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ERGONOMICS FOR WELL-BEING - A REVIEW

Nur Suraya Sahol Hamid[1], Nawal Aswan Abdul Jalil[2], Razali Samin[3*], Muhammad Firdaus Ismail[4]

[1] Kuala Lumpur Air Traffic Control Centre Complex, Civil Aviation Authority of Malaysia, KLIA, Sepang, Malaysia
Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia, Serdang, Malaysia
Email: nursuraya@caam.gov.my
[2] Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia, Serdang, Malaysia
Email: nawalaswan@upm.edu.my
[3] Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia, Serdang, Malaysia
Email: zali@upm.edu.my
[4] Kuala Lumpur Air Traffic Control Centre Complex, Civil Aviation Authority of Malaysia, KLIA, Sepang, Malaysia
Email: Firdaus.ismail@caam.gov.my
[*] Corresponding Author

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Abstract:

This article examines the numerous Ergonomics studies conducted in various fields, with a primary emphasis on preventing accidents as well as incidents that could result in ergonomic and human factors issues for industrial workers. Researchers have discovered several technologies that can be used to enhance ergonomic treatments and reduce the frequency of incidents. Despite the fact that safety has a significant impact on human parts and ergonomics, this article bases its discussion on the various industrial zones. Following that, the workplace can clearly execute mitigation and prevention strategies. The environment and comfort level zones are interconnected in a workplace that handles machinery. Ergonomics are important human factors, particularly in the manufacturing sector. This paper examined several approaches put forth by different industries, considering the difficult frequencies and postures associated with each occupational activity. Note that various comfort level zones that relate to the workers are defined by each study tool. On the basis of this, only further research was done, and the prior literature thoroughly identified the issues.

Keywords:

Accident Prevention, Ergonomics, Human Factors, Industrial Safety, Workplace Comfort

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Introduction

One physical characteristic that addresses how people should position themselves at work is ergonomics. Ergonomics in the workplace brings up several important issues that affect both safety and productivity. One of the main problems is the high number of musculoskeletal disorders (MSDs) caused by poor posture, repetitive tasks, and bad workplace design, leading to pain and injuries. Many workers and employers are not fully aware of the importance of good ergonomic practices, which makes the situation worse. Workspaces with uncomfortable seating, poorly placed tools, and inefficient setups add to these challenges. These issues not only harm employees' health but also reduce productivity, increase absences, and raise healthcare costs. Fixing these ergonomic problems is key to improving both worker safety and business performance. Among the performance factors and possible issues at work, awkward postures rank first (Qutubuddin, Hebbal, & Kuma, 2013). The assessment of the brick manufacturing business was carried out by Qutubuddin et al. (2013). In the brick production industry, they examine task performance. Product production and domestic manufacturing sectors both exhibit uncomfortable postures. It is unknown to them what safe working positions and appropriate postures are. The authors evaluate the workers' posture in light of their continuous working mode in order to research MSDs and implement ergonomic solutions (Karthikeyan, Phebe, Kaliappa, & Chandrasekaran, 2014). The appraisal of the evaluation in the leather apparel sector was carried out by Karthikeyan et al. (2014). This study attempts to detect and categorize Work-related Musculoskeletal Diseases (WMSD) dangers in the garment and leather manufacturing industries (Arroyave-Tobón & Osorio-Gómez, 2017). On the other hand, Arroyave-Tobón and Osorio-Gómez (2017) assessed the ergonomic hazards utilizing various modeling tools with regard to virtual-based analysis in conceptual design mode to decrease the ergonomic hazards (Upadhyay, Desai, Paghdar, & Jhala, 2015). Alternatively, Upadhyay et al. (2015) analyzed the ergonomic dangers existing in various industrial domain sectors as well as the ergonomic interventions available in the workplace (Andreoni, Santambrogio, Rabuffetti, & Pedotti, 2002). Meanwhile, Andreoni et al. (2002) developed the method with regard to the ergonomic interfaces as well as posture assessments' analysis with the car drivers' novel work investigations (Buchholz, Paquet, Punnett, Lee, & Moir, 1996). In addition to that, Buchholz et al. (1996) assessed the construction sector utilizing the job sampling method. On the other hand, Jones and Kumar (2010) performed an ergonomics risk assessment on a saw ball mill, evaluating four activities. Subsequently, the results identify areas requiring ergonomic interventions (Perez, De Looze, Bosch, & Neumann, 2014). Similarly, Perez et al. (2014) integrated the idea of system design modification and improvement into a workplace simulation for ergonomics analysis (Dukic, Rönnäng, & Christmansson, 2007). In 2007, Dukic et al. looked at the ergonomic risks of working in a virtual mode in the manufacturing industry (Ali, Qutubuddin, Hebbal, & Kumar, 2012). As Ali et al. (2012) did ergonomic studies in traditional Indian sawmills, they looked at the risks of musculoskeletal disorders at work and how the workers dealt with them. Every task in this work is assessed for a seamless ergonomic intervention process, then critically viewed and recorded (Li & Buckle, 1999). Li and Buckle (1999) focused on the physical factors considered during the ergonomic evaluation. This particular piece of work is among the assessments taken to determine the discomfort level zone with regard to the assessment category (Ozsoy, Ji, Yang, Gragg, & Howard, 2015). In 2015, Ozsoy et al. investigated the ergonomic risks present in the simulation mode to improve the virtual graphics with respect to each work activity. Additionally, they simulated drivers' performance referring to the interior seating design with regard to each work activity (Mali & Vyavahare, 2015). Correspondingly, Mali and Vyavahare (2015) presented the various ergonomic evaluation procedures that were carried out for the industrial workplace

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activities that were conducted. These procedures utilized a variety of reviews and methodology tools. In 2021, Koppiahraj, Bathrinath and Saravanasankar utilized the Fuzzy VIKOR methodology to identify appropriate ergonomic risk assessment methods aimed at minimizing industrial workers' exposure. Rajakarunakaran, Kumar and Prabhu (2015) employed the Fuzzy Expert framework in 2014 to determine the level of danger posed by LPG refueling stations. Karuppiah, Sankaranarayanan, Ali and Kabir (2020) used the SME methodology to identify ergonomic evaluation factors in the workplace at Leather Garment Productions. Additionally, Bhalaji, Bathrinath, Ponnambalam and Saravanasankar (2019) applied Fuzzy Decision-Making methodologies to assess risk factors and environmental health in the healthcare industries. Ortega Marchisio and Collao-Diaz (2023) conducted a systematic review, showing how ergonomic practices enhance productivity in manufacturing companies. Similarly, Maheshkumar et al. (2015) demonstrated that ergonomic improvements at workstations lead to increased comfort and operational efficiency. Additionally, Bindhu and Rao (2024) assessed workplace ergonomics, highlighting key factors that affect worker well-being and suggesting interventions to improve performance. These studies collectively highlight the positive impact of ergonomics in manufacturing environments. The table below (Table 1) illustrates the statistics on ergonomic issues in industrial settings.

Table 1: Statistics on Ergonomic Issues in Industrial Settings

Category	Industry	Statistics	Reference
Incidence of WMSDs	Brick Manufacturing	40% of workers reported discomfort in back and shoulders due to awkward postures	Qutubuddin et al. (2013)
Ergonomic Risk (MSDs)	Leather Apparel Industry	35% of workers experienced musculoskeletal disorders related to repetitive tasks and improper posture	Karthikeyan et al. (2014)
Productivity Loss due to MSDs	General Industrial Sector	20% loss in productivity due to absenteeism caused by ergonomic-related injuries	Upadhyay et al. (2015)
Impact of Ergonomic Interventions	Construction Industry	25% reduction in reported back pain after implementing ergonomic seating solutions	Buchholz et al. (1996)
Cost of Ergonomic Injuries (MSDs)	Healthcare Industry	Annual cost of $20 billion for ergonomic-related workplace injuries	Bhalaji et al. (2019)
Effectiveness of Ergonomic Interventions	Manufacturing Sector	Fuzzy VIKOR methodology reduced ergonomic risk exposure by 15% after assessment	Koppiahraj et al. (2021)

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Methodology

In terms of the instruments and methods employed in each ergonomic assessment, the numerous methodologies offered for ergonomics risk assessments are notable and innovative. The approach may vary depending on the many industries utilized to adopt and assess the various kinds of difficult postures associated with each activity. Here, the flowchart below (Fig. 1) illustrates the most straightforward manner of providing the reviewed technique for each task before discussing the assessment instruments. Based on this review workflow, some ergonomics analysis tools and apps can be studied and applied in various applications and domains. Note that the sample data illustrates the many kinds of tools utilized for various purposes (Table 1- Ergonomics Tools).

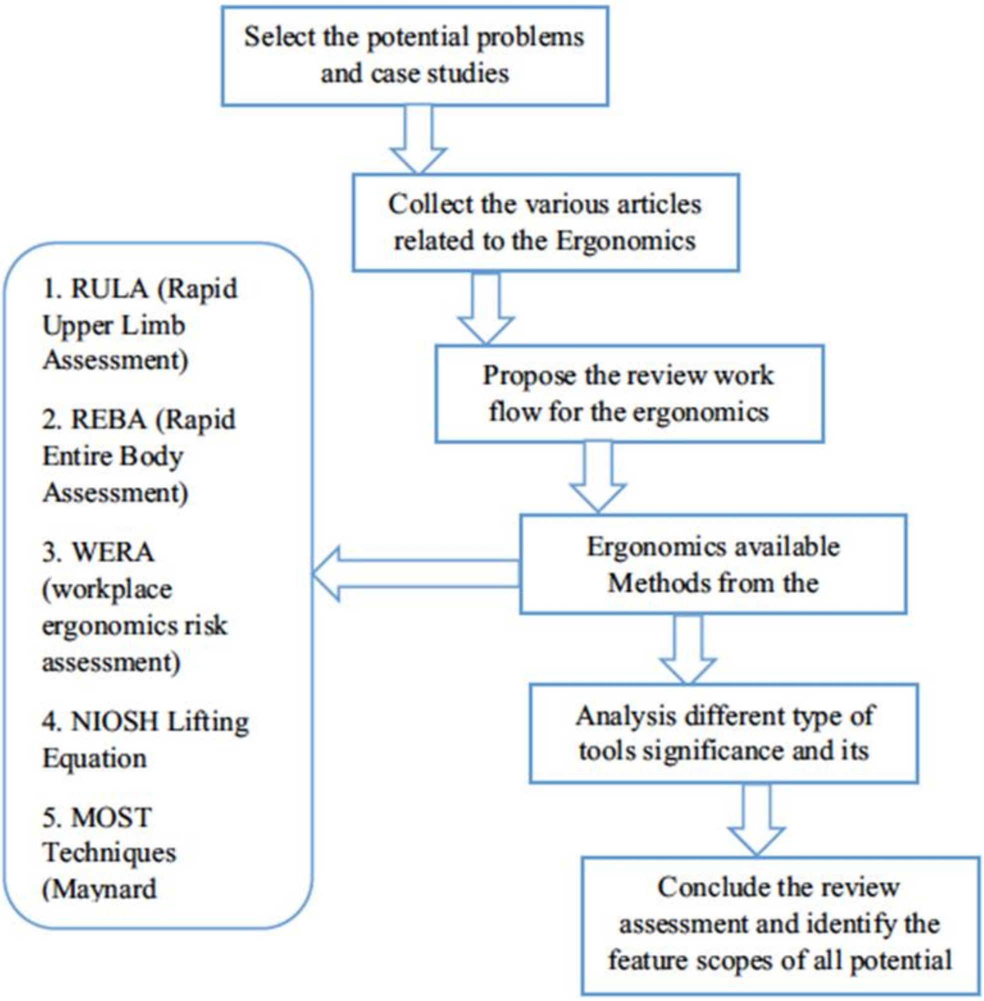

Figure 1: Ergonomic Tool's Flow Process

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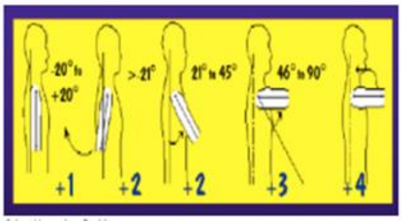
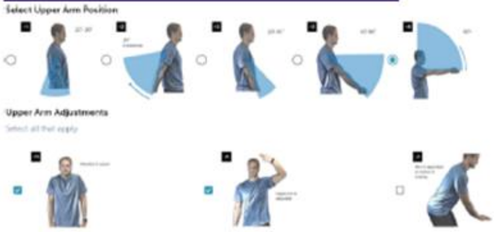
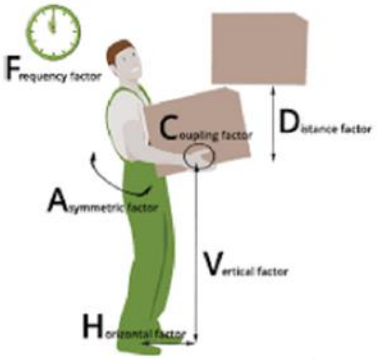
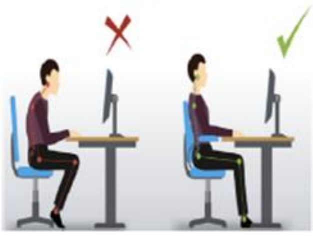
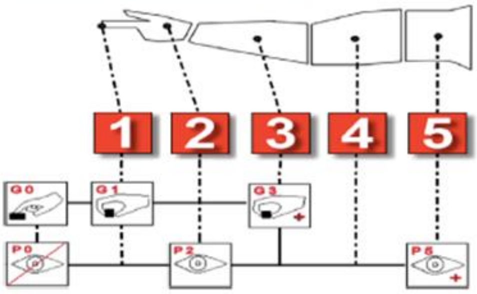
Table 2: Tools of Ergonomics

Type of activities representations	Ergonomics assessments Tools and Applications
	**RULA** (Rapid Upper Limb Assessments) is used for analyses the upper body parts assessments such as hand, twist neck and limbs.
	**REBA** (Rapid Entire Body Assessments) is used for analyses the entire body postures such as neck, hand, shoulder, leg and twist.
	**NIOSH** Lifting Equations is used for analyses the manual handling posture inside the workplace such as lifting lowering etc.
	**WERA** (Workplace Ergonomics Risk Assessment) used to analysis the observational good working postures and identify the awkward working postures.
	**MOST** Technique (Maynard Operational Sequence Technique) is used for analysis step by step operation of all activities in a single calculation to identify the risk factors involved in the workplace.

RULA

These methods were applied in order to evaluate ergonomic risk factors. The Rapid Upper Limb Assessment (RULA) survey technique was developed by McAtamney and Corlett (2009) to be used in industrial ergonomics assessment processes to look into specific possible issues, including stress, strain, and fatigue during work that might result in physical injury (McAtamney & Corlett, 2009). Research and testing methodologies are able to forecast uncomfortable postures and analyze body postures, including those of the hand, wrist, chest, shoulder, leg, as well as neck. Note that this tool is mainly employed to evaluate ergonomic

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hazards and reduce workplace risks, with three levels of hazard: Low, High, as well as Medium (refer to Fig. 2).

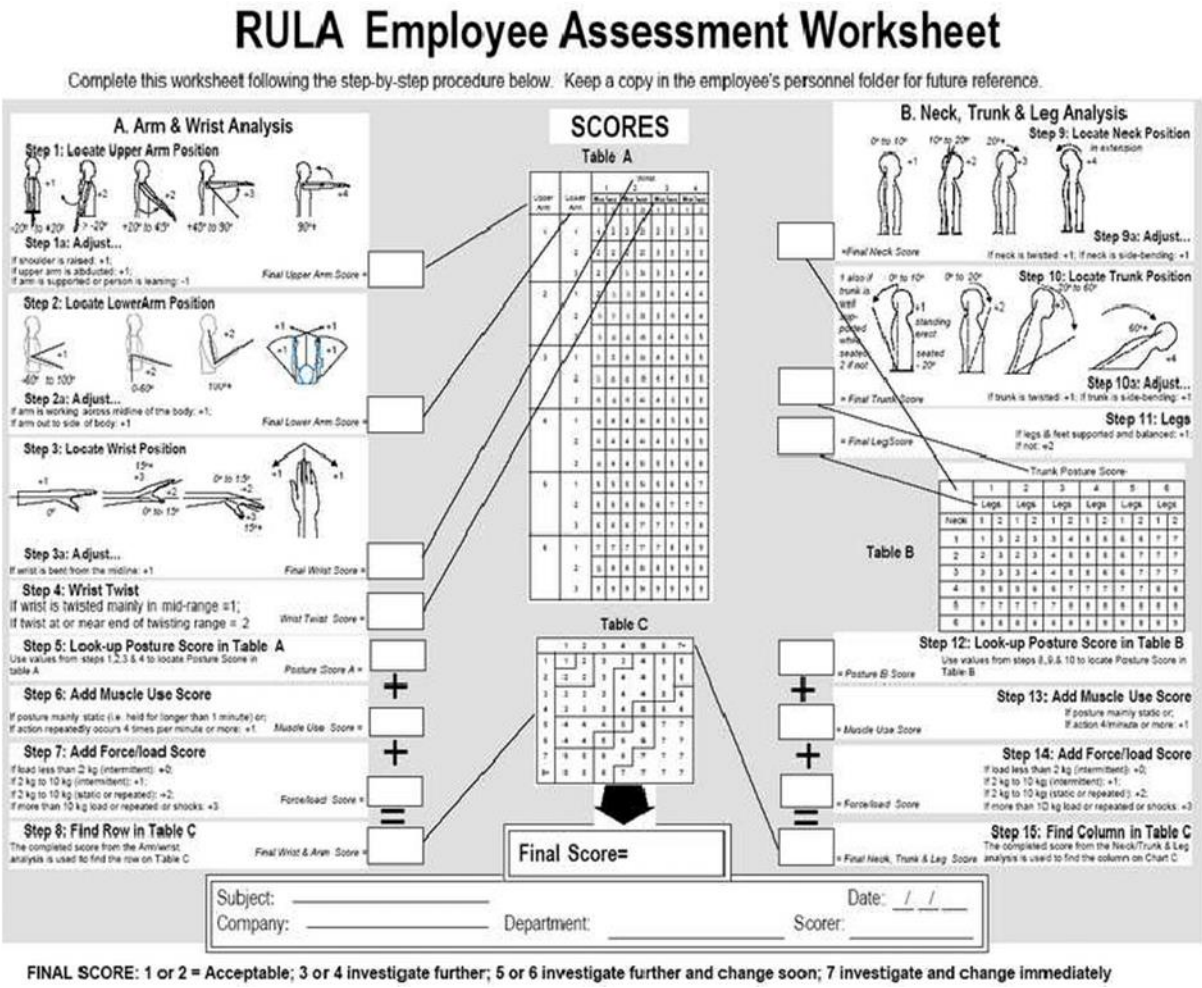

Figure 2: RULA

Steps for assessing the RULA Techniques:
1. Monitor each task
2. Examine the upper body parts with regard to each task
3. Take a photograph with regard to each task
4. Fill in the scores concerning the Provided RULA Table
5. Calculate PART A as well as PART B scores
6. Calculate the risk level available in the workplace

REBA Techniques

The Rapid Entire Body Assessment (REBA) tool was established by Hignett and McAtamney (2000) in order to assess the well-being of people who work in testing and research, particularly in the process and manufacturing industries. The REBA method and the RULA techniques use the same methodology. The only difference between RULA and REBA is that in RULA, only the upper body parts are taken for an assessment, while in REBA, the entire body is examined. The REBA technique is also useful in analyzing awkward or critical postures in several ways, particularly in healthcare sectors where awkward activities are practiced. Note that the scores may vary depending on the risk factors as well as human performance associated with these

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particular work performances. The data sheet below provides the format for this procedure. The light grey-colored sections of the datasheet are designated for data entry. It evaluates the right as well as left postures in Groups A (Legs, Neck, and Trunk) as well as B (Wrists, Lower Arms, and Upper Arms). Each region has modification remarks and a posture score scale for extra considerations. After that, the factors for coupling and load/force are scored. Lastly, it assigns a score to the postural activities for Groups A as well as B from Tables A and B, correspondingly. Only the table comes after the data-gathering sheet. The total of the Load/Force as well as Table A scores, is called Score A. The total with respect to each hand's Table B as well as Coupling scores, is called Score B. After reading Score C from Table C, enter it next to Scores A and B. The result of multiplying Score C by Activity is the REBA score. Note that the level of risk is displayed in the REBA decision table. The REBA scoring sheet (Hignett & McAtamney, 2000) is based on the work of Highnett and McAtamney (Fig. 3).

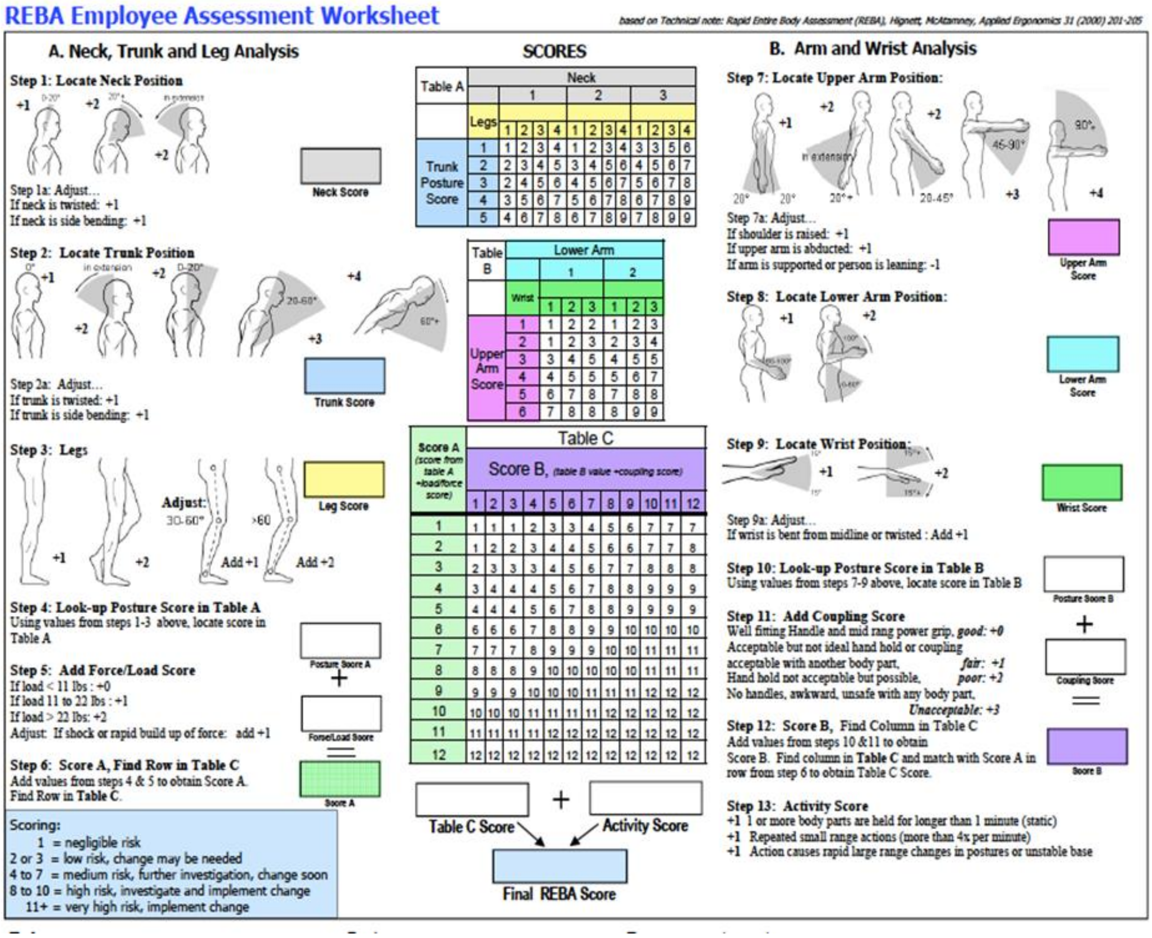

Table A	Neck	1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk Posture Score	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Table B	Lower Arm	1			2		
	Wrist	1	2	3	1	2	3
Upper Arm Score	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

Table C Score A (score from table A +load/force score)	Score B, (table B value +coupling score) 1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Figure 3: REBA Table

WERA Assessment

Here, the Workplace Ergonomic Risk Assessment (WERA) represents a method that involves recording as well as monitoring techniques to revise the way activities are monitored for factors related to manual handling and WMSDs. Note that the WERA tool method identifies six factors that contribute to the consequences of manual handling. These factors are time of work, continuous fatigue, shaking activities, mandatory factors, continuous behaviors of workers, as well as attitude performance. The consequences primarily affect five main body regions: leg,

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neck, back, wrist, as well as shoulder. The system incorporates a scoring mechanism as well as activity levels to determine the risk level and the necessity for further detailed assessments. This tool's reliability, validity, as well as usability were assessed during its development (Fig. 4).

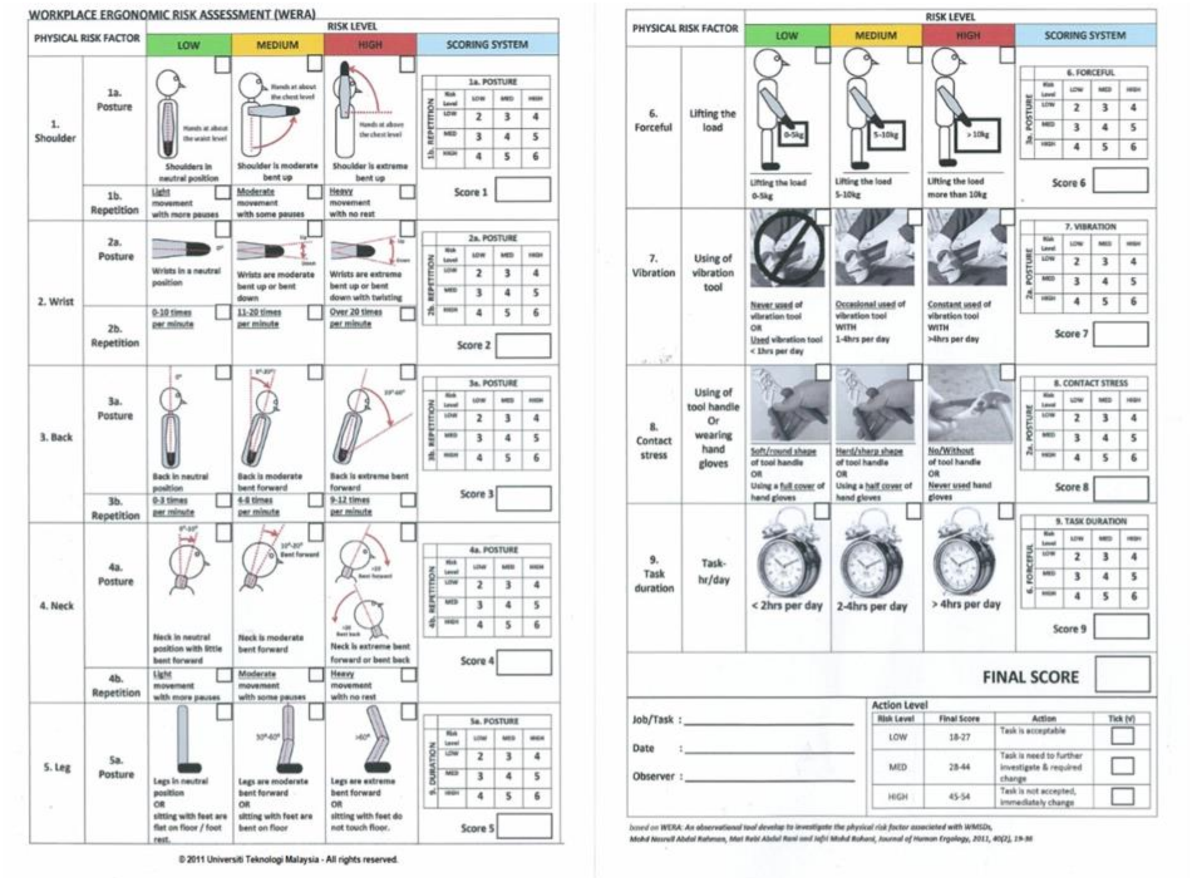

Figure 4: WERA

NIOSH Lifting Equation

In the year 1985, the National Institute of Occupational Safety and Health established a new committee to develop solutions to reduce the issues related to manual material handling in organisations. Following the committee's recommendation, a formal document was established for the revised lifting equation in 1991. Note that the equation was subsequently provided to the NIOSH personnel as well as the general public so that a methodology could be formulated and the risks associated with manual handling with regard to the workplace reduced. Subsequently, Waters et al. (1999) introduced the improvised NIOSH lifting equations, which were developed to address the industry's specific requirements and accommodate the growth of organizational setups. The updated lifting equations are employed to assess lifting activities, while the assessment of manual handling activities is conducted by workers on-site. The NIOSH lifting equations can be determined by utilizing the parameters listed below:

RWL = LC*HM*VM*DM*AM*FM*CM.

Recommended Weight Limit (RWL)
Load Constant (LC)

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Horizontal Multiplier (HM)
Vertical Multiplier (VM)
Distance Multiplier (DM)
Asymmetric Multiplier (AM)
Frequency Multiplier (FM)
Coupling Multiplier (CM)

Table 3: Standard Values Provided by NIOSH

		METRIC	U.S. CUSTOMARY
Load Constant	LC	23 kg	51 lb
Horizontal Multiplier	HM	(25/H)	(10/H)
Vertical Multiplier	VM	1-(.003 |V-75|)	1-(.0075 |V-30|)
Distance Multiplier	DM	.82 + (4.5/D)	.82 + (1.8/D)
Asymmetric Multiplier	AM	1-(.0032A)	1-(.0032A)
Frequency Multiplier	FM	From Table 5	From Table 5
Coupling Multiplier	CM	From Table 7	From Table 7

Source: (Waters et al., 1999)

Table 4: Frequency Multiplier (FM) Table

Frequency Lifts/min (F) ‡	Work Duration					
	≤1 Hour		>1 but ≤2 Hours		>2 but ≤8 Hours	
	V < 30†	V ≥ 30	V < 30	V ≥ 30	V < 30	V ≥ 30
≤0.2	1.00	1.00	.95	.95	.85	.85
0.5	.97	.97	.92	.92	.81	.81
1	.94	.94	.88	.88	.75	.75
2	.91	.91	.84	.84	.65	.65
3	.88	.88	.79	.79	.55	.55
4	.84	.84	.72	.72	.45	.45
5	.80	.80	.60	.60	.35	.35
6	.75	.75	.50	.50	.27	.27
7	.70	.70	.42	.42	.22	.22
8	.60	.60	.35	.35	.18	.18
9	.52	.52	.30	.30	.00	.15
10	.45	.45	.26	.26	.00	.13
11	.41	.41	.00	.23	.00	.00
12	.37	.37	.00	.21	.00	.00
13	.00	.34	.00	.00	.00	.00
14	.00	.31	.00	.00	.00	.00
15	.00	.28	.00	.00	.00	.00
>15	.00	.00	.00	.00	.00	.00

†Values of V are in inches. ‡For lifting less frequently than once per 5 minutes, set F = lifts/minute.

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Table 5: Coupling Multiplier (CM)

Coupling Type	Coupling Multiplier	
	V< 30 inches (75 cm)	V ≥ 30 inches (75 cm)
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

MOST Techniques

The Maynard Operation Sequence Technique (MOST), a work measuring method first created by H. B. Maynard in the United States, was reviewed by Gadakh, Ahire, Karad and Student (2017). This technique is mostly utilized to examine a broad spectrum of industrial applications, for example, the automotive, household appliance, and aircraft industries. The main flaw of the ergonomics intervention was the laborious and difficult techniques it employed. It can be applied in various industrial sectors, encompassing administrative and corporate techniques as well as strategies to enhance human productivity and optimize time constraints in assembly sections across all industries. Researchers and industry experts have suggested that the MOST technique be utilized to measure different workplace activities and conveniently monitor them in all kinds of industrial manufacturing and assembly sectors due to the issues they have uncovered. This method is essential for tracking difficulty as well as work-measurement jobs in terms of several versions, such as Fundamental, Small, including Enlargement assessments, in the field of Industrial Engineering. This technique is primarily used to rectify and detect issues in the production process as well as conduct an analysis for enhancing ergonomics. This technique is also implemented in the optimized process application (Fig. 5).

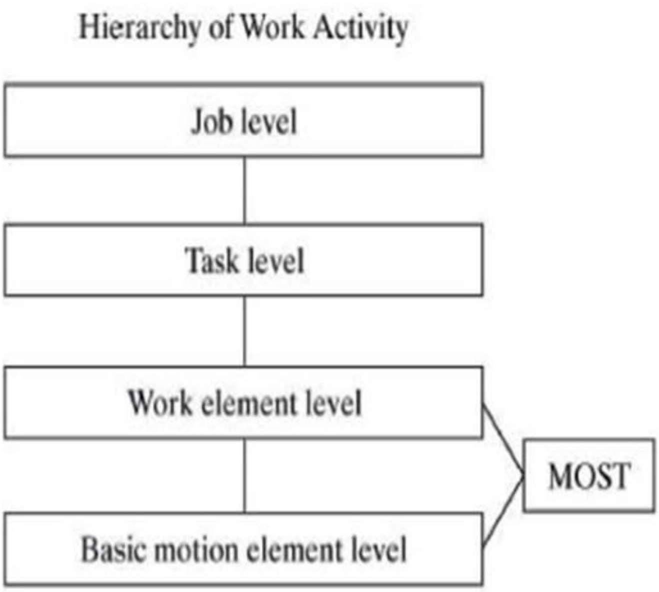

Figure 5: Flow with Regard to MOST Techniques

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Conclusion

It is advisable to utilize the most effective techniques and dependable tools to assess workers' job performance in the industrial setting. Only potential risks associated with manual handling and ergonomics may be countered by implementing and highlighting different levels of zones in the workplace. Nevertheless, the review may only be addressed using specific techniques. Through the analysis of reviews, we can identify and highlight each problem, as well as determine potential issues based on the frequency of incidents and accidents within the industry category. The task can be transformed into a tangible assessment to be used as a benchmark for identifying potential issues within a particular field. Future work can be thoroughly examined by utilising various tools to evaluate ergonomic hazards as well as developing the appropriate methodology to mitigate potential issues in the industry. Hence, the extent of work growth may be evaluated in any manufacturing sector by performing an initial assessment of safety and ergonomics within the workplace. Correspondingly, the review analysis serves as the foundational framework for future work to be conducted in a more practical evaluation.

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