1], N. S. Rayme*[1], S. Shamsuddin[1] and K. Husain[2]**
[1]Faculty of Manufacturing Engineering, University of Technical Malaysia Melaka, Hang Tuah Jaya 76100 Durian Tunggal, Melaka, Malaysia
[2]Kolej Unversiti Islam Antarabangsa Selangor (KUIS) Bandar Seri Putra, 43000 Kajang, Selangor, Malaysia

**E-mail:** *syafiqah.rayme@yahoo.com

**Abstract**. Warehouse is an important entity in manufacturing organizations. It usually involves working activities that relate ergonomics risk factors including repetitive and heavy lifting activities. Aerospace manufacturing workers are prone of having musculoskeletal disorder (MSD) problems because of the manual handling activities. From the questionnaires is states that the workers may have experience discomforts experience during manual handling work. Thus, the objectives of this study are; to investigate the body posture and analyze the level of discomfort for body posture of the workers while performing the repetitive and heavy lifting activities that cause MSD problems and to suggest proper body posture and alternatives to reduce the MSD related problems. Methodology of this study involves interviews, questionnaires distribution, anthropometry measurements, RULA (Right Upper Limb Assessment) assessment sheet and CATIA V5 RULA analysis, NIOSH lifting index (LI) and recommended weight limit (RWL). Ten workers are selected for pilot study and as for anthropometry measurement all workers in the warehouse department were involved. From the first pilot study, the RULA assessment score in CATIA V5 shows the highest score which is 7 for all postures and results after improvement of working posture is very low hence, detecting weight of the material handling is not in recommendation. To reduce the risk of MSD through the improvisation of working posture, the weight limit is also calculated in order to have a RWL for each worker. Therefore, proposing a guideline for the aerospace workers involved with repetitive movement and excessive lifting will help in reducing the risk of getting MSD.

## 1. Introduction

Ergonomic comes from Greek word which means “work law”, it also describes as “the effort to fit the system to the human” which means that to fit the unique human limitation and abilities by selecting and designing the informed decision, tasks, environment, tools and equipment. The dimensions that define ergonomics discipline include philosophy, theory, technology or environment, management, design, practice and education [1]. The main focus of this study is to improve the ergonomics body posture of workers in the aerospace manufacturing company.

The warehouse of the aerospace manufacturing company had been chosen because the working process design in the building involves repetitive task and heavy lifting activities. The risk of ergonomics can be seen affecting the workers in the building as they had complained about them experiencing fatigue and pains at certain areas of the body especially at the lower back of the body. The complaints had been retrieved through the distributed questionnaires. All those symptoms and

effects will greatly contribute to repetitive stress injuries (RSIs) and musculoskeletal disorder (MSDs). Both are known as parts of ergonomic injuries. Ergonomics injuries are the bad effects that caused by the existence of the ergonomics risk factors such as awkward postures, sustained postures, contact pressure, forceful exertion, forceful strain and exposure to vibration, heat or cold. When the risk factors combined, and exerted on the worker through a continuous period, the risk factors will lead to injury, pain and disability. As example, in a manufacturing company, if an injury occurs, the dangerous single event will place a stress on body tissues. Although the tissues are capable to recover its condition, the repetitions of the hard manufacturing activity that cause the injury will slower the healing process.

### *1.1. Problem Statement*

Based on the literature review and previous studies, the repetitive and heavy lifting activities can contribute to ergonomics injury. Besides, there are problems detected through the interview session with a manufacturing engineer and data collections of the questionnaires distributed to the workers. The activities in the warehouse involved manual handling task that needs the workers to lift and move heavy objects repetitively. The objects can be referred to tools and aircraft panels which are the products of the company. Although there is equipment such as forklift had been provided by the company to lift big panels, there are still many panels that are cannot be lifted by the equipment. It is due to their sizes and the space provided in the warehouse. All the intentions stated required the worker to lift the panels manually. Besides, the worker had to risk their body to muscle injuries while lifting the panels in order to follow the existing design of work process. According to the questionnaires data collections, majority of the workers had already been experiencing the back pain, shoulder pain and several other pains that related to muscle fatigue when there are too many panels that needs to be lifted. Anyhow, the lack of training about the importance of right manual handling techniques, the least awareness about the serious injuries like MSDs and RSIs can be seen as the main reason why the workers were maintaining their bad manual handling technique although they had already been experiencing the symptoms of the injuries.

### *1.2. Objectives*

Based on the problems arise related to the repetitive and heavy manual lifting activities in the warehouse, the objectives of the study are;

i) To investigate about the body posture of the workers while doing repetitive and heavy lifting activities in the warehouse.
ii) To analyse the discomfort body posture of the workers while undertaken the repetitive and heavy lifting activities that cause the musculoskeletal disorder problems.
iii) To suggest the proper body posture and ways to reduce the musculoskeletal disorder problems.

### *1.3. Scope and Limitations of Study*

This study only focus on the activities that involved the most repetitive and heavy lifting activities that was seen as the critical activities among all the activities involved in the warehouse. The data about the body posture of the affected worker had been retrieved. The musculoskeletal disorder problems of the workers had been retrieved by the distribution of questionnaires to the workers and RULA analysis methods. The working body posture of the workers had been reclaimed by taking the photos and videos of the workers while they are working. The working postures of the workers while performing the repetitive and heavy lifting activities had been observed and determined to be analysed. The ergonomics risk factors that had been studied include; awkward body posture, repetition movement, heavy lifting, contact stress and poor design work process. Besides that, other important things have

been considered in this study are the requirement of the working activities, ergonomics obligation, ergonomics problems and ergonomic principles.

In advance, other aspects such as NIOSH lifting equation, anthropometric measurement, muscle fatigue, musculoskeletal disorder (MSDs) and repetitive stress injuries (RSIs) had been enclosed in this study. The software that had been used to analyse the working body posture is CatiaV5. The working body posture analysis had been done to prove the effectiveness of the body posture improvement. However, the result of the study is only based on the simulation. There are no fabrication activities and real implementation occurred in order to test the suggested improvement. This study did not cover the labour productivity issue.

## 2. Literature reviews

Like in any other manufacturing industry, an aerospace manufacturing industry is also exposed to manufacturing activities that can risk the workers to the ergonomic risk factors [2]. It is important for a manufacturing industry to implement ergonomics technique in the working area because with the existence of proper ergonomics application; cost can be reduced, productivity level can be improved, quality of working can be increased, employee engagement can be improved and better safety culture can be created.

Ergonomics risk factor conferred by the United Stated Occupational Safety and Health Administration includes work environment, body posture, forceful exertion, prolonged static load, repetition, lack of rest and improper aid [3]. Thus, it is necessary for the employer to make sure that the ergonomics risk factor in the worker workstation is at the possible lowest term. In addition to musculoskeletal disorder leading to medical expenses, the ergonomics risk factor can leads to overtime wage, cost of training and hiring for replacement, loss of productivity, management cost and other miscellaneous charges.

In order to offer the worker the finest man-machine boundary and the required adjustability with the aim to prevent discomfort and workplace injuries, a good ergonomic design principles must be practised [4]. An article named “Ergonomic: The backbone of a more productive warehouse” mentioned that workstation design can give big influence on the ergonomic health of the workers and the ergonomics workstation is all about body posture. Body posture while working can be categorised to three types which are standing, sitting and both. The ability of the workstation’s features such as length and height to be adjusted so that its features are compatible to workers anthropometry measurement is a very good ergonomics workstation.

Rapid Upper Limb Assessment (RULA) is an assessment that used to analyse the disclosure of workers to ergonomic risk related to upper extremity musculoskeletal disorder [5]. The things that are mattered by the RULA ergonomic assessment tool are the postural load requirement and the biomechanical of job demand especially on the trunk, upper extremities and neck. The evaluation of the required body posture, repetition and force can be made by only single page worksheet. Both scores for section A which is for the arm and wrist areas and for section B which is for the neck and truck are must be inserted in order to obtain the evaluation score.

The manual handling operations regulation that was altered in 2002 is applied to the extensive assortment of manual handling activities include pulling, pushing, lifting, carrying or lowering. The type of loads may include living thing for instance animal or person, or non-living thing such as trolley or box. It was discussed that the improper manual handling activity is one of the utmost typical causes of the injury happened at workplace [6].

The musculoskeletal disorder can be the effect of the improper manual handling. The risk factors of the MSDs development include; manual material handling, manual labour, awkward postures and existing injury. Repetitive movement is a simple harmonic motion through back and forth movement placed at the equilibrium or the centre point where the optimum displacement on one side is equal to the optimum displacement on the other side as well [7]. The force used for the motion is always focus on the equilibrium location and is directly proportional to the distance from it, and the time interval of each complete vibration is equal to one another. In manufacturing industries, there are many repetition

movements that have to be carried out in order to achieve the requirement of the manufacturing activities. There are manufacturing activities like fitting, saw cutting, manual threading, painting, and machining that requires the worker to work in repetitive movement for the task completion. In warehouse, the manual material handling activity, wrapping activity and lifting activity can be seen as the activities that require the worker to work in repetition motion. However, rapid movement of the repetitive motion activities can risk the worker to the ergonomics injury.

Lifting is an activity in order to bring or move something upward generally from the ground or other support elements to a higher location. In warehouse, it is the main activity that is involved. Lifting in warehouse means to lift the inventory or equipment within the warehouse for receiving, storing, wrapping and shipping purpose. However, if the object to be lifted is heavy and not compatible with the worker, the situation can lead to injury. The biggest risk factors regarding to lifting activity are the cumulative trauma and overexertion [8]. It is advisable for the workers to use smart lifting techniques and only work in their own abilities so that they will be less exposed to muscle pulls, wrist injuries, back sprains, elbow injuries, spinal injuries and any other related injury. There are many causes that can contribute to all those injuries. Some of the causes are incompatible weightiness of loads, awkward body postures, high frequency of materials to be lifted and long durations needed for the lifting activities, inadequate handhold and environmental factors. The important aspects of design are the human fit, function and form in the demanding global marketplace. The best in class human modelling which is the human activity analysis permitted detailed investigation into human centred designation issue regarding to workplace's environment before it is existed. The way a human being interacts with objects in working environment, the effects of lifting activities; pulling, carrying task, lowering and pushing were the focus points of the human activities analysis. The equation used to measure the effects of all those activities is the NIOSH 1981/1991 and Snook and Ciriello equation. CATIA V5 promotes the solution towards ergonomic body posture in two main software tools [9]. The first software tool which is the human measurement editor is used to create detailed digital human model to extended analysis. It is capable of creating human manikin by using complex series of advance anthropomorphic tools and by adaptation of smaller number of crucial variables. The software human builder in CATIA which is the human builder consist from complex sets of tools that are devoted to create the human digital model which called manikin, the manikin manipulation and the interaction analysis with the product. In order to generate the view form, function and comfort, the manikin can be used.

Other than the mentioned tools, CATIA had also provides the analysis of workstation assembly. There are two other software modules has been created in order to fulfil the purpose which are the human activity analysis and the human posture analysis. The interaction between the human and the objects in the working area and the effects of the sinking, lifting, pressing and pulling can be analysed by the human activity analysis software. The software is able to evaluate all the aspects of the human effectiveness through the analysis of the static position to the complex activities by the execution of tasks. The software enables the user to maximize the safety, the comfort and the efficiency by the usage of wide spectrum of trolls to ergonomic analysis which involve complex evaluate the interaction between the manikin and the objects in the virtual environment.

The RULA (Rapid Upper Limb Assessment), push and pull analysis, loading analysis by load lifting according to NIOSH 1991, NIOSH 1981 and Snook & Ciriello, carry and biomechanical analysis. The workstation can be created in accordance with health and safety standards by this tool in order to maximize the safety and comfort. Next software tool provided by CATIA is the human posture analysis which analyse the way human posture influences the productivity by the execution of task. The tool can analyse preferred angles, the local and total postures and convenience. The user can do the quantitative and quality analysis of all the aspects of the manikin postures through the module. In addition, the model allows the user to test postures, generate the evaluation, optimized and iterated the data.

## 3. Methodology

The data collection started by the observation, interview sessions with manufacturing engineer and the distribution of questionnaires to the workers in warehouse department. These are to contemplate with the problem statement of the study. The next phase is the collection of anthropometry measurement of the workers, Nordic questionnaires, photos and videos of the workers while doing their tasks in the warehouse. The flowchart of the study is as in figure 1.

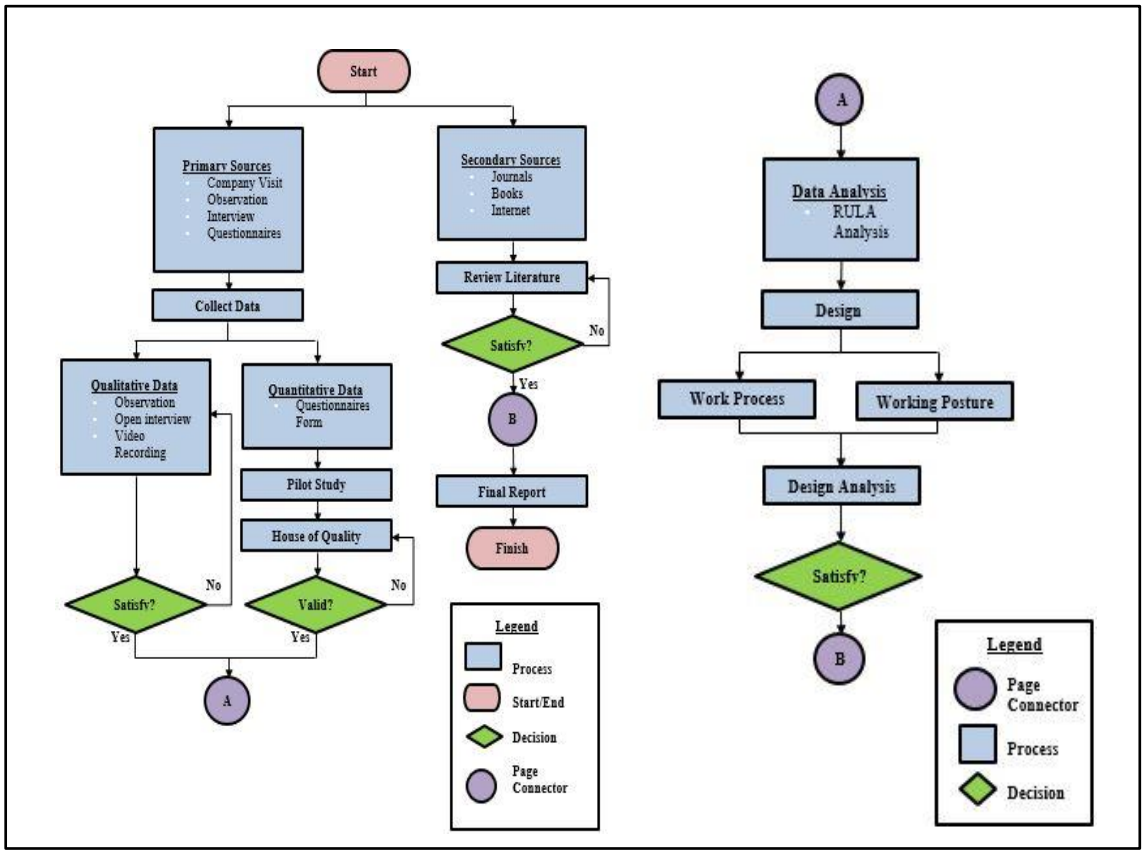


**Figure 1.** Overall flowchart of the study

Several observations had been done in the warehouse including the procedure of working tasks, layout and environmental of warehouse, type of body postures needed to conduct tasks and tools equipped to the workers. Another method that had been used in order to gather the qualitative data is by distributing questionnaires. The questionnaires were distributed to the workers in the company's warehouse. As for the pilot study, ten respondents has been chose for the questionnaires distribution. The respondents were divided into two different categories which are for workers under 30 years old and workers 30 years old and above. For the second phase of the study, more detailed questionnaires had been distributed to twenty workers involving in manual handling activities in the warehouse. The selected type of the questionnaire that will be distributed for the second phase of the project is the Nordic type of questionnaire. The Nordic questionnaire is one of the most known survey tool to detect musculoskeletal disorder [10]. Initially, the standardized Nordic questionnaires were created by an organized Nordic researcher's team. The main objective of the Nordic questionnaires creation is to screen the musculoskeletal disorders and for epidemiological studies.

## 4. Results and Discussion

The first part of data collection was the Nordic questionnaire data, which divided into two parts, Part A for respondents' basic data and Part B for respondent's cognitive data.

### *4.1 Analysis of Body Posture of the Worker While Handling the Tasks*

figure 2 shows the first worker is lifting 30 kilogrammes spoiler core up to 190meters height. The critical working posture involve repetitive heavy lifting activities and awkward working body posture. The frequency of lifting is 2 lift per minute. The middle worker in figure 2 shows a worker lifting a box of vacuum bag sealant weighed 8 kilogrammes from the lower rack. The critical working posture involve repetitive heavy lifting activities and awkward lifting body posture. The frequency of lifting is 3 lift per minute. The worker on the right in figure 2 shows worker is lifting a 7 kilogrammes box from the top storey of a rack. The critical working posture involve heavy lifting activities and awkward lifting body posture. The frequency of lifting is 3 lift per minute.

**Figure 2.** From left to right (Posture A, B and C respectively)

### *4.2 CATIA V5 RULA Analysis and Body Postures Improvement*

Besides analysing the body postures manually using the RULA assessment worksheet, the body postures had also been analysed using the CATIA V5 RULA analysis application software. The alignment of the body postures, the type of working mode involved and the weight of the load involved had been set up and inserted in the software to achieve more accurate RULA score. Then, the body postures had been improved as the suggestion to reduce the musculoskeletal disorder problem.

#### *4.2.1 Working Posture A before Improvement*

Figure 3 shows the working Posture A before improvement and can be considered as awkward body posture as the needs of the worker to raise his arm, hunching his back and involving excess use of the back muscle. Improper lifting or overstressing weak back muscles is the cause of an acute ligament sprain or muscle strain [8]. Figure 3 shows the high RULA score retrieved from the working posture A for right side of body.

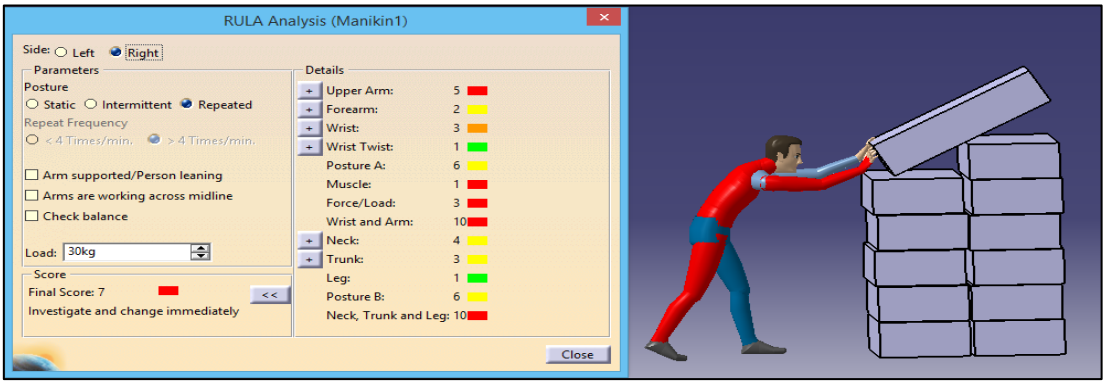


***Figure 3.*** *RULA Analysis for Posture A before Improvement (Right Side)*

*4.2.2 Working Posture A after Improvement*

The working posture A involve the repetitive heavy lifting of 30 kilogrammes load. The load that has to be lifted manually should not exceed 50 pounds which is 22.67 kilogrammes [8]. Otherwise, the manual heavy lifting task can lead to ergonomic related injuries such as back sprains. That is why even the working posture had been improved, the RULA score of the improved working posture is still high for both sides of the body which is 7 as shown in figure 4. The most affected body parts for the lifting activities are the muscle, wrist and arms.

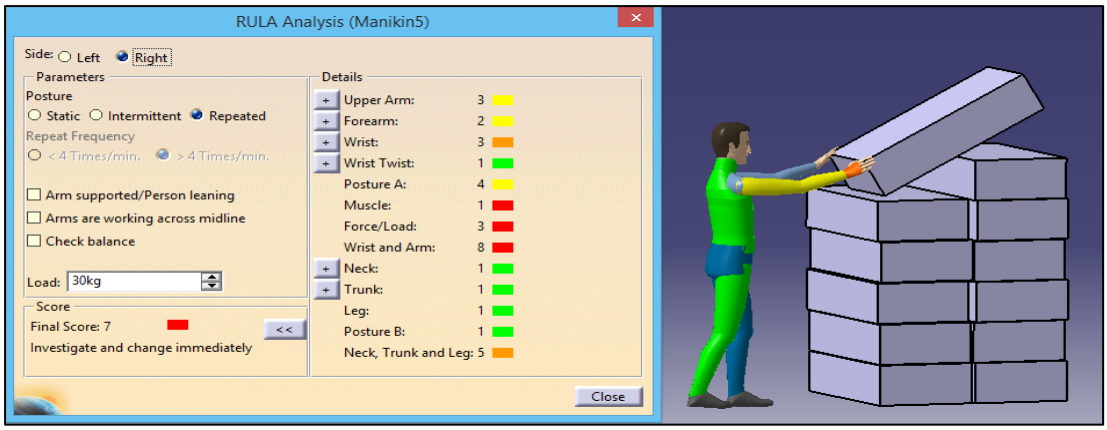


**Figure 4.** RULA Analysis for Posture A after Improvement (Right Side)

*4.2.3 Working Posture B before Improvement*

The working posture B as shown in the figure 5 involved awkward working body postures. The trunk part is bent too low which allow excessing pressure on the lower back of the body. The improper working posture can leads to herniation. Herniation is the condition occurred when a vertebral disk position misallocated or breaks within doing the inappropriate lifting activities [11].

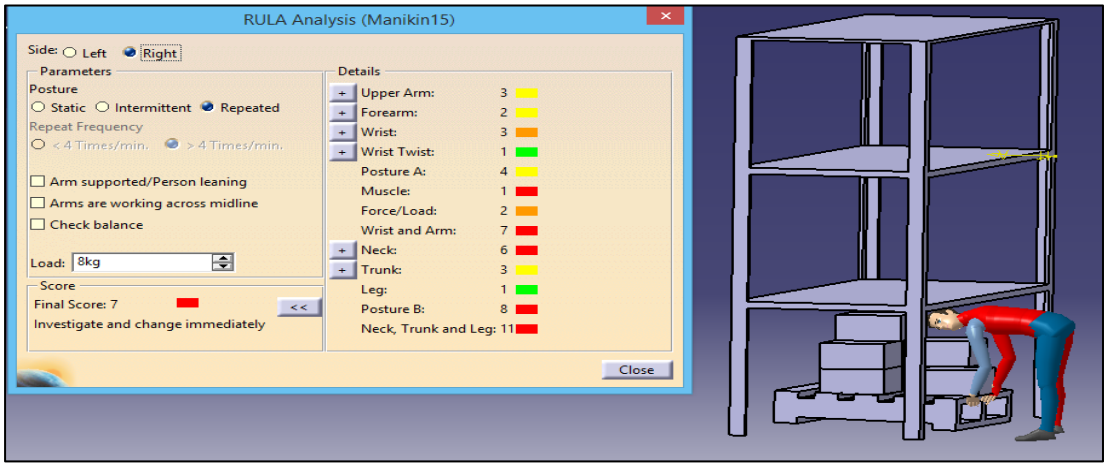


**Figure 5.** RULA Analysis for Posture B before Improvement (Right Side)

*4.2.4 Working Posture O after Improvement*

The RULA score after the working body posture are still high as shown in the figure 6. This is due to the repetitive working mode required to accomplish the lifting task. One of the factors that lead to the lifting related injuries that have to be avoided is the repetitive working mode which requires the worker to exerting force to their muscle repeatedly [8].

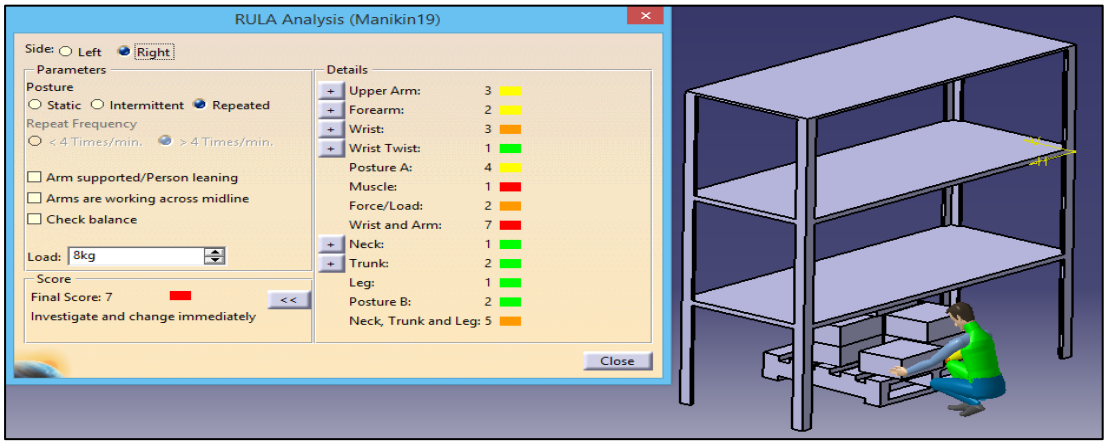


**Figure 6.** RULA Analysis for Posture B after Improvement (Right Side)

***4.2.5** Working Posture C before Improvement*

The working body postures shown in the figure 7 involved the overuse of wrist and arm of the worker. The increment pressure inside the nonflexible anatomical structure in the wrist can leads to the entrapment of neuropathy effect such as carpal tunnel syndrome [12]. Tennis elbow is a painful injury caused of the overuse of the elbow [13].

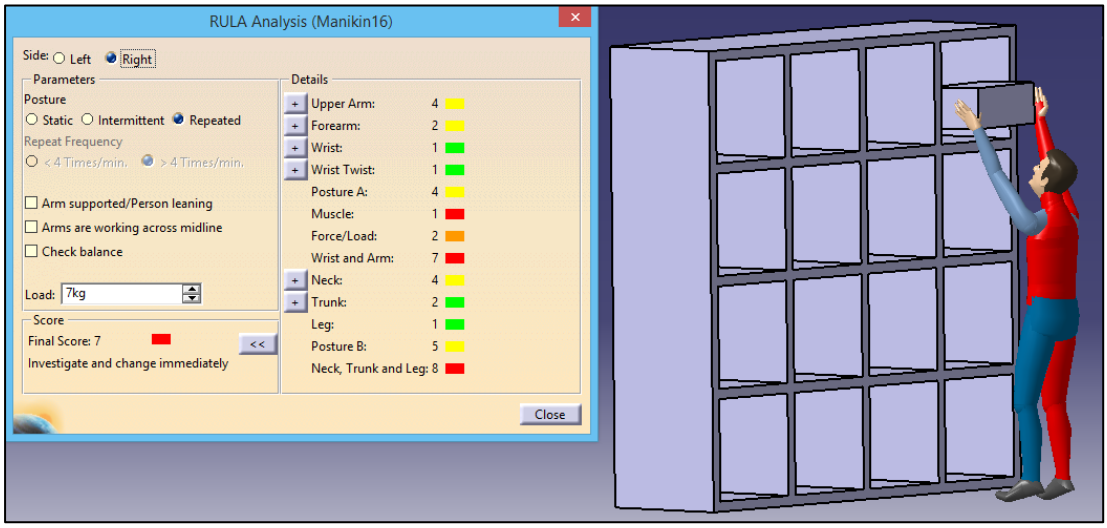


**Figure 7.** RULA Analysis for Posture C before Improvement (Right Side)

*4.2.6 Working Posture C after Improvement*

The RULA scores for the improved working posture C for right side as shown in the figure 8 are still high because of the workstation design is too high which requires the worker to lift up their arm to the maximum height. The employer should implement provide the suitable workstation design to minimize the ergonomic risk factor [14]. In Figure 8, the score is still not improved even though the colour of muscle had changed to green. This is cause by the repetitive movement and suggestions of additional aid device for the workers in order to reduce the score.

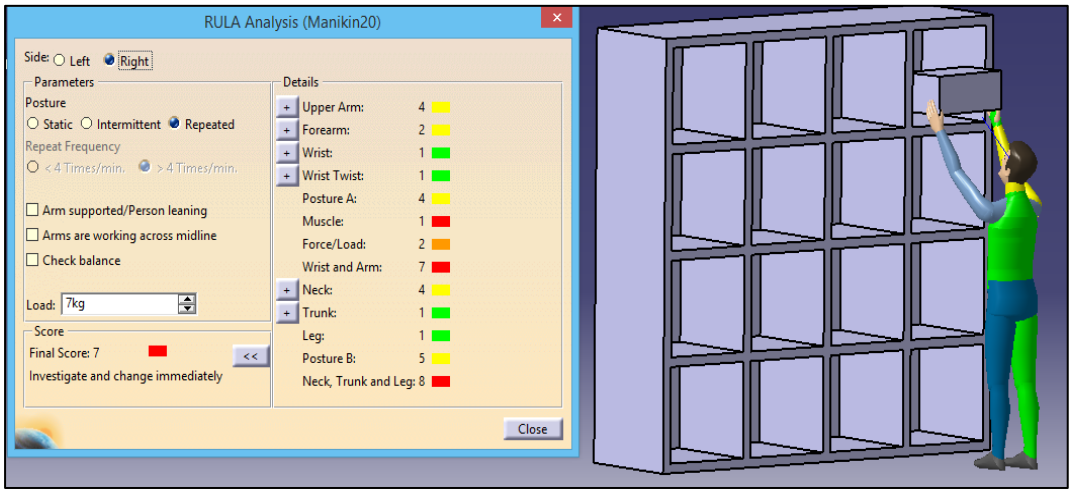


**Figure 8.** RULA Analysis for Posture C after Improvement (Right Side)

### 4.3 Suggestion Aid Portable Gantry Crane

The lifting equipment that had been suggested to replace the manual lifting task is the portable gantry crane. It is a small version of gantry crane that can be moved to replace the manual lifting task inside the warehouse. There are racks located inside of the warehouse that can be the constraints for the overhead crane to reach object in the rack. Therefore, this portable gantry crane can be used to lift objects placed in the rack or at the narrower space which cannot be reached by the forklift. Figure 9 shows the suggested design of the portable gantry crane.

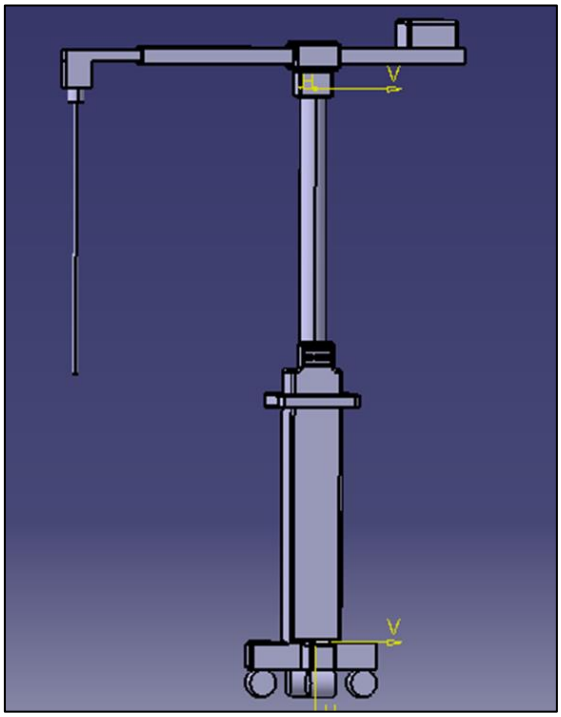

**Figure 9.** Suggested Design of Portable Gantry Crane.

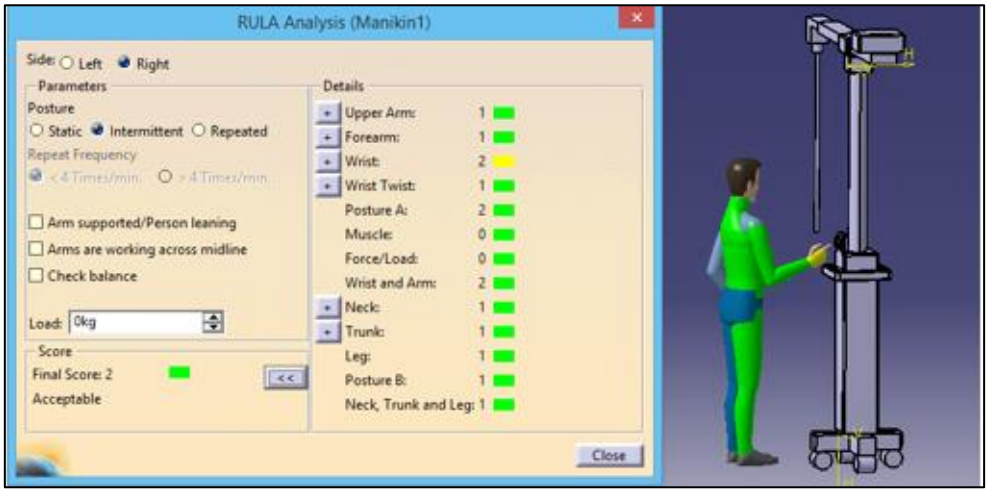


**Figure 10.** RULA Analysis for Worker's Body Posture While Using Portable Gantry Crane (Right Side)

Figure 10 shows the RULA score which is 2 for right side of the body that can be obtained if the manual lifting task inside the warehouse is replaced by the usage of the portable gantry crane. The RULA score 2 is the desired RULA score as it indicates that the posture is acceptable if it is not maintained or repeated for long periods of time [9]. It is favourable if the manual lifting task can be replaced by the usage of automation system to avoid from musculoskeletal disorder problem [6]. The portable gantry crane is an automated lifting equipment. The workers just have to control its axis movement by clicking the switches on the crane.

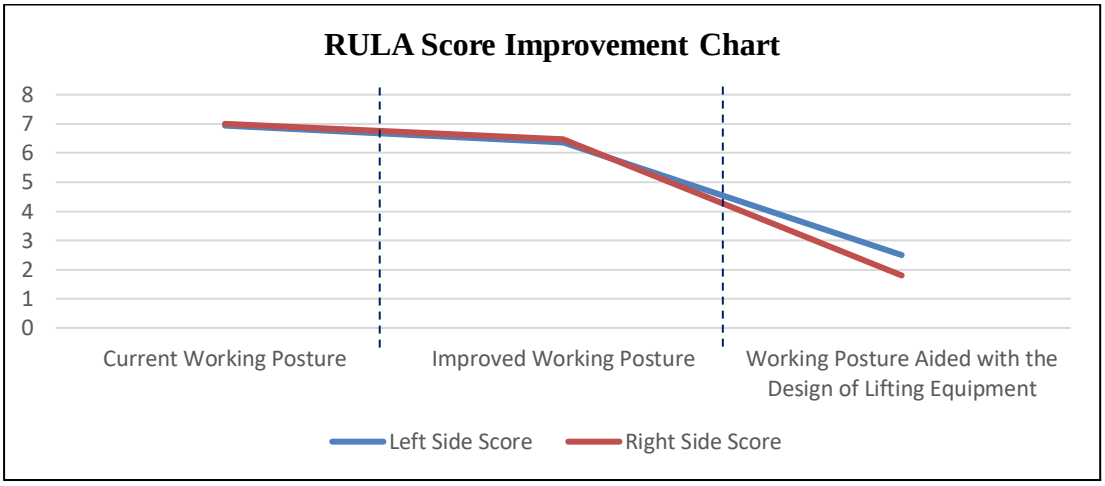


**Figure 11.** RULA Score Improvement Chart

Figure 11 shows the RULA score pattern of the current working posture, improvised working posture and the working posture aided with the design of lifting equipment. The decreasing pattern of the RULA score along the improvement effort is good as the smaller the RULA score, the safer the working posture is toward the ergonomic risk factor [9]. The decreasing value of RULA score from current working posture to the improved working posture is lesser than the decreasing value of RULA score from the improved working posture to working poster aided with the design of lifting equipment. This is due to involvement of heavy lifting task although the working posture is improved. There are many causes that can contribute to ergonomic injuries including muscle pulls, wrist injuries, back sprains, elbow injuries, spinal injuries and other related injury [13]. Some of the causes are incompatible weightiness of loads, awkward body postures, high frequency of materials to be lifted and long durations needed for the lifting activities, inadequate handhold and environmental factors.

## 5. Conclusion

The main idea of this study is to investigate and improve the ergonomics working postures of the workers working in the warehouse which focused on the task related to manual lifting activities. The current working body postures was analysed using CATIA V5 software application to identify whether the working body postures to identify the possible areas of improvement that can be made to reduce the ergonomic risk factor and to reduce the risk of musculoskeletal disorder among the workers. From the RULA analysis by the CATIA V5, even though the posture of the workers is improved by changing the posture, the score is still 7 and its convey a risk of getting ergonomic injuries because of the load of the task is still heavy and repetitions of work still occurs. However, when a design of helping device is added into the working environment, the score of RULA is decreases from 7 to 2. Thus, proved that the suggested working posture and helping device are required in order to reduce the risk of getting ergonomic injuries.

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