WORK RISK ASSESSMENT TOWARDS WOOD FURNITURE PRODUCTION ACTIVITIES USING MANUAL TASK RISK ASSESSMENT METHOD AND RODGERS MUSCLE FATIGUE ANALYSIS METHOD

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ABSTRACT

Work risk will affect directly to worker's health and indirectly to company. High risk level led to ineffective work time and work result will not be at its maximum. The purpose of this research was to assess work risk value of activities for identified the factors, body region which affected, and improve condition. This research focus on three activity of furniture production: "Cutting", "Assembly put on" and "Cut HPL". These activities are analysed used simple tool, manual risk assessment and Rogers Muscle Fatigue Analysis. The result showed that Assembly activity has the highest risk level although it revealed consequences on the body region start from the neck to lower limb. To reduce the risk to the appropriate level, the research proposed three improvements: (1) moving the job on the table, (2) allowing rest time in the middle of the activity to relax the muscle and (3) changing movement of the worker to avoid risk.

Key words: work risk assessment, ManTRA method, Rodgers Muscle Analysis Method.

1. INTRODUCTION

Work risk could be caused by many things, such as workplace and workers' postures. Work risk came up because of unhealthy workplaces, such as vibrations, excessive force, and contact pressure. [1]. Bad work posture and repetitive movement could create work risk too [1]. Both of them could cause musculoskeletal disorder or MSD [23]. MSD provoke loss of work time, injured workforce, and increased labor costs [1]. MSD could lead to injuries and disorders of the muscles, tendon, or others [18]. Safety and health management could help prevent the accidents or ill caused work risk at workplace. One of the ways to start safety and health management was to conduct work risk assessment.

There was a considerable amount of literature on work risk potential analysis. Consider, for example, studies conducted by Rahman (2015), Ansari (2014), Abedini (2013), Moussavi (2012), and Weigall (2005). All of them were about evaluating work risk but with different method and population. Rahman used RULA method, the population at ceramic manufacture's workers of Bangladesh. Rahman established the correlation between productivity and bad work posture. Ansari used RULA and REBA method, the population at small scale industry at MIDC wardha India. Ansari utilized software to get the results. Abedini used NIOSH and MAC method, the population at rubber industry's male workers, with the sample of people who were involved in MMH and lifting activities. Abedini showed relationship between MAC and the NIOSH method with statistical test. Weigall used ManTRA and RULA method; the subjects are workers in the cleaning industry steering committee.

Few researchers had addressed the issue of work risk assessment with several methods and subjects, such as ManTRA and rula method for cleaning activity [26]. This research used ManTRA and Rodgers Muscle Fatigue Analysis method for wood production activity. Both methods completed each other. The assessment used main activity in furniture production; cutting activity, assembly activity, put on and cut HPL activity.

The purpose of this research were to identify work risk factors at workplace, identify body region which affected by factors, and improvement to eliminate the factor. All activities assessed by all methods. Methods completed each other because every

method had its own classification and advantages over the other. Improvements had been applied to improve the work and the results had been assessed after the improvement applied to the work with similar methods.

2. METHODS

The three step processes to identify hazards or risks were (1) hazard identification, (2) risk assessment, and (3) risk control [7]. The two main methods used in this research were manual task risk assessment method and Rodgers Muscle Fatigue Analysis. This research used another tool; which is Hazard Identification Simple Tool. The tool used to identify whether there were any work risk factor or not for further action [20]. Knew the activity had work risk factors first, and then the assessment continued in depth assessment to identify the type of affecting factors. The others method needed for depth work risk assessment. Main methods needed different type of data. The main data sources used in this research were time of activities and conditions of work.

2.1. Time Activities and Condition of Work

The main activities in wood furniture production were (1) cutting activity, (2) assembly activity, (3) put on HPL (High Pressure Laminate), and (4) cutting HPL (Figure 1). Activity 3 and 4 were in one group because it had to be done together. Workers did all main activities in sequence for eight hours. The first two hours for activity 1, the next four hours for activity 2, and the next two hours for activity 3 and 4. Workers did the same activities every day. The reasons why the other activities in wood furniture production did not assess this research were because the other activities were not done every day and just complementary activities.

Both of activity time and condition of work were obtained from observation. There were several types of activity time used in this research; which were total time, duration, cycle time, and effort duration. Conditions of work described how workers do their activities, which were strength to do the activity, speed of movement, body posture worker when they do the activity, exposure vibration, effort type, and frequency of effort. Rodgers Muscle Fatigue Analysis method just needed three types of data, which were effort type, effort duration, and frequency of effort [5]. The other types of data belonged to ManTRA method.

Figure 1. Conditions of Work

Assembly activity had four work elements; (1) take cut of wood, (2) organize cut of wood, (3) take machine, (4) assembly (Figure 2). Work location of assembly activity was on the floor, therefore worker had to squat to do his activity. There were some critical position for assembly activity; (3-1) hand reaching sideways more than 30 cm from the body, (3-2) bending the back forwards more than 20 degrees, (4-1) twisting and grabbing actions with the hands or arms also excessive bending of the wrist, (4-2) working with one hands above shoulder height [24].

Figure 2. Critical Position of Assembly Activity

2.2. Manual Task Risk Assessment Method

Manual task risk assessment method (ManTRA) was an audit tool developed by Robin Burgess-Burgess-Limerick, Leon Straker, and Clare Pollock. ManTRA had two aims; the first one was to assist inspectors in auditing workplaces industries with the standard of Queensland Manual Task Advisory and there was no limitation about the type of the industry. All type of industries could use this tool. The second

one was to assess the exposure of work risk factors in the workplace to the workers [6].

A hazardous manual task was a task that related with repetitive or sustained force, high or sudden force, repetitive movement, sustained or awkward posture, and exposure to vibration [24]. On the other hand, there were three variable ergonomic which had relations with musculoskeletal; force, body posture, and repetition [13]. ManTRA method used that entire factor hazardous manual task and variable ergonomic as assessment factors. ManTRA had five assessment factors; they were total time, repetition risk factor, exertion risk factor, awkwardness, and vibration. All of the factors assessed each four body regions (lower limbs, back, neck/shoulder, and arm/wrist/hand). Each body region was assessed independently because each body region had a load difference and if one body region was overload it could cause injury [6]. The assessment would see the task as a whole, not individual task element. The result of assessment could not be generalized but just for a specific person performing the task. Each factor would have score; the score could describe condition of the factor at workplace. A high risk indicated by a maximum score for exertion for any body region (score 5), or a high combined exertion and awkwardness score (score 8 or greater), a high cumulative score for all of the factors (score 15 or greater).

Every table assessment contained scale (from 1 until 5) and explanations to describe every scale. But there were some scale that did not have explanation, so explanations should be added to support the assessment. For example, awkwardness factor had no exact number to describe the scale, only general explanation. Therefore, this research used biomechanical model to support the back posture assessment. Biomechanical model had five categories to describe back posture; vertical or 0°, bent ¼ of the way or 0°-23°, bent ½ of the way 23°-45°, bent ¾ of the way 45°-67°, and horizontal 67°-90° [4]. Table 1 showed a modification explanation each scale for assessment back posture in awkwardness factor.

TABLE 1. Modification Back Posture Factor (ManTRA Method)

Scale	1	2	3	4	5
Ori-ginal	All postures close to neutral	Moderate deviations from neutral in one direction only	Moderate deviations in more than one direction	Near end range of motion posture in one direction	Near end range of motion in more than one direction
Bio-Mecha-nical model	Vertical (0°)	Bent 1/4 of the way (0°-23°)	Bent 1/2 of the way (23°-45°)	Bent 3/4 of the way (45°-67°)	Horizontal (67°90°)

Explanation for ManTRA method would be explained with assembly activity as the example. Repetition score and exertion score should be known first (Table 2 and Table 3). Repetition score was a combination between duration code and cycle time code using the following key [6]. If the duration and cycle time code got higher, then the repetitive score also got higher. Duration was a typical time in a day for a task performed without a break [26]. The longer duration, the greater duration code. Cycle time was a typical time for the task to start and finish [6]. The faster the cycle time, the greater the cycle time code. Exertion score was a combination between force code and speed code using the following key [6]. If force and speed code got higher, then the exertion score also got higher. The capability of the person would determine the maximal force [6]. Force related to amount of effort or amount of pressure to do as the activity demands [18]. The code 3 for speed was reserved for static task only [6]. The greater the force and speed, the greater the exertion score. Repetition score and exertion score would combine with the score of total time, awkwardness, and vibration. Total time was work time in a day [6]. The longer the total time, the score would increase. Awkwardness related to body posture when workers did their activity. Awkward posture determined by range of motion, the farther a joint from neutral posture the more awkward the posture becomes [18]. Each body region assessed independently for work risk factors (Table 4). The greater the amplitude, the greater the vibration score. Score from Table 4 would be summed in accordance with the indication of high risk.

TABLE 2. Repetition Score for Assembly Activity (ManTRA Method)

Lower Limbs		
Duration	Cycle Time	**Repetition**
4	2	**4**
Back		
Duration	Cycle Time	**Repetition**
4	2	**4**
Neck/ Shoulder		
Duration	Cycle Time	**Repetition**
4	2	**4**
Arm/ Wrist/ Hand		
Duration	Cycle Time	**Repetition**
4	2	**4**

TABLE 3. Extertion Score for Assembly Activity (ManTRA Method)

Lower Limbs		
Force	Speed	**Exertion**
3	3	**4**
Back		
Force	Speed	**Exertion**
4	3	**4**
Neck/ Shoulder		
Force	Speed	**Exertion**
4	3	**4**
Arm/ Wrist/ Hand		
Force	Speed	**Exertion**
3	3	**4**

TABLE 4. Factors Score for Assembly Activity (ManTRA Method)

Lower Limbs				
Total Time	Repetition	Exertion	Awkwardness	Vibration
2	4	4	5	1
Back				
Total Time	Repetition	Exertion	Awkwardness	Vibration
2	4	4	2	1
Neck/ Shoulder				
Total Time	Repetition	Exertion	Awkwardness	Vibration
2	4	4	2	3
Arm/Wrist/ Hand				
Total Time	Repetition	Exertion	Awkwardness	Vibration
2	4	4	3	3

2.3. Rodgers Muscle Fatigue Analysis Method

Rodgers Muscle Fatigue Analysis method has a hypothesis; it was that if rapidly worker feels fatigue so more susceptible to injury and inflammation [5]. This method will assess for each of seven body region; that are neck, shoulders, back, arms/elbow, wrists /hands/fingers, legs/knees, and ankles/feet/toes. Assessment have done for right and left region of shoulders, arms/elbow, wrist/hands/fingers, legs/ knees, and ankles/feet/toes. There are three factors that used in assessment; effort type, duration of effort, and frequency of effort. Combination score of three factors seen as a code which determine category of priority risk factor [5]. Base on table Category Scores Grouped by Priority for Change in the Order of Effort, Continuous Effort Duration and Frequency from Thomas E Bernard, there are four categories; low, moderate, high, and very high. The work should be improve when the priority risk factor was in very high category, but it is important to assess task after the improvement applied to the work with the same tool to be sure the category changed to a lower level [5]. Explanation for Rodgers Muscle Fatigue Analysis method would be explained with assembly activity as example. The scores are a transformation from work condition to a code for every factor.

TABLE 5. Scores for Assembly Activity (Rodgers Muscle Fatigue Analysis Method)

Body Region		**Effort**	**Dur**	**Freq**
Neck		2	4	2
Shoulders	Right	3	1	3
	Left	2	1	3
Back		2	4	2
Arms	Right	3	2	2
	Left	1	2	2
Wrists	Right	3	1	3
	Left	2	1	3
Legs	Right	2	4	2
	Left	2	4	2
Ankles	Right	2	4	2
	Left	2	4	2

3. RESULTS

From ManTRA method, there are some factors cause activities in risk category. The results score for assembly activity can be seen in Table 6. Result score for cutting activity, put on and cut HPL activity obtained by same step with assembly activity. The bold one show that factors affected some body regions. The factors are duration, force, speed, and awkwardness. Long duration to do the activity in a day higher the risk because muscles require energy and metabolism will produce waste products [12]. That leads muscle to fatigue and pain [12]. Force and speed have combined to exertion risk factor. High exertion to do the activity is extra work for muscle. Wrong body posture when worker to do their

activities can lead to awkwardness posture. This factor is the prime factor which made activities in high risk level. Almost every worker postures are awkwardness posture. That is because condition of work did not ergonomic so worker forced to do wrong posture.

TABLE 6. Score for Assembly Activity (ManTRA Method)

Type of Score	Lower Limbs	Back	Neck/ Shoulders	Arm/ Wrist / Hand
Sum Exertion & Awkwardness	**9**	6	6	7
Cumulative	**16**	13	**15**	**16**

TABLE 7. Score for Cutting Activity (ManTRA Method)

Type of Score	Lower Limbs	Back	Neck/ Shoulders	Arm/ Wrist/ Hand
Sum Exertion & Awkwardness	**6**	6	7	10
Cumulative	**11**	11	**12**	**16**

TABLE 8. Score for Put On and Cut HPL (ManTRA Method)

Type of Score	Lower Limbs	Back	Neck/ Shoulders	Arm/ Wrist/ Hand
Sum Exertion & Awkwardness	**11**	11	10	11
Cumulative	**6**	6	**4**	**5**

The results category priority Rodgers Muscle Fatigue Analysis method for three activities can be seen in Table 9. Result category for cutting activity, put on and cut HPL activity obtained by same step with assembly activity. Category risk obtain from saw combination score Table 5 in Table from Thomas E Bernard. There are two factors causes activity in high risk level. The factors are effort type and effort duration. Workers do various type efforts, such as head forward, shoulder holding weight with arms away from body, squatting position, and fingers have to do pinch grips. Those are efforts including in awkward posture which have to be avoided [24]. Based on observation, there are two reasons why worker did high effort; the demand from activity or there is something incorrect in their work method. Work method will affected worker movement, if incorrect method is incorrect so worker movement can be incorrect too.

TABLE 9. Results Category Priority for Activities (Rodgers Muscle Fatigue Analysis Method)

Body Region		Assembly	Cutting	Put on & cut HPL
Neck		**Very High**	**Very High**	Moderate
Shoulders	Right	**High**	Moderate	**High**
	Left	Moderate	Moderate	Moderate
Back		**Very High**	**Very High**	Moderate
Arms	Right	**High**	Moderate	**High**
	Left	Low	Low	Low
Wrists	Right	**High**	**High**	**High**
	Left	Moderate	Low	Moderate
Legs	Right	**Very High**	Moderate	Moderate
	Left	**Very High**	Moderate	Moderate
Ankles	Right	**Very High**	Moderate	Moderate
	Left	**Very High**	Moderate	Moderate

Hazard Identification Simple Tool shown that activities have high priority to need some further action for improves the work condition. Every activity and each body region have various results. Both of subjects have almost same result, but worker A has more body region which affected that worker B because worker A has quicker movement that worker B.

Almost all of left body region in low risk level. Worker focus use right body region, especially right hand, to do the activity so right body region have more load than left body region. That is causes right and left body region in different risk level.

Assembly activity is the one activity which affected lower limb from result both of methods. Worker must do squatting position when they want to assembly, because work location for assembly activity on the floor (Figure 2). Squatting position influence the blood circulation therefore the work risk in high level therefore squatting has high risk [24].

4. DISCUSSION

Hazard Identification Simple Tool could not be used in depth assessment because the result just to identify the activity related work risk or not. Therefore, ManTRA and Rodgers Muscle Fatigue Analysis used in depth assessment for knew risk level and what body region that affected by work risk factors.

Two main methods and one tool that used in this research have some similarity and differences. Each method has its own assessment factors (Table 8). Hazard Identification Simple Tool and ManTRA have similarity factors; force, awkward posture, and repetition. Rodgers Muscle Fatigue Analysis have different factors with two others method.

Hazard Identification Simple Tool did not analyse specific body region, on the other hand ManTRA and Rodgers Muscle Fatigue Analysis have specific body region that assessed by assessment factors (Table 9). In ManTRA and Rodgers Muscle Fatigue Analysis, all of the factors assessed each of body regions. However, assessment factors in Hazard Identification Simple Tool did not assess each of body regions. Each assessment factor assessed different body region, such as awkward/fixed posture factor assessed neck, hand, elbow, lower limb, and wrist but repetition factor assessed neck, hand, elbow, wrist, and shoulder. Awkward/fixed posture factor assessed lower limb and did not assess shoulder, on the other hand repetition factor assessed shoulder and did not assess lower limb. Body region that assessed by Rodgers Muscle Fatigue Analysis more specific than ManTRA, however ManTRA has more assessment factor than Rodgers Muscle Fatigue Analysis. Therefore both of methods are completely each other to enrich the assessment.

TABLE 10. Assessment Factors for Each Method

Hazard Identification Simple Tool
Gripping
Force
Awkward/Fixed Posture
Repetition
Other Factors
ManTRA
Total Time
Repetition Factor (Duration & Cycle Time)
Exertion Factor (Force & Speed)
Awkwardness
Vibration
Rodgers Muscle Fatigue Analysis
Effort Type
Effort Duration
Effort Frequency

TABLE 11. Body Region that Assessed by Assessment Factors for Each Method

Hazard Identification Simple Tool
No specific body region
ManTRA
Lower Limbs
Back
Neck/Shoulder
Arm/Wrist/Hand
Rodgers Muscle Fatigue Analysis
Neck
Shoulders
Back
Arms/Elbow
Wrists/Hands/Fingers
Legs/Knees
Ankles/Feet/Toes

Risk level should be reduce to prevent long term consequence which caused by the factors. If there is not any improvement applied to reduce risk level, it could affect worker's health. The prevention should include know the signs or symptoms by notice workers' report and analyse that report, recognize risk indicators, every equipment must have information about standard operational procedure to reduce exposure, and look for work risk during workplace inspections [18].

Others improvements can be applied to the activities. First, worker must rest for a moment in the middle do the activities to prevent the long duration. The risk increases when the same body region repeat same motion without some breaks or chances for rest [18]. Rest could make muscle relax and release fatigue. Impact of this improvement could not see directly but worker could feel the difference. Second, to prevent risk position when workers do assembly activities the location should move from on the floor to on the table. Worker would not do squatting position again if the location moved. It can reduce the risk at lower limb (Table 11). After the location moved to on the table, speed of arm/wrist/hand was decreasing too because worker haven't used to done the assembly on the table (Table 10). Third, change movement worker when they do the activity. There are some movements in the risk category, such as extension or flexion. After worker knew to decrease amount of extension or flexion, score of arm/wrist/hand posture was decreasing (Table 11). Result from

implements the improvement are sum exertion & awkwardness score and cumulative score decreased (Table 12). Score of back and neck/shoulder did not change.

TABLE 12. Extertion Score after Improvement Applied

Lower Limbs			Arm/ Wrist/ Hand		
Force	Speed	**Exertion**	Force	Speed	**Exertion**
3	3	**4**	3	2	**3**

TABLE 13. Score Factors after Improvement Applied

Lower Limbs				
Total Time	Repetition	Exertion	Awkwardness	Vibration
2	4	4	3	1
Arm/Wrist/ Hand				
Total Time	Repetition	Exertion	Awkwardness	Vibration
2	4	3	2	3

TABLE 14. Result Score after Improvement Applied

Type of Score	Lower Limbs	Arm/ Wrist/ Hand
Sum Exertion & Awkwardness	7	5
Cumulative Score	14	14

5. CONCLUSION

Production activities have some work risk factors, especially at workshop al partnership. Manual task risk assessment method and Rodgers Muscle Fatigue Analysis method discovered the factors which affected worker; effort type, duration of effort, and frequency of effort, force, speed, duration, and awkwardness. Assembly activity has higher risk level than two others activities. Assembly activity affected almost all body regions, from neck to lower limb. While two others activities affected upper limb only. There are three improvement applied to the activity; move the location of assembly activity to on the table, workers need rest for a moment in the middle of time work to relax the muscle, and change movement of the worker when they did their activity to avoid risk movement. The implementation has impact to decrease the risk level.

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