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Prevalence of Work-Related Musculoskeletal Disorders Among Tire Workshop Mechanics in Pagoh, Malaysia

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Abstract: The risk of MSD disorders is pain that occurs in joints, muscles, tendons, ligaments, nerves, discs, blood vessels, and soft tissues. Most vehicle mechanics are often exposed to the risk of MSD disorders in the workplace due to ergonomic body posture while doing any type of job. This study aims to conduct an ergonomic assessment of the common posture of workers in tire shops using NMQ, REBA, and RULA assessments. The study was conducted at Chensing Tires World Sdn. Bhd. located in the area around Pagoh, Johor. This method uses a 3D Scanner, Geomagic for Solidworks, and Catia V5R21 to be scanned and edited for inclusion in engineering software. The results of the study found that the five actual postural conditions that are often performed by tire mechanics are the worst postures that invite the risk of MSD disorders in the workplace. A comparison through manual RULA analysis with RULA in Catia found that the risk of MSD disorders is easily exposed to the neck, trunk, upper arm, lower arm, wrist, and leg area of tire mechanic workers. The RULA analysis performed in Catia is the most accurate and in-depth assessment to determine the level of postural risk including the load imposed on each limb of a vehicle tire mechanic.

Keywords: Risk of MSD Disorder, NMQ, REBA, RULA, Catia V5R21

1. Introduction

Musculoskeletal disorders (MSD) are a sort of pain disorder that can cause undesirable things like work accidents. Most occupational accidents documented in earlier studies were MSD [1][2]. MSD is a mobility condition that affects joints, muscles, tendons, ligaments, nerves, discs, blood vessels, and soft tissues [3].

According to earlier research, workers in industries such as automotive, manufacturing, and construction suffer from MSD-related discomfort [4]. Hence, according to a WHO report, 1.71 billion

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people worldwide are at risk of MSD disorders, and the Bureau of Labor Statistics predicts that the number of maintenance mechanics will surpass other jobs by 2022 [3].

In Malaysia, 87.4% of automotive workers reported MSD problems [5]. Mechanics frequently handle heavy manual items such as tires, wheels, and stacking tires. This leaves them susceptible to occupational injuries, lower back discomfort, neck cramps, shoulder, arm, leg, knee, and elbow pain [3][6]. Furthermore, non-ergonomic mechanical work posture increases the chance of MSD spreading to the entire leg.

It is because maintenance employee jobs require them to adjust their body posture from standing to sitting or lying down, back and neck pain are important issues [7]. This causes MSD issues in the neck and back of the mechanic while maintaining the vehicle [8]. Many mechanics also do repetitious tasks like engine maintenance, lubricating oil and filter replacement, tire rotation and replacement, and wheel balance [3].

Mechanics in tire service centers are also at risk of arm vibration syndrome from handling pneumatic and electric vibration devices [9]. According to previous research, they use air impact wrenches to tighten and loosen the wheel nuts after a new tire replacement using an unergonomic body posture [10]. From 2010 to 2015, SOCSO Malaysia received more cases of ailments caused by vibration [9].

In summary, mechanics are ignorant that their daily work activities provide a risk for MSD diseases. The current investigation will identify numerous body postures, including lifting large loads, uncomfortable postures, arm vibrations, high force, repeated postures, extended standing, restricted space, prolonged sitting, prolonged squatting, and prolonged lying.

Several methods have been used to estimate the risk of MSD diseases in mechanics who are bad at work or while working. In this scenario, a risk assessment is done to limit the risk of MSD problems among mechanics to protect both their physical and mental health.

2. Materials and Methods

The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study.

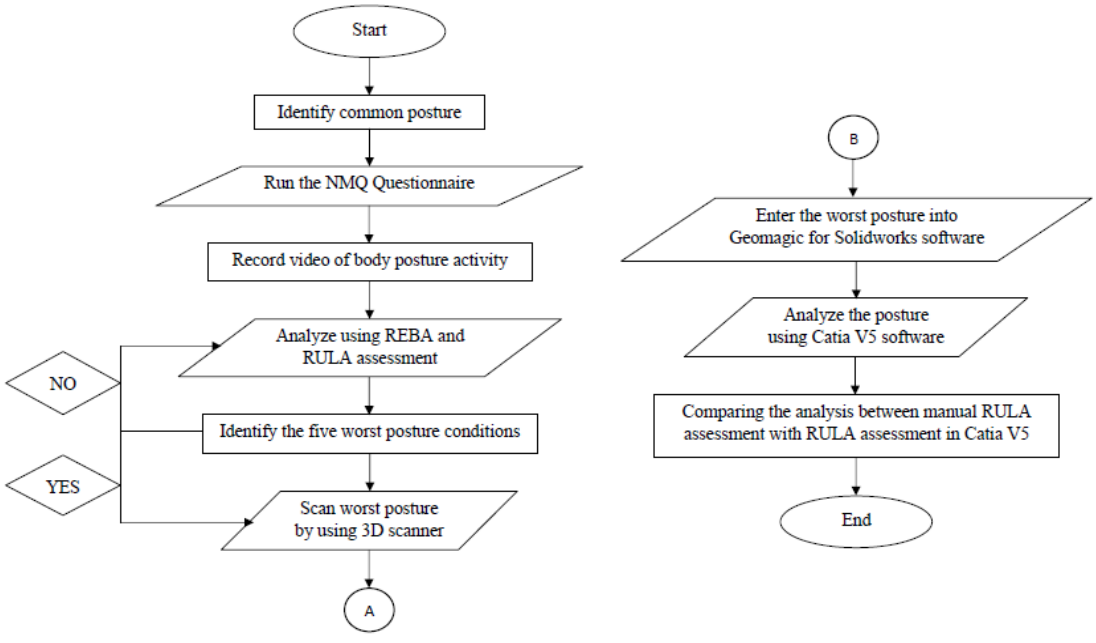

Figure 1: Project Main Process Flow

2.1 NMQ Method

With the Nordic Musculoskeletal Questionnaire (NMQ), mechanics will be asked about their MSD condition risk symptoms. A tick in the box shows that the limb has suffered from MSD in the last 3 months and whether it still suffers currently. To achieve the current study's results, NMQ data will be evaluated across age groups, BMIs, health levels, and risk of MSD disorders before assessing total limb posture.

2.2 REBA Assessment Method

A vehicle mechanic's total body posture has been chosen as a risk factor in numerous earlier research. Each limb at risk for MSD problems in the workplace will be assessed utilizing a REBA assessment before beginning the any research. REBA can analyze the static and dynamic movements of the trunk, neck, legs, arms, knees, elbows, and wrists while working. To improve posture in tire repair centers, REBA evaluation sheets were used to analyze five common bad posture samples.

2.3 RULA Assessment Method

The RULA is simple to use by simply evaluating the grade according to the RULA evaluation sheet's diagram. The RULA assessment may also study static and dynamic postures, but it focuses on the upper limbs, such as the upper back, shoulders, neck, elbows, hands, and wrists. With this second assessment, mechanics can determine the level of risk for MSD illnesses associated with each position they undertake daily. Thus, the current study's RULA assessment will additionally include video recording and risk analysis of the 5 worst posture examples.

2.4 Sense 3D Scanner

3D Body Scanning is a device that creates 3D models using scans of the worst postures taken by mechanics at tire servicing centers. Also, 360-degree photos of a mechanic's body posture were obtained and incorporated into computer software to create a 3D model. Furthermore, three-dimensional body scanning technology is a quick, accurate, and simple method that is widely employed in numerous fields, especially for ergonomic body posture.

2.5 Geomagic for Solidworks Software

Geomagic for Solidworks is a 3D scanning editing software that integrates reverse engineering tools straight into Solidworks. This editing program can also scan complex 3D models, saving time spent building genuine 3D models. After the 3D scan on the mechanic's body posture, editing software is necessary to follow the posture of the current study sample. Finally, editing software is widely utilized and will be employed in carrying out the current study's objectives.

2.6 Catia V5R21

Catia V5R21 is an extra approach for evaluating the results of REBA and RULA. Furthermore, the Catia V5R21 analysis of human activity will exclusively focus on the proposed methods or improvements of postural circumstances sampled in the current study. Furthermore, Catia V5R21can analyze all aspects of human performance, from static posture to dynamic posture while doing complex tasks. This study will use RULA evaluation in Catia to compare manual and technical assessment to estimate the actual risk level of MSD to the worst posture.

2.7 Worst Posture of Workers

This study found five examples of the worst posture activities of tire mechanics that are often performed at vehicle tire service centers. So, a 3D scanner was used to scan this way and analyze it in the Catia V5R21 software to get more accurate values including the load applied to the worst posture.

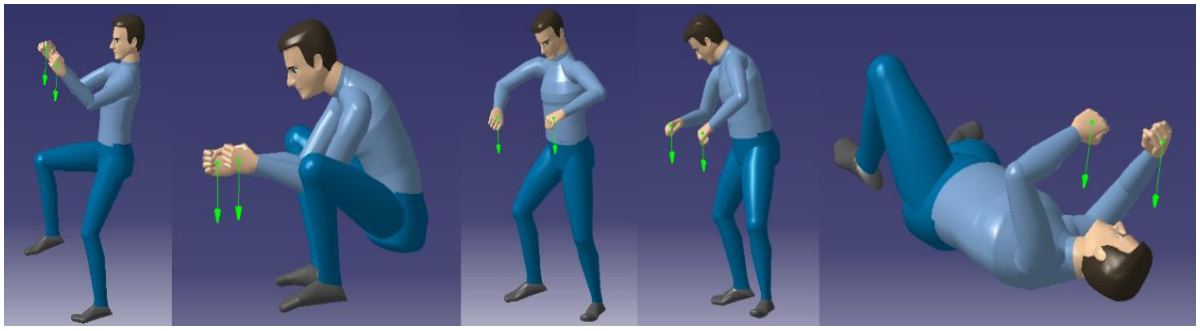

Figure 2: Worst posture of workers

3. Results and Discussion

The results and discussion section will provide the results of the RULA analysis in the Catia V5R21 with its comparison between the REBA and RULA assessment manually.

3.1 Results

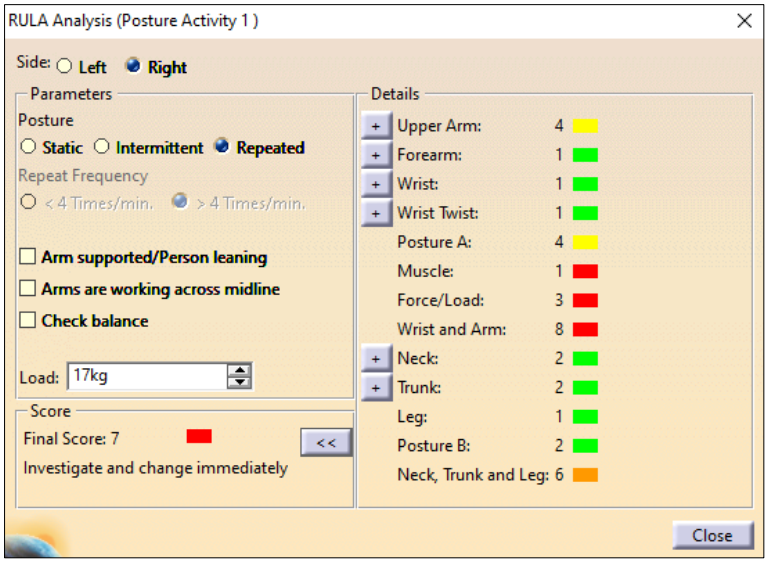

Figure 3: RULA analysis in Catia V5 for posture 1 activity

Figure 3 shows that the Catia V5R21 software engineering analyses activity type 1 connected to lifting heavy loads posture. Based on the analysis in figure 3, the overall score for this type of activity 1 is 7, indicating a high risk of MSD disorder and the need to improve work activity posture circumstances. Figure 3 also shows that this posture needs to be improved on the muscle, force/load applied, and wrist to avoid tire mechanics developing MSD diseases at work. As a result, the risk level assessment by Catia V5 stated that the posture had a very high risk of inviting MSD soon, whereas the risk level assessment conducted manually explained a moderate risk level to the posture situation. According to prior research, analyzing manually is the fastest approach, while analyzing in Catia V5 is the most accurate.

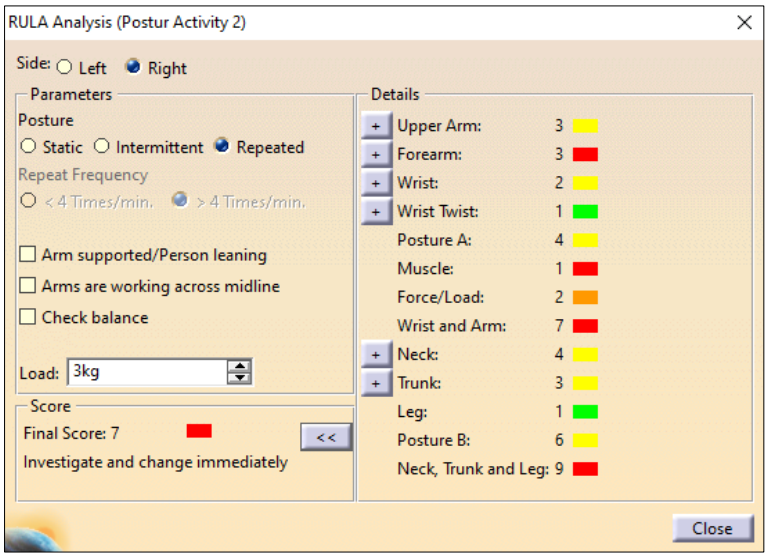

Figure 4: RULA analysis in Catia V5 for posture 2 activity

Figure 4 shows the Catia V5R21 engineering software analyzing type 2 activity associated with awkward posture. Based on the analysis in Figure 4, the total score for this type of activity 2 is 7, indicating a very high risk of MSD problem and the need to improve work activity posture circumstances. Figure 4 also shows that this posture needs to be improved on the lower arm, muscle, wrist, neck, trunk, and leg to avoid tire mechanics developing MSD diseases at work. As a result, the risk level assessment by Catia V5 stated that the posture had a very high risk of inviting MSD soon, whereas the risk level assessment conducted manually explained a moderate risk level to the posture situation. According to prior research, analyzing manually is the fastest approach, while analyzing in Catia V5 is the most accurate.

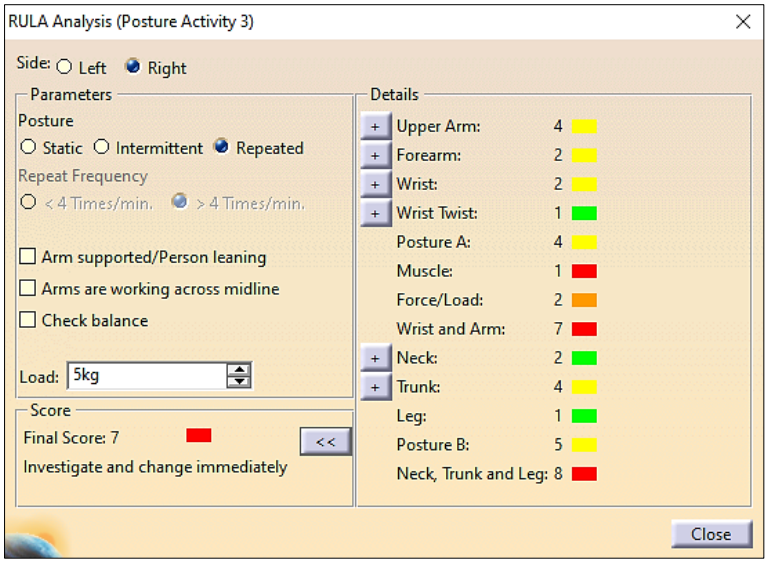

Figure 5: RULA analysis in Catia V5 for posture 3 activity

Figure 5 shows that the Catia V5R21 software engineering analyses activity type 3 associated with high force exertion posture. Based on the analysis in Figure 5, the overall score for this type of activity 3 is 7, indicating a high risk of MSD problem and the need to improve work activity posture circumstances. Figure 5 also shows that this posture needs to be improved on the muscle, wrist, neck, trunk, and leg to avoid tire mechanics developing MSD diseases at work. As a result, the risk level assessment by Catia V5 stated that the posture had a very high risk of inviting MSD soon, whereas the

risk level assessment conducted manually explained a moderate risk level to the posture situation. According to prior research, analyzing manually is the fastest approach, while analyzing in Catia V5 is the most accurate.

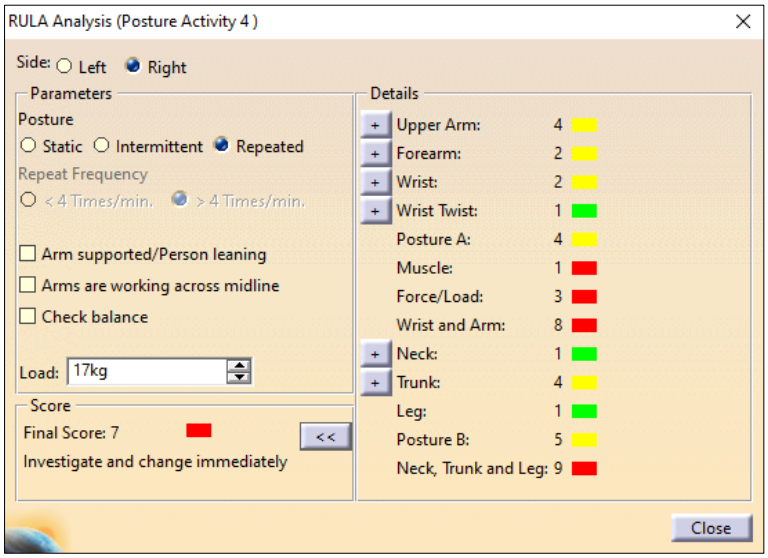

Figure 6: RULA analysis in Catia V5 for posture 4 activity

Figure 6 shows that the Catia V5R21 software engineering analyses activity type 4 related to posture repetition. This signifies that the posture is at a very high risk of suffering from MSD problems and that improvements need to be made to improve job activity posture circumstances. Figure 6 also shows that this posture needs to be improved on the muscle, force/load applied, wrist, neck, trunk, and leg to avoid tire mechanics developing MSD diseases at work. As a result, the risk level assessment by Catia V5 stated that the posture had a very high risk of inviting MSD soon, whereas the risk level assessment conducted manually explained a moderate risk level to the posture situation. According to prior research, analyzing manually is the fastest approach, while analyzing in Catia V5 is the most accurate.

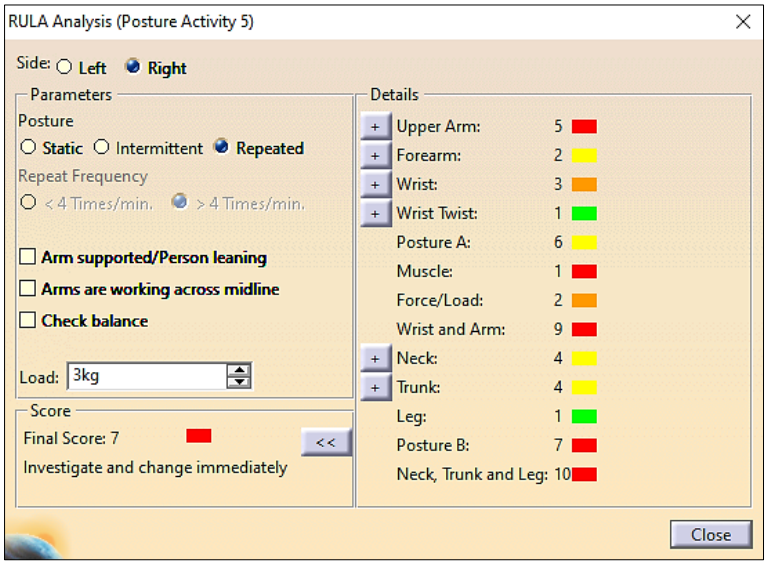

Figure 7: RULA analysis in Catia V5 for posture 5 activity

Figure 7 shows the Catia V5R21 engineering software analyzing activity type 5 connected to the laying down position. This signifies that the posture is at a very high risk of suffering from MSD problems and that improvements should be made to improve job activity posture circumstances. Figure

7 also shows that this posture needs to be improved on the upper arm, muscle, wrist, neck, trunk, and leg to avoid tire mechanics developing MSD diseases at work. Comparing the risk level evaluation by Catia V5 with a manual assessment produces a total score of 8 which suggests the level of risk is very dangerous to the postural condition and needs to be rectified immediately. According to prior research, analyzing manually is the fastest approach, while analyzing in Catia V5 is the most accurate.

3.2 Discussions

Table 1: Differences between REBA (MANUAL), RULA (MANUAL), and RULA (CATIA)

Posture	REBA (MANUAL)	RULA (MANUAL)	RULA (CATIA)
1	6 = 85.71%	5 = 71.43%	7 = 100%
2	8 = 114.29%	5 = 71.43%	7 = 100%
3	7 = 100%	5 = 71.43%	7 = 100%
4	7 = 100%	5 = 71.43%	7 = 100%
5	8 = 114.29%	8 = 114.29%	7 = 100%

Posture 1 showed more risk to the whole body imposed while doing work such as legs, wrist position, and wrist rotation but the no-load value was considered to each limb and had difficulty in reading posture angles more specifically.

Posture 2 showed more risk to the whole body imposed while doing work such as the trunk, leg, wrist position, and wrist twist but the no-load value was considered to each limb and had difficulty in reading posture angles more specifically.

Posture 3 showed more risk to the whole body imposed while doing work such as the neck, lower arm, and wrist position but the no-load value was considered to each limb and had difficulty in reading posture angles more specifically.

Posture 4 showed more risk to the whole body imposed while doing work such as trunk, leg, lower arm, and wrist twist but the no-load value was considered to each limb and had difficulty in reading posture angles more specifically.

Posture 5 showed the same amount of risk to the whole body and upper limbs imposed while doing work such as the neck, upper arm, lower arm, wrist position, and wrist twist but the no-load value was considered to each limb and had difficulty in reading posture angles more specifically.

Finally, the RULA (CATIA) on all posture is a more accurate assessment for more in-depth posture analysis applied to the any posture activity.

4. Conclusion

Both manual and technical assessments suggest results that require complete attention to modify towards a healthier one since the posture invites the danger of MSD illnesses in the job if it is still performed. Manual REBA and RULA assessments have been demonstrated to be effective in identifying whole-body and limb postures at risk for WMSD. RULA (CATIA) can assess each angle of the posture position of the whole body and limbs more specifically including the load exerted on the posture. Concerning MSD risk, the RULA assessment in Catia is the most precise analytical assessment, especially for tire mechanics in car tire service centers. In conclusion, the research on the postural

analysis of the position of the whole body and limbs of tire mechanics using Catia V5R21 can be improved by improving as follows:

- Convert the posture of the mannequin to a real human posture in 3D more clearly and accompanied by the idea of improvement on the posture in the form of modeling.
- Obtain the worst posture sample in all conditions that can occur in a vehicle tire service center by using various analysis methods.
- Suggest making more samples and posture analysis on the activities of truck mechanics in heavy vehicle service centers.

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