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THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND MUSCULOSKELETAL DISORDERS (USING THE RULA, GPAQ AND NBM METHODS)

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Abstract

This research at PT Inspira Multi Karya, a furniture-producing company where most activities are done manually. Lot of physical activities may cause workers to suffer from musculoskeletal disorders (MSD) whose symptom are feelings of pain and discomfort in muscles. Therefore, this study aims to see the relationship between physical activity and MSD complaints and also the sensitivity of tools for improving work systems. Tools to measure physical activity used the Global Physical Activity Questionnaire and tools to measure MSD complaints used Rapid Upper Limb Assessment and Nordic Body Map. The observed operators total 15 people, working at 6 different workstations with different postures. Interesting findings show that there is a significant correlation between physical activity and complaints of musculoskeletal disorders. When physical activity increases, MSD complaints also increase. The research findings show that 60% of operators have a work posture that needs immediate attention to be corrected because it has a high chance of causing MSDs complaints. The body parts that experience the biggest subjective complaints of MSD are the left calf, waist, forearm, back, right hand, and right calf. Mainly urgent repairs need to be done on the press machine (operators work in static postures for more than 10 minutes, with a lifting load of 2 kg-10 kg). Improvements were made by increasing the height of the base of the press machine as high as 50 cm. The improvement of work system can reduce MSD score from 7 to 4 in RULA scale. A comparison of the three methods shows that the RULA is the most suitable methods for analysing MSD in furniture factories because it can analyse upper/lower extreme body postures, both in static and dynamic postures, with repetitive activities, with loads, and carried out for a long time.

Keywords: Rapid Upper Limb Assessment, Musculoskeletal Disorders, Global Physical Activity Questionnaire, Nordic Body Map, Furniture Manufacturing Company.

Introduction

According to the World Health Organization, musculoskeletal disorders (MSD) are disorders of damage to the muscles, tendons, nerves or the vascular system that are not directly the result of an incident or accident but are chronic and progressive (Moradi et al., 2017). Health problems at work that require physical activities are caused by an

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accumulation of injuries or damage to the musculoskeletal system due to repeated trauma, which causes pain or discomfort are called Musculoskeletal Disorders (MSDs). Musculoskeletal complaints are complaints in the part of the skeletal muscles that are felt by a person ranging from mild complaints to complaints of pain (Sofyan, 2019), which has the effect of numbness, tingling, swelling, stiffness, shaking, sleep disturbances, and burning sensation (Christogianni et al., 2018).

Physical activity is activity in the form of movement through the skeletal muscles so that energy is released (Yi et al., 2017). Physical activity can be categorized in different domains, for example activities to do various jobs, transportation, or recreation (Bull et al., 2009). These activities can be quantified through Metabolic Equivalent of Task (MET), which is a physiological measurement that states the amount of energy or calories needed to perform a physical activity (Ainsworth et al., 1993). When carrying out physical activities at work, musculoskeletal disorders (MSD) can occur where workers feel pain and discomfort in various parts of their muscular system (Kamalinia et al., 2009). Various factors influence the occurrence of MSD in the workplace, including: level of effort, duration of work, and frequency of work (Restuputri et al., 2021). Pratiwi (2022) analyzed effort level, work duration, and work frequency to determine muscle fatigue in shoe factory workers and found that the parts of the body that have greater risk for MSD are the back, neck, and right hand. This muscle fatigue certainly affects the productivity of these worker therefore it needs to be minimized.

Musculoskeletal disorders are one of the main causes of worker absenteeism (Mohammadfam et al., 2010), and are occupational diseases that are common throughout the world. The OSHA organization reports that 42% of all occupational diseases are associated with awkward work postures and the musculoskeletal system (Rowshani, Mortazavi, et al., 2013). The economic impact of occupational diseases caused by musculoskeletal disorders in 2001 was estimated at more than 54 billion dollars (Rowshani, Khavanin, et al., 2013). Musculoskeletal disorders rank second in frequency and severity among occupational diseases according to the National Institute of Occupational Health and Safety of the United States (Mostaghasi et al., 2011). Risk factors for musculoskeletal disorders can be grouped into several factors, namely genetic, morphological, psychosocial and biomechanical factors Choobineh (2009) and individual work patterns (Mattioli et al., 2006). Biomechanical risk is the most important factor causing musculoskeletal disorders, which is indicated by the presence of repetitive motions, duration of work, strength, posture, inadequate rest periods (Choobineh, 2004; Choobineh et al., 2012; Fathallah, 2010; Kamalinia et al., 2009).

PT Inspira Multi Karya is a furniture manufacturing company. PT Inspira Multi Karya has 6 work stations with 15 operators. The operators at PT Inspira Multi Karya are required certain body postures for a long time. Work posture at the 6 work stations is different according to the work process at each work station. Observations at 6 work stations show that operators experience MSD complaints at different levels, including complaints on: shoulders, back, waist, calves, thighs and others. The conditions of workers in furniture factories show that operators work with poor posture, repetitive

movements, manual lifting/carrying activities, working without ergonomic tools, standing for long time. These working conditions tend to cause MSD complaints and have an impact on work-related illnesses. Operators who experience MSDs generally show several complaints, including 1) neck and back, elbows or ankles feel sore and stiff; 2). Hands, wrists, shoulders and feet ache and lose flexibility and swelling; 3). Fingers lose mobility, stiffness and lose strength and sensitivity; 4). feet and heels have tingling, cold, stiff or hot sensations. Working conditions like this are also felt by workers at PT Inspira Multi Karya. Therefore, it is important to conduct research that aims to measure physical activities and their relation to MSD at work stations. Tools to measure MSD complaints are: RULA (Rapid Upper Limb Assessment) and NBM (Nordic Body Map), while tools to measure physical activities is GPAQ (Global Physical Activity Questionnaire).

RULA is a method for assessing posture, style and movement of work activities related to the upper limbs. RULA is suitable to measure static postures with repetitive actions on production line work. Previous research was conducted by Kee (2022), showing that the RULA method was more suitable for assessing postural load compared to OWAS and REBA. The classification of RULA in the assessment of MSD complaints is: 1-2 (acceptable), 3-4 (needs further investigation); 5 - 6 (needs further investigation and corrective action), 7 (needs further investigation and immediate changes. Despite its merits, the RULA method cannot identify which part of the body is experiencing discomfort. Therefore, the Nordic method is used a Body Folder where this method can identify body discomfort and identify the source of the cause of MSD complaints. The affected part of muscle which experiences complaints, ranging from not feeling pain until the point of pain can be known through the method of the Nordic Body Map (NBM), using a questionnaire that performs an assessment at 28 points. The NBM method was used by Sofyan (2019) to examine MSD complaints of tailor operators, where the findings showed that the body parts that experienced subjective MSD complaints were 93% of the waist, 87% of the buttocks, 87 % of the lower neck, 80% of the left shoulder, 80% of the back, and 80% of the wrists 80% hand. Thus the NBM method can be used to determine limb discomfort.

WHO has developed the GPAQ standard to measure physical activity (Herrmann et al., 2013). Physical activity is measured by the expended energy needed when carrying out body movements, which is produced by skeletal muscles. With this method, the amount of energy expended for carrying out certain activities can be known, which is calculated through the metabolic equivalent of task (MET). where one MET is equivalent to the energy expended by a person sitting at rest (1 MET is equivalent to the consumption of calories 1 kcal/kg.hour). The GPAQ is an enhanced version of IPAQ aimed at capturing physical activity through 16 questions (Keating et al., 2019). The GPAQ has been used in various international population groups Bull (2009) and culturally diverse populations (Mathews et al., 2016), so the GPAQ can be used for this research, to obtain data on the level of physical activity which is produced by skeletal muscles. Esgin (2021) found that low levels of physical activity and high sitting time contributed to the high prevalence of chronic diseases.

Although these three ergonomic tools are often used, but it is very rare to study the relationship between physical activity levels and MSD complaints that arise when doing these activities. It is hoped that this research will produce findings that can explain the relationship between physical activity and MSD complaints. Besides, this study also aims to analyze the sensitivity of the three ergonomic measuring tools in relation to the improvement of the work system.

Research Method

This research is a cross-sectional study. The methodological framework of this study was to compare 2 MSD complaint measuring tools associated with measuring tool for physical activity levels of workers using the GPAQ in furniture factories. The methodological choice was made within a theoretical framework to ensure the most appropriate measuring instrument measuring MSD complaints for workers in furniture factories. In this context, participatory action research methods are used to measure the occurrence of complaints during the production process which are associated with high physical activity so that research findings can be used to improve work systems.

1. Respondent

   Respondents in this study were all operators working at the furniture factory PT. Inspire Multi Karya. The process of explaining to respondents about the GPAQ, RULA and NBM instruments was carried out in the early stages of the survey implementation. Feedback from participants was an increase in understanding and readability of survey instruments.

   There are 15 operators working on 6 production lines, namely: *Press* Machine (3 workers), cutting (4 workers), coating/ *edging* (3 workers), providing holes/drilling (3 workers), assembly (1 worker), *quality control* (1 worker). The data was obtained based on the results of interviews and observations, which were conducted in October 2021. Field observations with the observation method are usually used to assess workplace ergonomic risks. Observation is combined with interview activities, because risks in the workplace can be identified by conducting interviews with people involved in the work system. Interviews were conducted by asking workers about their name, age, length of work and perceived complaints.

2. Procedure

   Respondents' participation in this study was voluntary which aimed to determine physical activity and MSD while working. The research procedure was explained to each participant so that they understood well and then the consent of all participants was obtained before conducting the survey. The questionnaire was filled out by the participants guided by the researcher to ensure that the questionnaire was well understood and could be completed properly.

3. Data Analysis

   Physical activity (at work, travel and recreational physical activity) expressed as MET-minutes per week is used as the dependent variable in the inferential statistical model. In the GPAQ method, the respondent's physical activity is classified as high,

moderate or low depending on the total MET-minutes per week or other combination criteria (Jetté et al., 1990). In this study, the classification of physical activity with GPAQ will be divided into 3 categories, namely: 1) high: heavy activity with intensity of 1500 MET minutes/week; 2) Moderate: physical activity with intensity between 600 and 1500 MET minutes/week; 3) Low: activity light with intensity less than 600 MET-minutes/week.

To measure MSD complaints, RULA and NBM were used. *Nordic Body Map (NBM)* questionnaire using a Likert scale of 5. The NBM questionnaire consisted of 28 questions related to limbs assessed by workers based on how they feel while working. The NBM classification consists of: low (NBM 0-20), medium (21-41), high (42-62) and very high (NBM 63-84) classifications. To identify work , researchers are assisted by supervisors in related sections. Furthermore, the RULA method was used to assess the risk of musculoskeletal disorders in relation to the risk factors for each posture, by evaluating 15 postures while working. RULA classification is 1-2 (acceptable), 3-4 (needs further investigation); 5 - 6 (needs further investigation) and corrective action), 7 (needs further investigation and immediate changes). Subject data was taken based on personal factors, work factors, and MSDs complaints. Data is collected according to personal factors such as age, years of service, and body measurements using BMI (Body Mass Index). Then the data was processed and analyzed to find out MSD complaints and to compare the sensitivity of the three measuring instruments to the measurement of MSD complaints in furniture factories.

Reliability and validity tests were used to measure the consistency value of the questionnaire. Reliability means that it can be trusted and proven that the measuring instruments used can be accounted for. Validity is the accuracy of the instrument in measurement. Furthermore, correlation testing is carried out to determine the testing hypothesis whether there is no significant relationship or correlation between physical activity and complaints of musculoskeletal disorders. The test was carried out with a significant level (α) = 5%. The statistical test used is Pearson's correlation (r).

Results and Discussion

The work postures carried out at the six work stations can be seen in Figure 1 below.

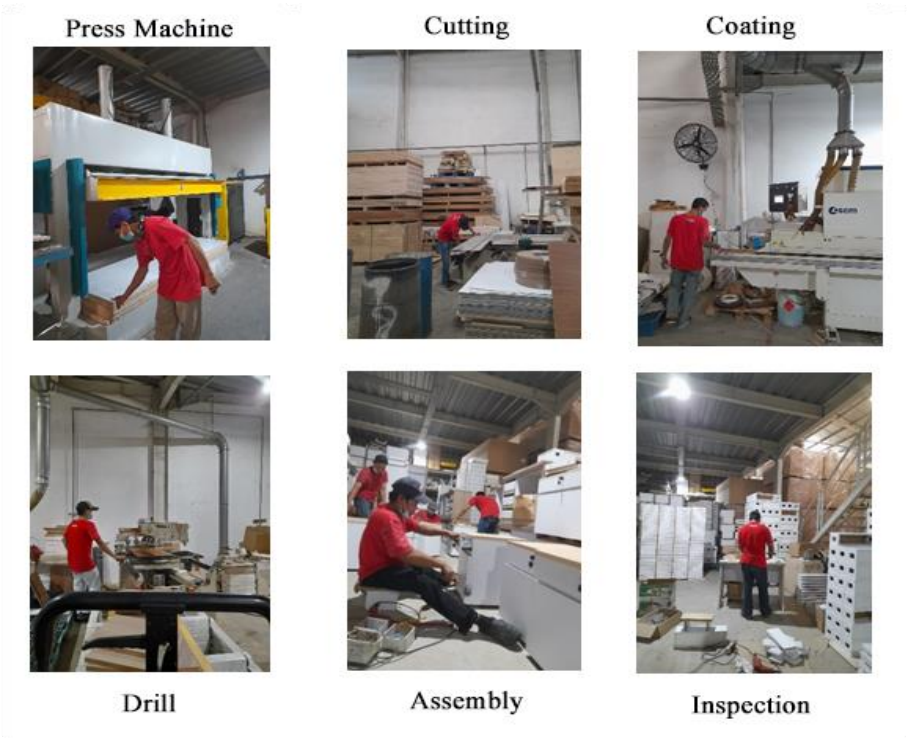

Figure 1. Posture at Six Work Stations

Sources of data obtained based on the results of interviews and observations. The characteristics of the respondents can be seen in Table 1 below.

Table 1
Characteristics of Respondents

Work Station	Age		Height		Weight		Body Mass Index	
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
Press	43,7	1.5	163.0	10.5	58.0	15,6	20.76	3,28
Cutting	38,8	4,4	164.5	3,1	55.0	5,1	20,69	1.67
Coating	39,3	8,6	166.7	5,9	60,7	6,7	21.80	1.08
Drill	41.0	7,2	166.3	6.0	59,3	6,7	21.40	1.05
Assembly	41.0	1,4	170	0.7	41.0	6,4	24,91	1.43
Inspection	43.0	1,4	169	0.7	43.0	6,4	22.06	1.43
Average	41,1	4,1	166.6	4,5	52,8	7,8	21.94	1.66

A. Measurement of Physical Activity and MSD Complaints

1. Nordic Body Map (NBM)

The NBM questionnaire is used to identify worker complaints when carrying out work activities. The results of the NBM questionnaire reported health complaints experienced by workers mainly on the calves, waist, forearms, back and right hand. The NBM score is in the range of score 1 (complaints of slight pain in the body) to score 2 (indicates complaints of moderate pain). This problem comes from the attitude at work, including: the legs are in a static condition when working, the arms are stretched beyond the shoulder posture, the waist is tilted, the back bends forward and the manual handling process when moving material. The comparison of NBM values can be seen in Figure 2 below.

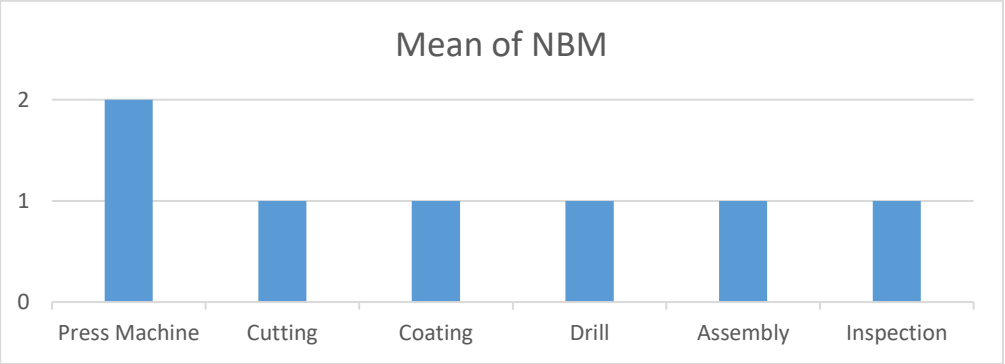

Figure 2. Graph of Average NBM

Based on the NBM calculation, the highest complaint was shown by the press machine operator (average NBM value of 2). As for the other five work stations, they are at score 1 (complaints of slight pain in the body).

The types of complaints that often found are the waist (7%), left calf (7%), left forearm (6%), right forearm (6%), right hand (6%), right calf (5%).

2. Rapid Upper Limb Assessment (RULA)

Figure 4 shows press, drill, assembly and inspection machine operators have an average score of 7 (level 4), which indicates the needs for immediate attention to improve work posture for the four work stations. The research findings show that 9 operators (60%) have a RULA score of 7, which indicates that it needs immediate attention to improve the operator's work posture. The results of the work posture assessment based on the average value at each work station using the RULA method are shown in Figure 4 below .

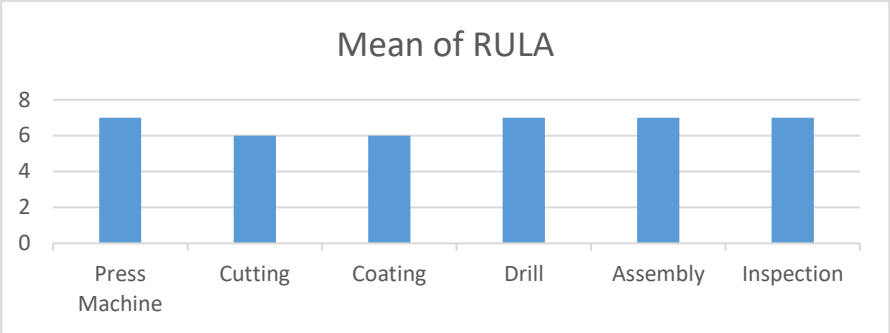

Figure 3. The average RULA score at six work stations

3. **Global Physical Activity Questionnaire** (GPAQ)

The Global *Physical Activity* Questioner (GPAQ) consists of 16 questions regarding workers physical activity. The results of calculating the average GPAQ for each work station are shown in Figure 3 below.

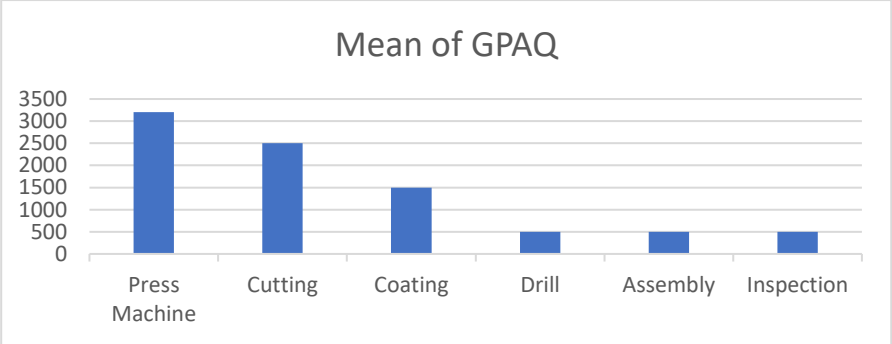

Figure 4. Average GPAQ score

The metabolic value of press and cutting operators has a physical activity value of more than 1500 MET (high). This workstation needs to take corrective action as soon as possible to avoid more inconvenience. Meanwhile, the GPAQ calculations for the other 4 work stations (edging, drilling, assembly and quality work stations) are in the moderate category.

4. **Measurement of Physical Activity Levels and MSD Complaints**

Results of measuring activities on the production floor using RULA, GPAQ and NBM is shown in Table 2 below.

Table 2
Result of Measuring with RULA, NBM and GPAQ

Activity	Description
Press Machine work station	RULA is at score 7 (level 4) which indicates the need for immediate consideration of change, while the GPAQ score is in the high category. This shows that the workers at the press machine work

RULA 7 *NBM 2* *GPAQ 3200* *MET*	station carry out strenuous activities (activities that can cause shortness of breath), workers do approximately 80 minutes. The average score of *the Nordic Body Map* is 2, which shows that workers experience body complaints with quite aches, this happens because most workers use their hands when doing work.
Cutting workstation *RULA 6* *NBM 1* *GPAQ 2550* *MET*	RULA is at score 6 (level 3) so corrective action is needed, while the GPAQ score is in the high category. This shows that workers at the cutting work station carry out strenuous activities (activities that can cause shortness of breath), workers do this for approximately 80 minutes. The average score of *the Nordic Body Map* is 1, which shows that workers experience body complaints with a bit of pain, work is done repetitively for 8 hours of work so that it has an impact on pain in parts starting from the neck, shoulders, arms, thighs, to the thighs and calf.
Coating workstation *RULA 6* *NBM 1* *GPAQ 1466* *MET*	RULA is at a score of 6 (level 3) where corrective action is needed, while the calculation of *the metabolic equivalent* of workers at the coating work station shows moderate activity (activity that causes a harder pulse), workers do for a minimum of 40 minutes. The average score of *the Nordic Body Map* is 1, which shows that workers experience body complaints with a slight feeling of pain, dominant pain in the legs, thighs and calves.
Drill work station *RULA 7* *NBM 1* *GPAQ 600* *METs*	RULA is at a score of 7 (level 4) or requires immediate change and consideration, while the *metabolic equivalent calculation* based on the GPAQ score indicates that physical activity with a minimum intensity of 600 met-minutes/week is in the medium category. This shows workers at the drill work station doing activities that can cause shortness of breath for at least 40 minutes. The average score of *the Nordic Body Map* is 1, which indicates that workers experience body complaints with slight pain, postures that are carried out statically for more than 10 minutes and occur on the back, arms and legs.
Assembly workstation *RULA 7* *NBM 1* *GPAQ 600* *METs*	RULA is at a score of 7 (level 4) or requires immediate change and consideration, while the *metabolic equivalent calculation* shows workers at the assembling work station doing physical activity with a minimum intensity of 600 met-minutes/week, the score is in the medium category. This shows workers at the coating work station doing activities that can cause shortness of breath for at least 40 minutes. The average score of *the Nordic Body Map* is 1, which shows that workers experience body complaints with a bit of pain, when doing work the body bends slightly so that complaints are experienced in the neck, shoulders.

Inspection workstation *RULA 7* *NBM 1* *GPAQ 600* *METs*	RULA is at a score of 7 (level 4) or requires immediate change and consideration, while the *metabolic equivalent calculation* shows a score showing workers at the assembling work station doing physical activity with a minimum intensity of 600 met-minutes/week, the score is in the medium category. The average score of *the Nordic Body Map* is 1, which shows that workers experience body complaints with a bit of pain, dominant complaints on the legs.

Press machine, drill, assembling and QC work stations have a RULA with a score of 7 (level 4), which indicates that it needs to make changes immediately. The GPAQ method shows that 2 work stations (press machine and cutting machine) need attention because they are activities heavy with intensity more than 1500 MET minutes/week. The NBM method found 1 work station (press machine) which indicated that it needs immediate repair because the operator experienced body complaints with considerable pain (NBM 2). The research findings show that work stations that need immediate attention are press machine work stations (RULA scores of 7, GPAQ 3200 MET, and NBM 2), where operators work in static postures for more than 10 minutes, lifting/moving loads weighing 2 kg-10 kg, *repetitive* work with a slightly bent back. This is due to the posture of the material (wood) which is placed 3 meters away from the machine, so that the operator needs energy to pick up the wood to be processed on the press machine.

5. Sensitivity of RULA, NBM and GPAQ

RULA is used to measure static postures with repeated actions. RULA can significantly assess complaints in the neck, forearm, and also relevant functional areas (McAtamney & Corlett, 1993), (Shuval & Donchin, 2005), and (Yazdanirad et al., 2018). Therefore, the research findings show that R ULA is more suitable to be used to assess MSD complaints in furniture manufacturers. RULA can assess postural loads related to complaints in the upper arms, forearms, wrists, neck, trunk and legs, where these limbs are widely used by operators when carrying out activities. at 6 work stations. RULA has also taken into account the workload. Thus, RULA can not only reduce injuries, but also prevent MSD complaints. Making furniture has many activities with posture static, work done with repetitive, mostly related to the upper limbs, operators work long hours so RULA is suitable for production lines like this (Jadhav et al., 2014).

RULA is not only effective in analysing static postures with repeated actions, but also in workers with dynamic movements involving postures of the lower extreme body (trunk part), body, and feet, this method is also effective. This is shown in the calculation of the B score which calculates the posture and trunk load body, And feet. In cutting and coating work stations where the worker's posture is stooped with lower limbs which are often unstable due to bent knees, indicating that RULA can be used. This is in line with research by Gómez-Galán (2020)which shows that

RULA is also used to assess postural loads that require postures of the lower limbs that are often unstable or awkward such as squatting and kneeling.

The results of the RULA assessment were refined using the NBM Method. By analyzing NBM body map, it is possible to estimate the type and level of skeletal muscle complaints felt by workers. This method relies on the use of a questionnaire that has an assessment of 28 points on the body. The findings of a study with NBM showed that the highest prevalence of limb disorders was found in the left calf (7%), waist (7 %), forearm (6%), back (6%), right hand (6%), right calf. (6%). This is in line with RULA findings which show that the operator's work posture does a lot of lifting activities, *repetitive* work with a slightly bent back, shifting lifting loads which are done repeatedly. Therefore, the NBM method supports the findings of RULA and is more specific in identifying the limbs that experience MSD complaints at work. NBM's findings show that the *press* workstation is a work station that requires investigation to be repaired immediately. While the parts of the body that are important to pay attention to in order to reduce MSD are the waist, left calf, forearm, back, right hand and right calf

The GPAQ is a questionnaire for measuring activity in developing countries, where measurements of physical activity will be classified based on MET (Metabolic Equivalent). In his research, Xiang (2020) argues that to carry out physical measurements, the GPAQ is needed as a level of measurement of physical activity related to work, sports and recreation. The GPAQ is a complementary instrument in this study, Because it can see the physical activity needed when doing work. These findings suggest that the GPAQ can be a useful way to measure the physical activity and behavior of operators when engaging workers in different working postures. The GPAQ measurement shows that the metabolic values of press and cutting operators get the highest physical activity scores (more than 1500 MET), which indicates that press and cutting machine operators are doing strenuous activities (activities that can cause shortness of breath). This is in line with findings which show that operators who require the most physical activity actually have high RULA and NBM scores.

This research systematically compares three methods of ergonomic using different characteristics. Therefore it is not easy to compare these observation techniques directly because each method has its own strengths and limitations. The RULA method aims to determine the postural load associated with limb pain or discomfort (taking into account the limbs involved, workload and especially the upper extremist body parts), NBM aims to determine the highest limb complaints in certain work postures while the GPAQ aims to determine the operator metabolism when working with certain body postures. The research findings show that the three methods complement each other to analyze work posture, so that the results of the evaluation can be used to improve work systems to reduce MSD and increase worker productivity.

6. Relationship Physical Activity and Musculoskeletal Disorders

Test of Realibility and Validity

In this study, a reliability test was carried out to measure the consistency value of the questionnaire. Reliability, which means that it can be trusted and proven that the measuring instruments used can be accounted for.

Tabel 3
Hasil Realibilitas dan Validitas

Realibilitas	
Cronbach's	0,647
Validitas	
R CounT	0,695
R Table	0,514

The table shows the results of the reliability test with a value of 0.647. So it can be said that the reliability is high because its value is greater 0.600. Furthermore, the validity test was carried out to see the accuracy of the instrument in measurement. The results of the validity test were obtained at 0.695 while for the r table is obtained at 0.514. Thus the validity test is said to be valid the valu of r counted is greater than that of r table.

In this study, the hypothesis was tested by using regression analysis with Pearson's correlation (r).

The hypothesis that is built is:

H0: There is no significant relationship or correlation between physical activity and complaints of musculoskeletal disorders

Ha: There is a significant relationship or correlation between physical activity and complaints of musculoskeletal disorders

The test results can be seen in the table below.

Table 4
Correlation Test between Physical Activity and MSD Complaints

Variable	**Keluhan**			**r**	***p value***	**Tabel**
Physical Activity	**Low**	**Moderate**	**N**			
Low	2 25%	0 0%	2 25,0%			
Moderate	4 50%	0 0%	4 50,0%	0,695	0,004	0,514
High	2 25%	7 100%	9 73,3%			

Total	**4 100,0 %**	**11 100,0%**	**15 10 0 %**

.In Table 5.7 the output of significance value shows a value of 0.004 which is < 0.05. This shows a significant correlation between physical activity and MSD complaints. The correlation coefficient (r) is 0.695 while the table value is 0.514. So it can be said that there is a relationship between physical activity and MSD complaints. In other words, increasing physical activity will also increase MSD complaints in workers.

7. Work System Improvement

Improved work posture and assistive devices can reduce MSD complaints. Tri and Titan (2022) designed a tool to make holes in tempe plastic wrap that is ergonomic so that it can reduce musculoskeletal complaints of pain in the upper neck, thereby reducing the initial Visual Analog Scale (VAS) score of 65 (high category) to the category of mild pain with a score scale 25. Likewise, it is also necessary to improve work systems in furniture factories.

The results showed that the highest scores for RULA, GPAQ, and NBM were at the *press machine work station.* The work carried out at the press machine work station is: applying glue/adhesive to wood, lifting wood that has been given adhesive and lifting wood that has been given adhesive. Work is performed in a standing posture. To improve posture while working, a design is carried out by adding height to the base so that the worker's posture does not slouch. Additional base with a size of 50 cm. The following is a picture of the base design on the press machine.

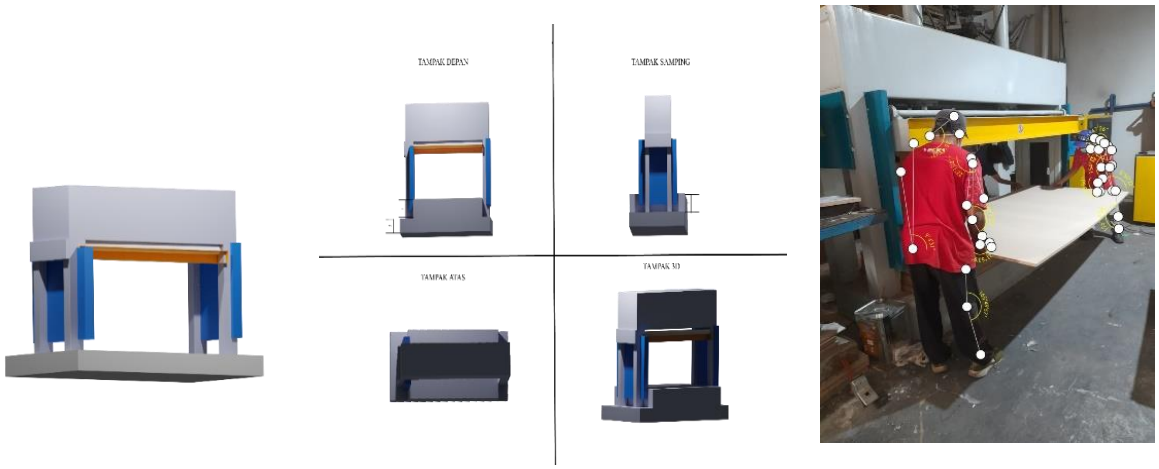

Figure 6. Press Machine Base & Working Posture After Repair

Based on calculations using the machine height that has been adjusted to the operator's height, it can be seen that the working posture of the neck has improved (reduced to 35° and 61°). Likewise, the posture of the worker's torso changes to 9°

and 8°. The results of measuring MSD complaints after repairs based on RULA show a change in value from a score of 7 (high category requiring immediate consideration of changes) to a score of 4 (low category).

Conclusion

There is a relationship between physical activity and musculoskeletal complaints. The more physical activity increases, the musculoskeletal complaints also increase in these workers.

The GPAQ measurement results are in line with the findings of RULA and NBM. Work stations with the greatest physical activity show high MSD complaints.

RULA, NBM and GPAQ were used in this study to measure and analyse MSD complaints felt and physical activity by furniture manufacturing workers. Of the three existing methods, RULA is the most appropriate method to measure and analyse MSD complaints because it considers all aspects of the limbs used in work (upper and lower parts of the feet), as well as static and dynamic postures. Besides that, also consider the workload. In the furniture factory there are many activities that require displacement and movement related to the upper limbs so this method is suitable for use. With RULA it can be known the posture of those who experience work-related accidents to prevent MSDs, so RULA is not just assessing posture while working.

The occurrence of MSDs in industry furniture is a result of repeated activity practice which keep going continuously, namely lifting load and repeated exertion. The highest prevalence of disorders was found on the body parts: left calf, waist, forearm, back, right hand and right calf.

Corrective action, mainly needs to be carried out immediately on the press machine. This is because the press machine operator has a RULA score of 7, 3200 MET, and NBM 2. To reduce the MSD on the press machine, it is recommended to increase the height of the press machine base so that it makes the operator work in an ergonomic posture. This aims to avoid the process of lifting weights and transferring loads with a bent back, which is done *repetitively* and over a long period of time. Improved work posture changed the RULA value with an initial score of 7 decreased to 4.

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