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Relationship between Improper Working Posture among Maintenance Workers using Different Assessment Methods

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ABSTRACT

The purpose of ergonomics is to take advantage of human ability limits in order to implement an efficient and comfortable interface to use. When the worker is performing an improper posture, it may cause the worker to feel discomfort when doing the work and may lead to getting musculoskeletal disorders (MSDs). According to past research, there is a relationship between improper working posture and MSDs. The objective of this study was to determine the relationship between improper working posture at maintenance workers using different assessment methods. CMDQ, RULA, REBA and ENBORA were conducted among 34 maintenance workers around Parit Raja, Johor. The selected maintenance workers were interviewed via CMDQ and RULA, REBA and ENBORA were conducted based on their working posture at the time of the interview. The data were analysed and compared based on similar observed body parts. Among the respondents, lower back discomfort was most prevalent (70.59%), followed by right and left shoulders (58.82% and 55.88%, respectively) as well as right wrist (29.47%) and left wrist (55.88%). The mean RULA Score for the respondents was 4.76 (SD=1.37), which indicates a medium risk level. The mean REBA Score for the respondents was 7.41 (SD=2.26), which indicates the average REBA risk level was high. The mean value for the ENBORA Final Score was 33.56 (SD=11.98), indicating that the respondents overall have a negligible risk of getting MSD based on their working posture. The body parts compared in CMDQ, RULA, REBA and ENBORA were neck, upper arm, lower arm, wrist and trunk. Based on findings, ENBORA has the highest Pearson Correlation to CMDQ followed by RULA and REBA. In conclusion, the maintenance workers were found to be exposed to ergonomic risk factors (ERFs) and ergonomics improvement were needed in future.

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1. Introduction

Ergonomics can be defined as a scientific disciple concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance [4]. In ergonomics, the posture and movement of a worker are important information for determining the risk of musculoskeletal disorders (MSD) in the workplace [12]. Besides, ergonomic intervention is the best strategy to prevent WMSDs and it aims to redesign the workstation and process to improve health, safety, and productivity [3].

Musculoskeletal disorders (MSD) are health problems involving the joints, cartilage, muscles, nerves, tendons, skeleton, ligaments, and related to the intensity and severity of work, although often light activities such as housework or exercise may also be involved [11]. Besides, these injuries are most commonly in relation to the muscular components of the neck, back, arms and legs [1]. For WMSDs, it falls under the category of MSD that are caused by occupational exposure, which could be the reason for work restriction, work-time loss, and at times work leave [16]. In order to prevent MSD, the major risk factors of MSD should be quantitatively analysed and there were several observational techniques have been developed for assessing risk factors of MSD [5].

Ergonomic Risk Assessments (ERA) are systematic plans that use to identify, assess and control ergonomic risk factors associated with the work task and activities in the workplace [4]. There are many types of ERA such as Rapid Upper Limb Assessment (RULA), Rapid Entire Body Assessment (REBA) and Entire Body Risk Assessment (ENBORA). One of the most common methods to evaluate MSD was using Cornell Musculoskeletal Discomfort Questionnaire (CMDQ). This is because CMDQ combines the frequency and intensity of musculoskeletal pain and complaints with work-related impairments for 20 body regions in a chart on only one page [9].

There are relationships between postures of the neck, shoulder, and low back and WMSDs in a review of over 600 epidemiological studies and Kee *et al.,* [8] also pointed out that upper extremity postures were related to WMSDs. Besides, improper work design, postural disorders, repeated movements, high work load, difficult carrying works, lots of bending and stretching lead to musculoskeletal disorders, back, neck, shoulder, knee and hip complaints, head rotation and injuries [20]. In Malaysia, the number of reported musculoskeletal disorders (MSD) reported by the Social Security Organization (SOCSO) was increased from the year 2005 to 2014 when only 10 cases of reported MSD reported by SOCSO in the year of 2005 but the number of cases increased to 675 cases in the year of 2014 [4]. The objective of this study was to determine the relationship between CMDQ and RULA, REBA and ENBORA methods.

2. Methodology

2.1 Introduction

The methodology can be described as actions to be taken to investigate a research problem and the rationale for the application of specific procedures or techniques used to identify, select, process, and analyse information applied to understanding the problem, thereby, allowing the reader to critically evaluate a study's overall validity and reliability [7]. Before the study was conducted, the topics of this research has been reviewed so that the topics was following the title and objectives of the research. After the topics does not out of title and objectives, the sample size of the research was determined. In this study, the sample size was 34 maintenance workers around Parit Raja. The respondents were given CMDQ as an interview for their own standing of their health condition. After that, some footages of their working condition were recorded to perform the ergonomic risk assessments. RULA, REBA and ENBORA have been performed by using a goniometer and force gauge, and the data was collected on site. The results were recorded and analysed to compare the ergonomic risk assessment and identify their relation to CMDQ.

2.2 Population and Sample Size

The sample size must be determined before conducting any research. This is because, without a sample size, the limitation of the research cannot be determined and will cause the research to be less accurate. For this research, the sample size was around 30 to 40 maintenance workers. The sample size of this research was calculated using the formula below [18]. The sample proportion is 0.5, the confidence level of the sample size is 90% and the margin error is 15%.

$$\text{Sample size} = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1+\left(\frac{z^2 \times p(1-p)}{e^2 N}\right)} \tag{1}$$

Where, the sample proportion, p, the margin error, e, the z-score of desired confidence level, z, and the population size, N.

2.3 Selection of Work Area

The work area for this research was Parit Raja. Parit Raja is a town located in Batu Pahat district in Johor state, Malaysia. Parit Raja is approximately 7 km from Ayer Hitam and 22km from Batu Pahat. It takes approximately 3 hours to reach Parit Raja from Kuala Lumpur, the capital city of Malaysia because the distance was around 261km. One of Malaysia's public universities, Tun Hussein Onn University of Malaysia (UTHM) also is located in Parit Raja, Batu Pahat, Johor. The population of Parit Raja is around 17400. There were at least three work areas in Parit Raja selected as workplaces. This is because different work areas can get different data for different working postures. The data of working posture obtained has been performed RULA, REBA and ENBORA.

2.4 Cornell Musculoskeletal Discomfort Questionnaire

The CMDQ questionnaire has 6 components [6]. Two for sedentary workers, two for standing workers and the rest for hand symptoms. The questionnaire for sedentary workers and standing workers were divided into the male version and the female version. For hand symptoms questionnaire, it was divided into left hand and right hand. The questionnaire for sedentary workers and standing workers were questionnaire for the entire body questionnaire. Since the questionnaire is used to research screening purposes, it cannot be used as a diagnostic tool. This is because there is various factor that causes MSD. As this research is focused on the working posture of the maintenance workers, only standing workers questionnaire were used.

2.5 Rapid Upper Limb Assessment

The RULA tool is a screening tool based on observation, which is used to assess exposure to load factors due to posture of the neck, trunk and upper limb along with muscle use and forces [4,14]. Since RULA is an observational method, it does not need an advanced degree in ergonomics or expensive equipment to be conducted. RULA is conducted by assigning scores for each body region and the data were used to compile the risk factor variables and generate a single score that represents the level of MSD risk [4]. RULA scores were assigned to each body part, which includes the arm, wrist, neck and trunk and leg according to their position. Besides, RULA can only apply to evaluate one side of the body.

2.6 Rapid Entire Body Assessment

REBA is an ergonomic risk assessment that means to assess posture for risks of work-related musculoskeletal disorders and it was used to evaluate evaluating jobs that involve dynamic and static postures [10]. Before the REBA is conducted, the posture that were evaluated were selected by the participant based on the difficulty to perform the posture, the time taken for a period of a posture or the load of the posture. For REBA, the score was assigned based on the position of the arm, wrist, neck, leg and trunk.

2.7 Entire Body Risk Assessment

As an observational method, ENBORA is also very easy to be conducted because it has the benchmark of risk level as well as action on the evaluation of tasks in the workplace [15]. ENBORA has been separated into 4 parts. The first part is related to the physical risk factor. This part covers the position of the body part, which is the neck, shoulder, elbow, wrist, back and legs. Before conducting the assessment, the participant was required to provide their personal information such as weight and height. This is because it was used in the fourth part of the ENBORA. The first part also covers the frequency of the posture and the load of the posture. Part 2 of the ENBORA covers the psychological risk factors. The risk included work stress, work load, work pace, social entertainment and monotony task. The risk factor in part 3 of ENBORA was work organization risk factors. This part covers the working hours per week and the task duration. The last part of ENBORA was individual risk factors, which include the body mass index (BMI) and smoking history of respondents.

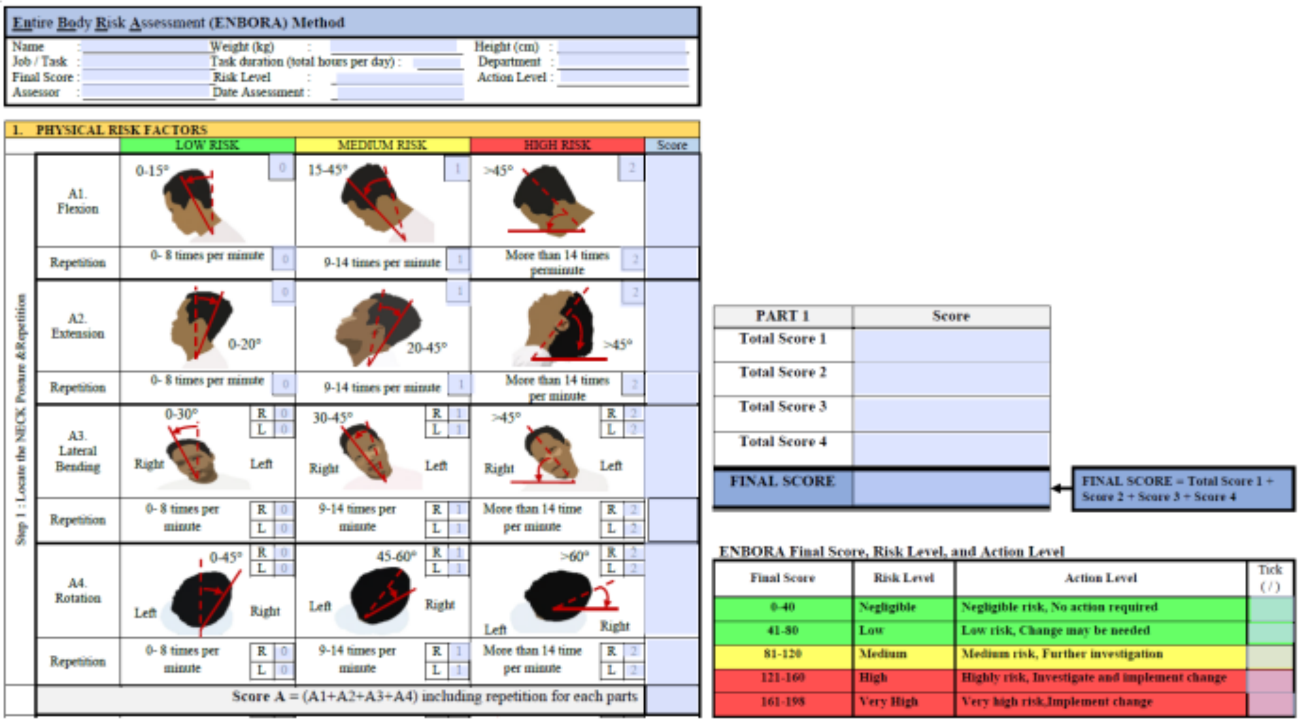


Fig. 1. Sample of ENBORA evaluation table and scores table

2.8 Data Collection

The data collected for this research were surveys and interviews conducted on respondents, their risk assessment score sheet and the analysis of the score sheet. After the interview, the working postures of respondents were observed and recorded. The observation time for each working posture were between 3 minutes to 5 minutes. Each respondent was observed based on their current working posture during the interviews and 1 working posture was observed for each respondent. During the observation process, video recordings and photos also has been taken as proof and used for risk assessment. Besides that, tools such as a goniometer and weight scale were used to identify the posture angle and the posture load. When the data required is collected, RULA, REBA and ENBORA were conducted on respondents based on the same working posture that observed for each respondent. After the score sheet for each risk assessment was done, analysis and comparison of the data occurred.

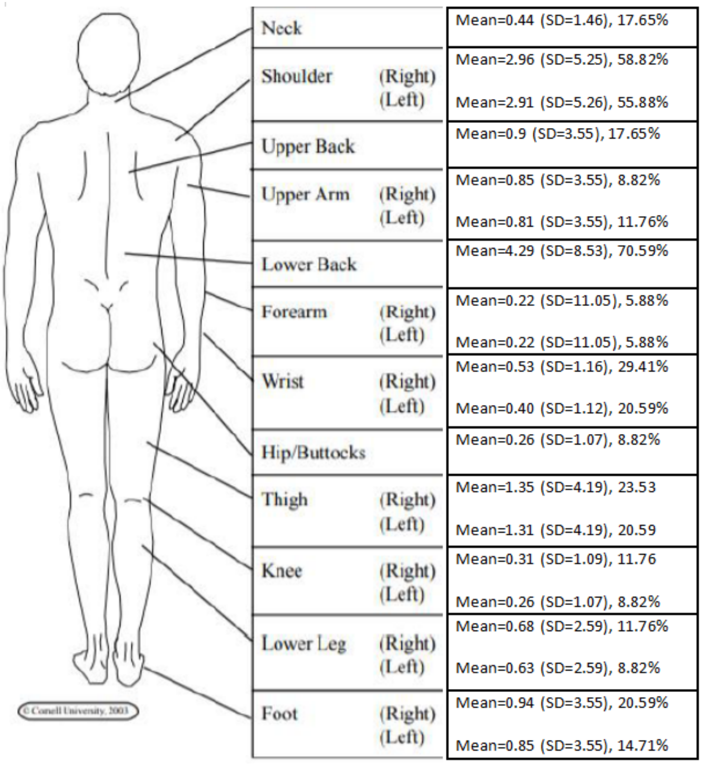
2.9 Data Analysis

By using the Wrist & Arm Score and Neck, Trunk, Leg Score, the RULA Score can be obtained. By locating the corresponding score of Wrist & Arm Score and Neck, Trunk, Leg Score in Table C of Appendix E, the RULA Score was identified. In order to identify the REBA Score from the REBA worksheet, Score A and Score B were used in the row and column of Table C in REBA to locate the Score C. The REBA Score was obtained after adding the Score C and Activity Score. For the ENBORA, the total score for each risk factor was added to obtain the Final Score. After the score and risk level of each risk assessment were found, the data were analysed by using EXCEL and Statistical Package for the Social Sciences (SPSS) Pearson Correlation. The comparison of the data can be shown clearly by using these methods. After the comparison is concluded, the relationship between CMDQ and each risk assessment was determined.

3. Results
3.1 Results of CMDQ Questionnaire

This study found that most of the respondents have discomfort in the lower back during the interview. There were 24 (70.59%) of the respondents who had at least 1 to 2 times of discomfort in the lower back for the past working week. The second most discomfort that occurred in body parts was the shoulders. There were 20 (58.82%) and 19 (55.88%) respondents had discomfort in their right shoulders and left shoulders respectively. The third most discomfort experienced body part was the wrists. There were 10 (29.47%) respondents who have right wrist discomfort while 7 (20.59%) respondents who have left wrist discomfort.

According to past research on aircraft maintenance workers, the most common discomfort body part among them was the lower back (41%), followed by the shoulders (31%) and wrists (29%) [2]. The questionnaire used for 194 interviews was Nordic Musculoskeletal Questionnaire (NMQ) among the aircraft maintenance workers [2]. The results were similar to this study as the lower back, shoulders and wrists were the 3 most common discomfort body parts among the respondents. Besides that, past research also showed the most common discomfort body part among vehicle repair workers in Hawassa city, Ethiopia also was the lower back (62.8%), followed by the shoulders (61%) and wrists (32.3%) [19].



* the % is the percentage of respondents experienced discomfort at least 1-2 times per week for each body part

Fig. 2. Data for CMDQ for each body parts

3.2 Results of RULA

Based on the data analysis, the neck has the highest mean value in the RULA, which was 3.03 (SD=1.11). The second highest was the trunk with a mean value of 2.65 (SD=1.18). The upper arm has a mean value of 2.41 (SD=1.16), which was the third highest mean value among the body parts in RULA assessment. According to past research, their research found that the body part with the highest mean value was the neck with 4.39 (SD=0.28) [17]. Their second highest mean was the trunk with 3.61 (SD=0.26) followed by the upper arm with 2.66 (SD=0.23) [17]. The results of RULA in this study were similar to theirs. The slight difference may be caused by the different variety of postures performed by respondents.

Table 1
Results of RULA

Body Part	Mean	Standard Deviation (SD)
Upper Arm	2.41	1.16
Lower Arm	1.71	0.76
Wrist	1.94	0.89
Wrist Twist	1.21	0.59
Neck	3.03	1.11
Trunk	2.65	1.18
Leg	1.32	0.53
Final Score	4.76	1.37

3.3 Results of REBA

Based on the analysis, the neck has the highest body part mean values among other body parts in REBA. The mean value of the trunk was 2.85 (SD=1.05). The second highest was the upper arm, with a mean value of 2.47 (SD=1.13) followed by the leg with 2.26 (SD=1.36). The results of REBA obtained from past research were different compared to the results of this study [17]. Their highest mean value of body part was the leg with 3.37 (SD=0.36) followed by the trunk with 3.20 (SD=0.41) and the upper arm with 2.09 (0.15) [17]. The position of the legs of respondents might be different and cause the difference in the arrangement of the top 3 highest mean value body parts.

Most of the respondents in this research have the REBA Score between 8 to 10. The percentage of respondents was 50%. Past research done on aircraft maintenance workers has found that most of them have the REBA Score between 8 to 10 with 57% of their respondents [2]. Besides that, past research has found that 55.5% of auto mechanics were at high and very high levels of risk [13]. This showed that the results of the REBA Score of this study were similar to the past research.

Table 2
Results of REBA

Body Part	Mean	Standard Deviation (SD)
Neck	1.94	0.74
Trunk	2.85	1.05
Leg	2.26	1.36
Upper Arm	2.47	1.13
Lower Arm	1.38	0.49
Wrist	1.41	0.56
Final Score	7.41	2.26

3.4 Results of ENBORA

Based on the analysis, the hands/wrists body part has the highest mean value of 4.94 (SD=3.96). The second highest was shoulders with a mean value of 4.62 (SD=3.45). Legs have the third highest mean value in physical risk factors of ENBORA, which is 3.88 (SD=3.58). The fourth highest mean value was neck with 2.29 (SD=2.15). The results obtained were different compared to past research [2,13,17]. This is because ENBORA is taking considers the repetition of the individual for each movement and body part. The respondents in this study have a low repetition cycle within 1 minute and this will affect the total score of physical risk factors and ENBORA Final Score. Therefore, the result of ENBORA determined the respondents have low and very low risk level while the other assessment determined high and very high risk.

Table 3
Results of ENBORA

Risk Factors	Mean	Standard Deviation (SD)
A - Neck	2.29	2.15
B - Shoulders	4.62	3.45
C - Elbows	1.47	1.89
D - Hands / Wrists	4.94	3.96
E - Back	1.97	2.52
F - Legs	3.88	3.58
G - Forceful exertion	0.21	0.54
H - Contact stress	1.82	0.58
I - Vibration	0.09	0.38
J - Work stress	0.65	0.69
K - Work load	1.88	0.69
L - Work pace	1.94	0.34
M - Social environment	1.47	0.93
N - Monotony task	0.97	0.58
O - Task duration	2.00	0.00
P - Work Schedule	2.00	0.00
Q - BMI	0.38	0.70
R - Smoking History	1.03	1.00
Final Score	33.56	11.98

3.5 Comparison of CMDQ, RULA, REBA and ENBORA

After the data for each questionnaire and assessment were obtained, the data for each similar section were compared by using SPSS. The similar section among the CMDQ, RULA, REBA and ENBORA were the neck, trunk, upper arms, lower arms and wrists. Table 1 below shows the result of the comparison. The ENBORA has the highest correlation to the CMDQ as it has the highest Pearson Correlation in most of the compared body parts. The second was RULA as it has 4 body parts that have the second highest Pearson Correlation to CMDQ. The third was REBA. Even though ENBORA has the highest correlation among other assessments, there were no correlations higher than 0.500. This may be caused by the sample size and the difference in questionnaires and assessments. The results obtained were similar to the past research's results for RULA and REBA [17]. Their results were RULA has a higher correlation to the prevalence of WMSDs compare to REBA for upper arm, lower arm, wrist, trunk and neck body parts [17]. The negative correlation that occurred may be caused by the low mean value for the CMDQ neck part. The CMDQ neck score has a low mean value while the other assessments have scored with a high mean value. For the trunk body part, ENBORA has a negative correlation when compared to CMDQ because the mean value of the trunk was the lowest among the assessments. This is because the scores of ENBORA also consider the repetition of each body part. If a body part has a high bend but its repetition within a minute is low, the outcome will be low compared to other assessments.

Table 4
Comparison of CMDQ, RULA, REBA and ENBORA

Body Part		CMDQ	RULA	REBA	ENBORA
Neck	Pearson Correlation	1	-0.008	-0.187	-0.233
	2-tailed significance		0.963	0.289	0.185
Upper Arm	Pearson Correlation	1	0.115	0.104	0.368*
	2-tailed significance		0.518	0.557	0.032
Lower Arm	Pearson Correlation	1	0.311	0.183	0.379*
	2-tailed significance		0.074	0.301	0.027
Wrist	Pearson Correlation	1	0.208	0.145	0.333
	2-tailed significance		0.238	0.414	0.054
Trunk	Pearson Correlation	1	0.177	0.090	-0.029
	2-tailed significance		0.318	0.614	0.873

* Correlation is significant at the 0.05 level (2-tailed)

4. Conclusions

The first objective was to investigate MSD among workers related to working posture using CMDQ. It was completed as CMDQ was used when interviewing the respondents before conducting the ERA. Since there was no past research done based on ENBORA, it was compared by using other ERA and the results were different. The most common discomfort in body parts among the respondents was lower back (70.59%), followed by right and left shoulders (58.82% and 55.88%, respectively) as well as right wrist (29.47%) and left wrist (55.88%). This is because ENBORA also considers the repetition of each body part, unlike RULA and REBA.

The mean RULA Score for the respondents was 4.76 (SD=1.37), which indicates a medium risk level. The mean REBA Score for the respondents obtained was 7.41 (SD=2.26), which indicates the average REBA risk level was high. For ENBORA, the mean value for the ENBORA Final Score was 33.56 (SD=11.98), which indicate the respondents overall have a negligible risk of getting MSD based on their working posture. Based on findings, ENBORA has the highest Pearson Correlation to CMDQ followed by RULA and REBA. The Pearson Correlation of ENBORA to CMDQ were highest for upper arm (0.368), lower arm (0.379), and wrist (0.333). The Pearson Correlation of RULA to CMDQ were highest for neck (-0.008)and trunk (0.177). The Pearson Correlation of REBA to CMDQ was the lowest among others ERA for the upper arm (0.104), lower arm (0.183) and wrist (0.145). Besides, it was found that there was a strong relationship between CMDQ and RULA, REBA as well as ENBORA as most of the Pearson Correlations for each body part does not close to zero. In conclusion, the maintenance workers were found to be exposed to ergonomics risk factors (ERFs) and ergonomics improvement was needed in the future.

For recommendation, suggestions can be made and advised to respondents to help further reduce their risk level of getting MSD. The results of this study can be used in future research when selecting suitable tools to identify the risk level of workers related to working posture. Other than that, future similar research is also recommended to seek professional advice and review to further improve the accuracy of data as well as identify the effect of ergonomic factors, such as noise, temperature and illuminance level towards muscle activities through repetitive loading and unloading tasks [21,22].

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