Conference Paper

Development of Working Facility to Improve Work Posture at Packaging Section in Organic Vegetable Industry

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Abstract

Working facilities may influence worker's working posture. CV.Tani Organik Merapi (CV.TOM) is an organic vegetables company. The company provides "dingklik" (footstool) for working. While working with "footstool", workers must bend their legs with high bend degrees as well as their back. This poor working posture is caused by bad working facilities. It's important to check the working posture to know whether the improvement of working facilities is needed or not. Ovako Working Analysis System (OWAS) was used to check the badness level of working posture in every CV.TOM's working activities. It's identified that packaging section has the worst working posture. Then it was decided to provide a new working facility to improve working posture in packaging section. CATIA V5 was used to design the new working facility. Three ergonomics tools were used to compare footstool" working posture with the new working facility. Those tools are Rapid Upper Limb Assessment (RULA), Manual Task Risk Assessment (ManTRA), and Rodgers Muscle Fatigue Analysis (RMFA). It was found that the new working facility can substitute "dingklik" with lower posture score and safer.

Keywords: Ergonomics; Catia; Comfortability; Facility; Working posture

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INTRODUCTION

One of the causes for unnatural working posture is the plan and design of work facilities which do not pay attention to the capabilities and limitations of the workers [13]. The deviated posture occurs when there is excessive bent (curved) or rotated joint(s) of the human body. In the deviated position, muscles, tendons, and joints have to work harder, causes fatigue quickly [6]. It can be said that a working posture is categorized as bad if it does not meet the ergonomic principles that focuses on workers' comfort when they are working.

There are various factors in the environment and working system that can affect the working posture, one of which is working facilities. Good working facilities can result in work postures that make workers feel comfortable when working [2]. The quality of working facilities provided by the business owner directly determines the establishment of the working posture. Therefore, the provision of working facilities must be adapted to the ergonomic principles of so that the workers can feel safe when working using the related facilities.

CV. Tani Organik Merapi (CV.TOM) is an industry operates in organic vegetables. CV. TOM provides "dingklik/footstools" as working facilities for the workers. "Footstool" is a small bench with a height of about 15 cm with a narrow space to sit. The workers should use "dingkik" when working. When working using the "footstool", they have to bow and bend their legs with a very high leg bending angle. The working posture is far from normal posture so that it can be regarded as a bad working posture. Working with bad posture can cause the pains in certain body parts and can cause fatigue quickly after starting to work.

The impacts felt by workers as a result of the work done can be classified in the category of work related musculoskeletal disorders (WMSDs). WMSDs should be avoided or at least minimized for the potential. Therefore, there are some improvements on work facilities of CV.TOM to create better and safer work postures for the workers.

In assessing the postures, it used Ovako Working Posture Analysis System (OWAS) and Rapid Upper Limb Assessment (RULA). OWAS and RULA are ergonomic tools that can objectively assess the work postures [5]. After obtaining a work station that has the worst working postures, the design of the work facilities was conducted by using CATIA V5 software. The comparison of the work postures before and after improvement was conducted by using other ergonomic tools, namely Manual Task Risk Assessment (ManTRA), and Rodgers Muscle Fatigue Analysis (RMFA).

MATERIAL AND METHODS

Material

Work related musculoskeletal disorders (WMRDs)

Ergonomic risk is used to express the factors at working activities that can affect the musculoskeletal disorders or often referred to the work that has the MSDs (work related MSDS/WRMSDs) impacts. Ergonomic risk can be defined as physical stress

factors at work within the working environment, where the risk can have an impact on the destruction and pain suffered by workers' musculoskeletal systems. Ergonomic risk is also affected by working conditions, including lighting level, noise level and temperature, weight-lifting activities, and posture that can indicate a deviation from the normal posture [14].

Musculoskeletal Work Related Disorders (WMSDs) are all kinds of pain and illnesses suffered by the workers as a result of their work. WMSDs will have more severe impact when the work is not performed in an ergonomic posture. The indication of a job can cause WMSDs is if the work meets the following criteria [7].

- Performed repeatedly
- Performed in excessive forces
- Performed in idle or static position
- Performed in the presence or resulting vibration around the working environment
- Performed in the condition that requires any part(s) of the body to perform maximally

WMSDs have been already big problems in many industrialized countries and are common causes of lost time production that is quite high. As a result, the prevention of WMSDs becomes an important topic, not only for the welfare of the workers, but also the long-term impact for the industry. The preventions are based on the existing complaints as a whole by performing proper treatment. Ergonomic principles should become a part of the proper treatment, not only to speed up the healing process but also to prevent the repetition of the occurrence of WMSDs [10].

Work fatigue

Fatigue is one of the protective mechanisms of the body to avoid further damage for recovery after taking a break. The term fatigue usually shows varying conditions of each individual, but all of them result in loss of efficiency and a reduction in work capacity and endurance. Fatigue is classified into two types, namely muscle fatigue and general fatigue. Muscle fatigue is a tremor in muscles / pain on the muscles. While general fatigue is usually characterized by the reduced willingness to work caused by the monotony, intensity and duration of physical working, the environment, the mental causes, health status and nutritional state [4].

Planning and designing the working system

The efficient application of ergonomics in designing the working system can result in a balance between the characteristics of workers and job responsibilities. Ergonomics can also increase work productivity, work satisfaction, and workers' safety (both physically and mentally). The working system design is intended to allow people to live and work on the system well; that is achieving the desired objectives through the work, effectively, safely, healthily, and comfortably. [1, 12].

The person conducting the product design has to integrated all information related to work-process, used equipment, machines, work performed, and the workers in order to produce a design that is acceptable and good for all elements. The ability to improve is the primary thing in the design process. This ability can guarantee user's satisfaction, reduce product costs, and increase comfort. It has to be related to ergonomics and workers factors (Human Factor Ergonomics / HFE) [17].

Ergonomic principles are used as references in the manufacture of working tools and facilities in the industry, including the followings [11]:

- Working postures affected by the shape, structure, and placement of working tools.
- Anthropometric sizes on the related body parts as the basis for creating and placing the working tools
- Additional workload from the effect of minimized working environment

Methods

Determination of working station with the worst working posture

There is a determination on which work stations that has the worst working posture by using OWAS tools. In OWAS tools, the length of working hours in one work shift will determine the final score of their postures assessment. Scores of bad working posture, but conducted in a shorter total working time can lower the final score of the assessment as well as the contrary [5].

Further working postures analysis

It is known that the packaging work station has 6 working elements with the worst scores. Therefore, it was decided that the facility improvement will be focused on the

packaging work station. The elements of work with the worst score in the packaging work station will used as a reference in the comparison of the working postures before and after improvement. The worst working elements were further assessed with three ergonomic tools, the Rapid Upper Limb Assessment (RULA) to assess work postures in more detail, Manual Task Risk Assessment (ManTRA) to assess the work risks, and Rodgers Muscle Fatigue Analysis (RMFA) to assess the level of work fatigue [8, 9, 15].

The concept design of working facilities improvement

The concept design was conducted by using the CATIA V5 software. CATIA V5 is software to assist the design process, engineering, and manufacturing. The advantage of this software is that there is a mannequin feature that is adjustable of body posture position and able to directly assess by RULA [3].

The selection of the best working facilities improvement design

There were two concepts of improvement design generated. The design was selected by using the zero one and evaluation matrix. Zero one matrix is used to determine the weight/value of the interests of each function or parameter. While the evaluation matrix is used for decision-making to the parameters that have been given for weights previously [16].

Working posture assessment with the new working facilities

Once the design 1 chosen as the best working facilities and had been tested, there was a re-assessment conducted on work posture by using the new working facilities. Then, the results were compared to the initial working posture (before improvement).

RESULTS

The determination of the work station with the worst working posture

Work posture analysis was conducted on all elements of the work at each work station owned by CV.TOM by using OWAS tools. Work station with the worst elements of work

Table 1: Result of OWAS Analysis.

Element of Work	Score				Initial Code	Initial Score	%Working Time	Final Code	Final Score
	B	*A*	*Le*	*Lo*					
A. HARVESTING									
Picking the vegetables	4	1	3	1	4131.A1	2	13,58	2111.A1	2
Transport to packaging	1	1	7	2	1172.A2	1	3,81	1112.A2	1
Weighing	4	1	2	1	4121.A3	2	0,22	1111.A3	1
B. PACKAGING									
Handling and weighing	2	1	4	1	2141.B4	3	64,13	2141.B4	3
Cutting stem	1	1	4	1	1141.B5	2	12,72	1121.B5	1
Plastic packaging	1	1	4	1	1141.B6	2	16,36	1121.B6	1
Giving barcode	2	1	4	1	2141.B7	3	2,09	1111.B7	1
C. DISTRIBUTION PREPARING									
Distribution into basket	2	1	7	1	2171.C1	2	19,72	1111.C1	1
Checking order	1	1	7	1	1171.C2	1	9,21	1111.C2	1
Moving basket	2	1	7	3	2173.C3	3	0,59	1113.C3	1
Moving basket into pickup	4	3	3	3	4333.C4	4	0,47	1113.C4	1
D. RETAILER DISTRIBUTION									
Unloading basket	4	3	7	3	4373.D1	4	1,23	1113.D1	1
Returning basket	4	3	7	1	4371.D3	2	0,83	1111.D4	1

will be determined as the worst work station. The following is Table 1, showing the results of the analysis on work posture with OWAS.

Explanation:

- B = Body
- A = Arms
- Le = Legs
- Lo = Load

Figure 1: Working Posture at Handling and Weighing Materials Element of Work.

It is known that elements of work of handling and weighing the materials on the packaging work station have the worst OWAS scores. Therefore, the determination of packaging work station as the worst will be the focus of the improvement of working facilities.

Further working posture analysis

There is an analysis conducted on work postures in handling and weighing materials element for the comparison of work postures, before and after the improvement. Here is Figure 1 that shows the working posture at handling and weighing materials element of work.

The first analysis is a working posture analysis with RULA tools. The analysis is performed automatically in CATIA V5 software. The results showed that the legs and back have a bad score. The final score of RULA assessment showed a score of 6 indicating immediate corrective action is needed. Here is Figure 2 showed the results of the analysis of RULA with CATIA V5.

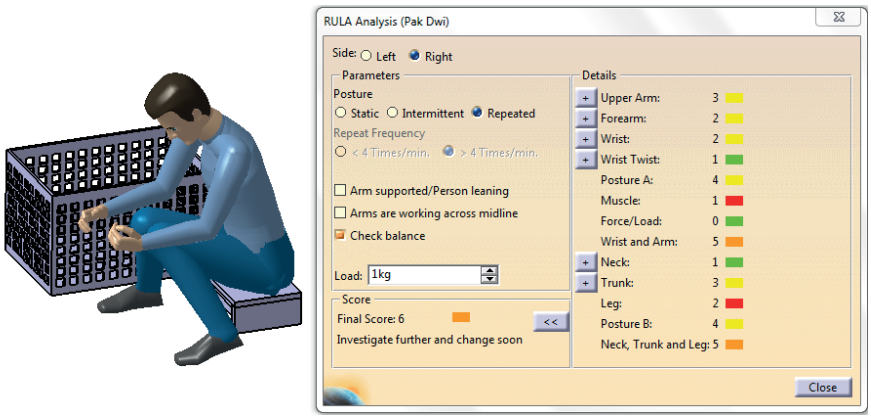

Figure 2: Result RULA-CATIA of Footstool Working Posture.

The second analysis is regarding the risks of working with ManTRA tool. ManTRA assessed the work risks contained in the four parts of the body, the legs, back, neck, and hands. There are three categories that indicated a body region have a risk. There here are.

- If exertion risk reach the maximal score, which is 5
- If exertion risk + awkwardness score is 8 or greater
- If cumulative score is 15 or greater

Showed that the legs meet the criteria for job uncertainty while others are not. Here is Table 2 shows the results of the ManTRA analysis.

The third analysis concern on the level of muscle fatigue with RMFA tools. It is showed that the back has a moderate level of fatigue while the legs and feet got very high levels of fatigue. Here is Table 3 showed the results.

The concept design of working facilities improvement

The concept design was conducted on work facilities improvement for packaging work station with by using CATIA V5 software. There were two design concepts of working facilities generated. Design was adjusted from part of body which has the worst score (legs and back). These designs were distinguished on the basis of the involvement of the existing working facilities (existing in CV.TOM) or not. Design 1 is the completely new working facilities design while the design 2 involves the existing desks. The following is Figure 3 that shows the design 1 and Figure 4 which shows the design 2.

Table 2: Result ManTRA of Footstool Working Posture.

Parameter of Assessment	Score			
	Legs	Back	Neck	Hands
Total Working Time	3	3	3	3
Duration	1	1	1	1
Cycle Time	5	4	3	5
Repetition Risk	3	2	2	3
Force	4	3	1	2
Speed	3	3	2	4
Exertion Risk	4	4	1	3
Awkwardness	4	3	1	1
Vibration	1	1	1	1
Exertion Risk + Awkwardness	8	7	2	4
Cumulative Risk	15	13	8	11

The selection of the best working facilities improvement design

The selection of those two design was conducted by using one zero and evaluation matrixes. Zero one matrix is used to determine the weights of the assessment parameters. There is a determination of 4 parameters that are going to be compared, they are:

- comfort when working with working facilities (parameter a)
- the flexibility of the setting of supporting work facilities (parameter b)
- the ease of moving the working facilities (parameter c)
- suitability of working facilities with the anthropometry of the workers (parameter d).

Each of these parameters will be assessed in pairs. If one parameter is considered more important than others, given for a score of 1, and the automatic parameter for comparison got a score of 0. So that we can find which parameter considered as most important and can be specified for weight for each parameter. The following is Table 4 which shows the results zero one matrix.

After finding weights for each parameter, there was an assessment on the design 1 and design 2 associated with the four parameters. Assessment was conducted on

Table 3: Result RMFA of Footstool Working Posture.

Body Parts	Score			Level of Corrective Action
	Effort	*Duration*	*Freq.*	
Neck	1	1	2	*Low*
Shoulder (R)	1	1	2	*Low*
Shoulder (L)	1	1	2	*Low*
Back	1	3	2	*Medium*
Arms (R)	1	1	3	*Low*
Arms (L)	1	2	2	*Low*
Wrist/Hand (R)	1	1	3	*Low*
Wrist/Hand (L)	1	2	2	*Low*
Legs/Knees (R)	2	4	2	*Very High*
Legs/Knees (L)	2	4	2	*Very High*
Ankles/Feet (R)	2	4	2	*Very High*
Ankles/Feet (L)	2	4	2	*Very High*

Table 4: Result of Zero One Matrix.

Parameter	a	b	c	d	Total
a	X	1	1	1	3
b	0	X	0	0	0
c	0	1	X	1	2
d	0	1	0	X	1

four workers of CV.TOM. The Assessment is conducted by giving rank 1-4 for the parameters. Ranking 1 for parameter that is considered as the most unimportant and 4 for the most important. Ranking will be multiplied by the weight of each parameter and summed. The results of the assessment were made in the evaluation matrix. The following is Table 5 that shows the detail.

From the evaluation matrix, the total number of scores showed that design 1 is more than design than 1. This result indicates that the design 1 preferred by the four assessors than 2 design based on parameters associated with the design. Thus, it was decided that the design 1 is chosen for the prototype creation and tested.

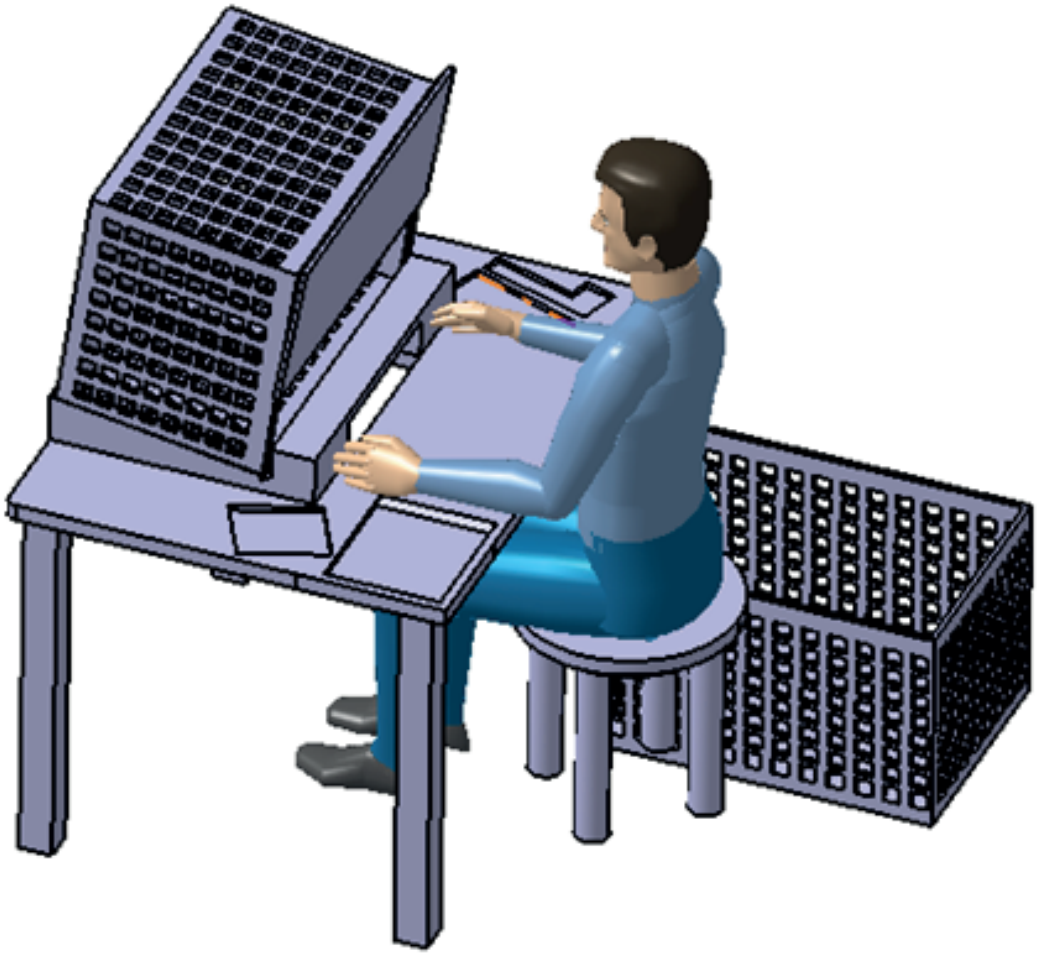

Figure 3: Design 1.

The assessment of working posture with new working facilities

The new working facilities that have been created and tested on working systems and workers of CV.TOM in packaging division. There is a decline in the work cycle time of handling and weighing materials working elements. The initial cycle time is 64.64 seconds, after the workers use the new work cycle time becomes 42.85 seconds. Here below Figure 5 that shows the new working facility.

In addition, the three analysis were conducted again on work posture with the new working facilities. In RULA-CATIA analysis, it found all the body parts that have a low score and a green colored. The final score of RULA has a rating of 2. This indicates the working posture can still be accepted by the body of the workers. The following is Figure 6, which shows the results.

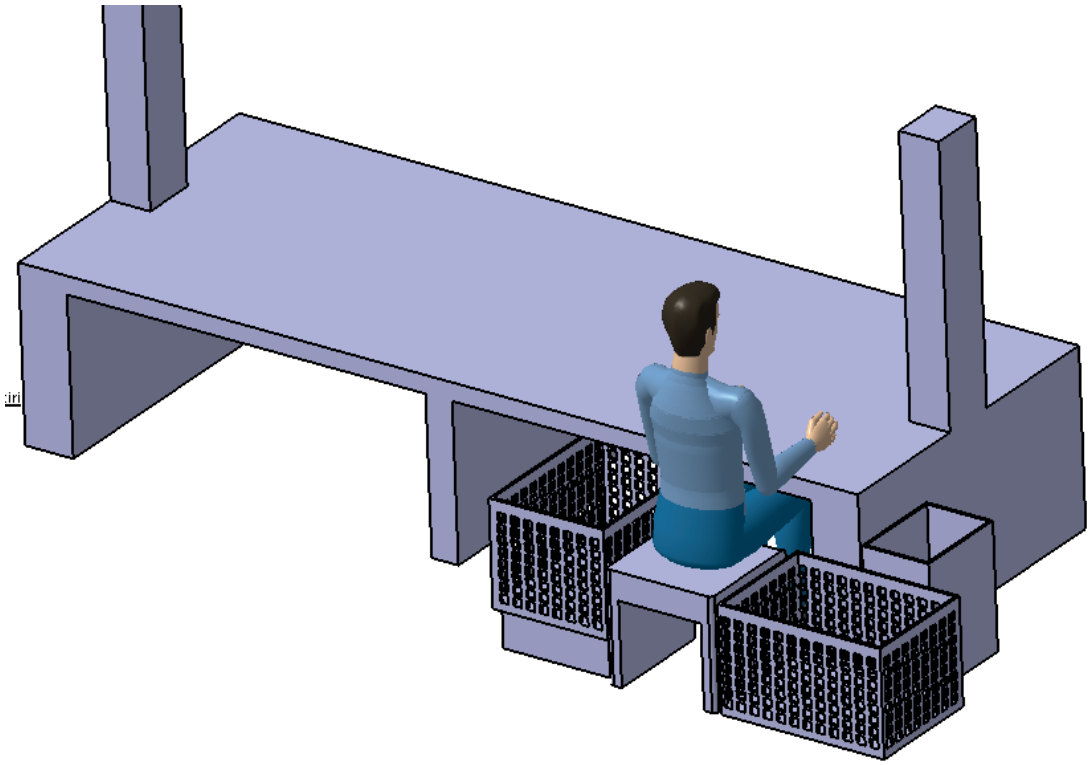

Figure 4: Design 2.

Table 5: Result of Evaluation Matrix.

Design	Workers	Parameter				Total Score	Cumulative Score
		1	2	3	4 (0,2)		
		(0,4)	(0,1)	(0,3)			
1	R	3	1	4	2	2,9	11,4
	S	3	1	4	2	2,9	
	T	3	1	2	4	2,7	
	U	4	1	2	3	2,9	
2	R	2	3	1	4	2,2	7,9
	S	2	4	1	3	1,7	
	T	1	3	2	4	2,1	
	U	2	4	1	3	1,9	

In the ManTRA analysis, it was found that the body parts that have any work risks. This is because of the reduced feet angle that resulted in workers' legs so that the lower the assessment scores. The following is Table 6 that shows the detail.

Figure 5: The New Working Facility.

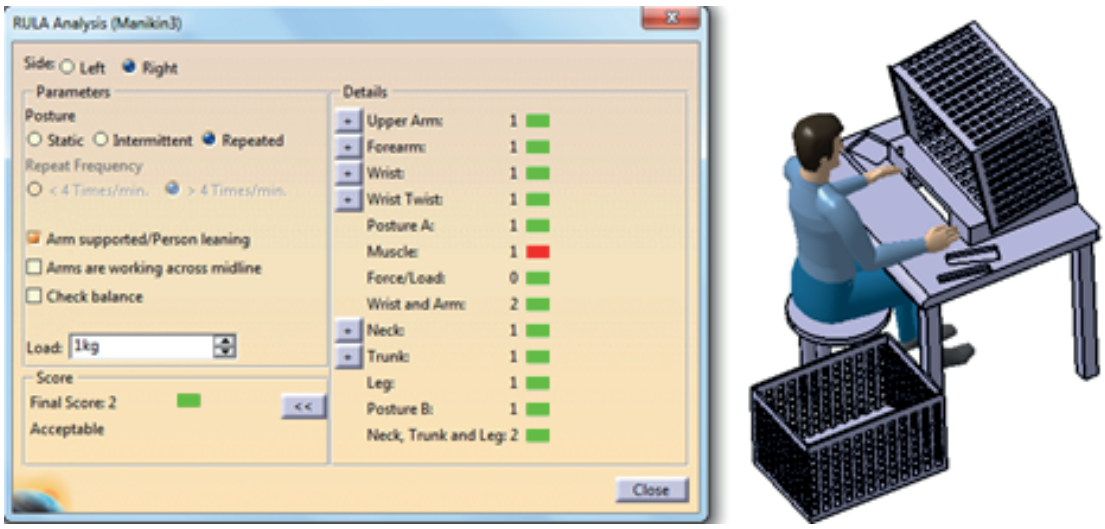

Figure 6: Result RULA-CATIA of New Facility Working Posture.

In RMFA analysis, all the parts of the body have low levels of fatigue. It was the result of an improvement in the posture of the back and legs and decrease the work cycle time. The following is Table 7 that shows the detail.

Of the three the analysis, it obtains the working postures with the new working facility have the scores of working postures, work risks, and lower levels of fatigue when compared to the initial working postures (using the "footstool").

Table 6: Result ManTRA of New Facility Working Posture.

Parameter of Assessment	Score			
	Legs	Back	Neck	Hands
Total Working Time	2	2	2	2
Duration	1	1	1	1
Cycle Time	5	4	3	5
Repetition Risk	3	2	2	3
Force	1	1	1	1
Speed	3	3	2	4
Exertion Risk	2	2	1	2
Awkwardness	1	1	1	1
Vibration	1	1	1	1
Exertion Risk + Awkwardness	3	3	2	3
Cumulative Risk	9	8	7	9

DISCUSSION

This research has two main goals, first is to identifying whole of the element of work in TOM's activity with tools OWAS to decide which element of work have the worst working posture score. Every element of work analyzed by OWAS in 4 sections, there are body, arms, legs, and loads. Combination of those score results the initial score. Then these score combined again with %working time of a day working. %Working time can influence the initial score. When lower initial score meets longer %working time, initial score can be increase the final score. The OWAS result is shown in Table 1. At that table, we know that "handling and weighing" element of work on packaging section has the worst final score. Then the further ergonomics analysis will be focused on this element of work.

The second aim is to make an improvement of working posture at the worst element of work. Before we can do that, we need to make some further ergonomics analysis on the worst element of work. Further ergonomics analysis can be used as a comparison between the initial working posture and working posture with improvement.

The reference of the analysis is "handling and weighing material" working posture shown at Figure 1. It was done with 3 further ergonomics analysis, there are Rapid Upper Limb Analysis (RULA), Manual Task Risk Assessment (ManTRA), and Rodgers Muscle Fatigue Analysis (RMFA).

Table 7: Result RMFA of New Facility Working Posture.

Body Parts	Score			Level of Corrective Action
	Effort	*Duration*	*Freq.*	
Neck	1	1	2	*Low*
Shoulder (R)	1	1	2	*Low*
Shoulder (L)	1	1	2	*Low*
Back	1	2	2	*Low*
Arms (R)	1	1	3	*Low*
Arms (L)	1	2	2	*Low*
Wrist/Hand (R)	1	1	3	*Low*
Wrist/Hand (L)	1	2	2	*Low*
Legs/Knees (R)	1	2	2	*Low*
Legs/Knees (L)	1	2	2	*Low*
Ankles/Feet (R)	1	2	2	*Low*
Ankles/Feet (L)	1	2	2	*Low*

Results of these analyses are exactly mentioned in result section of this paper. RULA analysis has the final score 6 within 1 to 7 range (Fig.2). ManTRA analysis has said that the legs section has a risk (Table 2). And RMFA analysis produce results that back section has medium level of corrective action while legs and ankles section have very high level of corrective action (Table 3). In summary of that three analysis is "handling and weighing material" working posture really need an improvement in order to make the working posture better and safer to the worker.

Legs and back section are the highlight point based on the analysis. Bad posture of legs and back are the main reason caused the "handling and weighing material" element of work became the worst element of work. Legs and back posture in this posture caused by dingklik (footstool) used by the worker. Then if we can provide more ergonomics working facility, the working posture also becomes better and safer.

Software CATIA V5 used to design the new working facility. There are two design. In order to choose the best design, we used one zero matrix and evaluation matrix. Based on those matrixes, design 1 was chosen to build up. Then the new working facility of design 1 tested to the workers. After that, worker's working posture with the new facility was analyzed again and the analysis results were compared.

The new working posture has better score compared to the initial working posture (using dingklik). RULA analysis shown final score of 2, there was no risk in all of body section in ManTRA analysis, and all of body region have low level of corrective action. In addition, working's cycle time was also decline from 64.64 seconds to 42.85 seconds if worker work using the new facility.

CONCLUSSIONS

From the research above, it can be concluded that:

1. Packaging working station is the work station with the worst working posture. It can be caused by the handling and weighing the materials that have the worst scores from OWAS analysis.

2. The new working facilities in the form of packaging desks are proved to improve the working posture in the packaging work station. It is stated by the analysis scores related to the reduced working posture from the initial working posture. The RULA-CATIA score decreases from 6 to 2, the ManTRA results showed that there is no work risk on all of body parts, and RMFA results showed the low fatigue level on all of body parts. In addition, the working cycle time of handling and weighing materials element decreases from 64.64 seconds to 42.85 seconds.

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