Journal Engineering Sciences (Improsci)
e-ISSN 3031-7088
p-ISSN 3032-3452

Analysis of Occupational Posture Risk and Physiological Load in Grinding and Moving HVAC Filter Products Using Rula-Reba, *Heart Rate*, and Borg RPE

Iwan Aang Soenandi*, Roy Theo Sabattian
Industrial Engineering Study Program, Faculty of Smart Technology, Krida Wacana Christian University, Jakarta
*Correspondence Author: iwan.as@ukrida.ac.id

Abstract
This study aims to study the risk of work posture, heart rate response, and operator workload perception in gluing, lifting, and laying HVAC filter products in the *epoxy center* area of PT XY. In this study, *the Rapid Upper Limb Assessment* (RULA), *Rapid Entire Body Assessment* (REBA), *Heart Rate*, and *Borg Rating of Perceived Exertion* (Borg RPE) methods were used. This study was conducted on six operators through field observation, photo/video documentation, *Heart Rate* measurement, Borg RPE assessment, *manual handling* recording, anthropometric measurements, and brief interviews. The results showed that, compared to gluing and lifting activities, laying activities had the most prominent ergonomic risk patterns. This is shown by relatively high RULA and REBA scores, the highest average *heart rate*, and the perception of workload which is generally in the weight category. In addition, gluing activities indicate postural risks, especially due to the posture of bending, reaching, and the use of *nozzles* and hoses during the work process. Because it involves moving products manually, lifting jobs have a relatively lower risk. However, this work still requires supervision. The mapping results show that improvement should be a top priority. Then followed by gluing and product lifting activities. Ergonomic improvements are aimed at adjusting the placement height of *the pallet support facility*, regulating the position of products, hoses, and nozzles during immersion, and reducing manual displacement distances when lifting. The results of the simulation of the reassessment of RULA and REBA based on the proposed posture showed the possibility of reducing the risk of working posture, especially in the excavation and laying work.

Keywords: ergonomics, RULE, REBA, *Heart Rate,* Borg RPE, *manual handling*, work posture, HVAC filter

INTRODUCTION

PT XY is a manufacturing company engaged in automotive filters and radiator water. In its production development, this company has divisions that play a role in the production of components and the development of new products, one of which is the *Heating*, *Ventilation*, *and Air Conditioning* (HVAC) division. In this HVAC division, there are several work processes that are carried out manually in product work, one of which is *the epoxy center* process. This gluing process is carried out to provide an adhesive to the product. During this process, the operator is directly involved in every activity, including manual gluing, lifting, and placing of products. This is in line with research by Primasari and Kurnianingtyas (2022), which shows that *material handling* work done manually by employees can result in a high risk of work posture. Based on the results of observations made in the *epoxy center* area, the operator carried out three main activities, namely gluing, lifting after the gluing process was completed, and placing the product to work on other products. All three activities are still done manually, so operators must interact directly with the product during the workflow. This condition is shown in Figure 1.

Figure 1. Working Conditions of *Epoxy Center Operators*

In gluing activities, the operator must orient the *nozzle* according to the shape of the product being worked on, so that the position of the arms, wrists, waist, and back must be maintained during the gluing process. Anwar *et al*. (2024) states that WMSDs in manual workers are related to static or incorrect posture, prolonged repetitive movements, and sustained use of force on certain parts of the body. Once the immersion process is complete, the operator must move the product by manually lifting it and then take it to the laying area about 2–4 meters away on foot. Next, the operator places the product on an area of *the pallet* that has a lower position compared to when doing the initial lift, so that the body position used becomes lower when placing the product.

In this manual work activity, the operator is required to maintain several working postures during the process. In gluing activities, the operator tends to maintain the position of the arm to reach the product, and the wrist remains directed the *nozzle* following the shape of the product. Meanwhile, in the process of lifting and laying the product, the operator manually lifts the load, then brings the product to the storage area, then puts it in a lower position so that his body is bent. Based on the results of field observations supported by initial informal communication with operators, some operators said that they experienced pain or pain in their arms, wrists, shoulders, and waist shortly after performing the activity. According to Primasari and Kurnianingtyas (2022), manual *handling* activities can pose a high risk of working posture and require ergonomic attention.

Work activities that involve non-neutral posture, manual lifting of weights, and repetitive movements within a certain period of time can increase the risk of disorders of the musculoskeletal system or Work-related *Musculoskeletal* Disorders (WMSDs). This condition is in line with Primasari and Kurnianingtyas (2022), that manual material removal can increase the risk of work posture and WMSDs complaints if done repeatedly. These risks can arise if work activities do not pay attention to ergonomic principles, so that they can cause discomfort at work, get tired quickly, and reduce the quality of the operator's work.

Various previous studies have shown that jobs involving manual activities with a non-neutral work posture have the potential to have ergonomic risks that require further evaluation. According to Kee (2022) and Ogedenbek *et al*. (2023), observational methods are important in the work measurement process because they are able to provide a direct overview of ergonomic risks based on real working conditions in the field. The findings show that manual work activities need to be evaluated to determine the level of ergonomic risks faced by operators and be the basis for the preparation of proposals to improve working conditions.

In addition to assessing the risk of working posture, several studies also use anthropometric data as the basis for the preparation of ergonomics improvement proposals. Kartika and Mukhtar (2023) show that work posture risks can be identified using the RULA and REBA methods, as well as considering anthropometric data. The results of the research of Sitompul *et al*. (2024) shows that anthropometry in the design of work aids or facilities can be used to reduce work risks. These findings show that ergonomics evaluation not only aims to determine the level of risk, but can also be used as a basis for drafting improvement proposals that are more appropriate to working conditions in the field.

Based on the results of the literature search conducted during the preparation of the research, there have been many studies that discuss the evaluation of ergonomics in manual work activities using various methods of assessing work posture. However, in this study, the study of the immersion, lifting, and placing of products in *the epoxy center* area in the HVAC area is still not widely found. Most of the previous research was conducted on objects, types of work, and production processes with different characteristics of work activities, so they do not fully represent the actual conditions of the *epoxy center process*. Therefore, this study aims to analyze the ergonomic conditions of the operators in the process so that the level of risk in each work activity can be identified as the basis for the preparation of improvement proposals that are in accordance with the working conditions in the field.

Based on the working conditions and previous research, this study uses a combination of several methods to examine the relationship between methods and analyze the ergonomic condition of the operator. Posture assessments that involve a lot of upper body, such as immersion activities, use *Rapid Upper Limb Assessment* (RULA). Meanwhile, the activity of lifting and placing products was evaluated using *Rapid Entire Body Assessment* (REBA), as it involved overall posture. Hunusalela *et al*. (2022), using RULA and REBA to determine the level of risk at several workstations. Meanwhile, Kartika and Mukhtar (2023) use RULA, REBA, and anthropometry to support the improvement of work facilities. The study also used *Heart Rate* to describe the physiological response of the operator during the activity. HR that reflects the functioning of the autonomic nervous system and can be monitored through wearable devices without interfering with work activities, and has commonly used physiological measures (Li *et al*., 2023). *The Borg Rating of Perceived Exertion* (Borg RPE) is used to determine the perceived workload of the operator. This will provide a relevant subjective context for repetitive work (Gobbo *et al*., 2025). Based on this description, research is needed to analyze the ergonomic conditions of operators in the *epoxy center process* in the HVAC area so that the level of risk in each work activity can be identified and used as a basis in the preparation of repair proposals in accordance with working conditions in the field.

Table 1. Previous Research

Author and Year	Research Object	Method	Findings	Weaknesses / Limitations	Linkage to Research
Nwar *et al*. (2024)	Harvest mushrooms manually on farm workers in Canada	*Ergonomic evaluative* using RULE, CTD *Index*, and questionnaire *discomfort*. Data was collected through field studies and recordings of work activities.	85% when picking posture needs to be changed immediately because RULA score is 6-7, CTD *index* 1.16 which indicates a potential *repetitive strain*. So that there are complaints in the hands and shoulders.	The focus of the research was on mushroom farming work, did not discuss product movement in an industrial environment, did not use REBA, and did not consider anthropometry	Supports the idea that manual work with a non-neutral posture and repetitive activities can increase the risk of WMSDs. Therefore, this topic is relevant because it addresses the risks of manual work in this study.

Varghese *et al.* (2025)	Employees *rubber trapping* in Kerala, India	Observation using video with 51 employees and 1111 postures. Rating	RULA focuses on *the upper limb* and is considered best suited for loads dominant posture	The focus of this research is the comparison of methods in the context of agriculture. None Recommendations for specific improvements,	It is very important to place OWAS and PERA as methods Deep Comparator

METHODS

This study is a descriptive observational field research with a *cross-sectional design*. These observations are made under working conditions without changing the operator's working methods. The focus of this research is a series of work in the epoxy center area that includes three work activities, including immersion, lifting, and product laying. RULA and REBA were used to determine the occupational posture risks associated with the likelihood of WMSDs. Borg RPE indicates the perception of the operator's workload, while the Heart Rate indicates the operator's physiological response pattern relatively speaking. The results of all four measurements were mapped based on the same operators and activities as the main data of the study. Manual handling, anthropometry, facility conditions, and interview results were used to support ergonomics improvement proposals. Linkage analysis is not carried out through statistical correlation tests, medical diagnoses, or cause-and-effect relationships, but rather descriptively and conceptually.

The research was carried out during practical work activities, especially HVAC production, at PT XY, the Epoxy Center workstation section. Data collection is carried out when the operator performs its work in actual conditions. The observations carried out include three work activities, namely wiping, lifting, and laying products. Observations are made without providing treatment or changing the way the operator works.

Table 2. Operationalization of Research Parameters

Aspects	Parameters	Results	Analysis
Risks of upper body posture	Right and left RULA, posture, muscle use, and weight	Score 1-7 and *action level*	Determining upper posture risk and score Highest representative
Risks Full body posture	REBA, posture, load, *coupling*, and activity	Score 1-15 and risk categories	Determining posture risk Overall
Physiological response	*Heart rate* during the activity	HR friendly in BPM and relative patterns	Comparing pulse responses Inter-activity heart

Perception workl oad	Borg RPE scale 0-10	RPE scores and categories	Describe the workload perceived by the operator
Manual handling	Weight, distance, beginning-end height, and position.	Description of characteristics Transplant	Supports interpretation and Proposed improvements
Anthropometry	Height, standing elbow height, and forward arm reach	Results measureme nt on each operator	Supporting the suitability of the proposed improvement dimensions

The simulation was carried out as a conceptual evaluation of the ergonomics improvement proposals that had been prepared. The evaluation was carried out by comparing the RULA and REBA scores in actual conditions with the scores of the proposed posture simulation results. Thus, the success of the proposal in this study is assessed based on the potential to reduce the level of posture risk, not through direct implementation in the field.

DISCUSSION

The recapitulation of results per operator is carried out to combine the results of data processing RULA, REBA, *heart rate*, and Borg RPE for each work activity. This recapitulation is compiled based on all operators totaling six observed in three work activities, namely gluing, lifting, and product placement. Thus, the results of each method can be viewed simultaneously to facilitate the analysis process at the next stage.

Table 3. Per-Operator Results Recapitulation

Operator	Activities	RULES Right	LEFT RULE	RULES Representative	Pattern RULES	REBA Score	Pattern REBA	HR Averag e	RPE Average	Categorie s RPE
OP1	Polishing	6	6	6	Height	6	*Medium Risk*	88	6	Weight
OP1	Lifting	3	3	3	Medium	2	*Low Risk*	97	6	Weight
OP1	Laying	6	6	6	Height	4	*Medium Risk*	105	6	Weight
OP2	Polishing	4	4	4	Medium	6	*Medium Risk*	94	6	Weight
OP2	Lifting	3	3	3	Medium	4	*Medium Risk*	98	6	Weight
OP2	Laying	7	7	7	Very Height	5	*Medium Risk*	108	6	Weight
OP3	Polishing	6	6	6	Height	6	*Medium Risk*	94	4	Medium
OP3	Lifting	3	3	3	Medium	3	*Low Risk*	96	4	Medium
OP3	Laying	5	5	5	Height	7	*Medium Risk*	107	5	Weight
OP4	Polishing	7	7	7	Very Height	5	*Medium Risk*	91	6	Weight
OP4	Lifting	3	3	3	Medium	3	*Low Risk*	98	6	Weight
OP4	Laying	6	6	6	Height	8	*High Risk*	106	6	Weight
OP5	Polishing	6	4	6	Height	7	*Medium Risk*	95	6	Weight

OP5	Lifting	3	3	3	Medium	3	*Low Risk*	98	7	Very Weight
OP5	Laying	5	5	5	Height	7	*Medium Risk*	107	7	Very Weight
OP6	Polishing	6	6	6	Height	6	*Medium Risk*	87	6	Weight
OP6	Lifting	3	3	3	Medium	4	*Medium Risk*	95	6	Weight
OP6	Laying	7	7	7	Very Height	7	*Medium Risk*	105	6	Weight

Based on the recapitulation of results per operator in Table 3, the data is then rearranged based on work activities to identify patterns of RULA, REBA, *Heart Rate*, and Borg RPE results in each activity observed. This preparation aims to facilitate analysis per activity so that which activities have a higher level of risk can be identified more clearly.

A recapitulation of actual data patterns per activity

A recapitulation of actual data patterns per activity was made to show the trend of the results of the assessment of RULA, REBA, *Heart Rate*, and Borg RPE in the three activities. This recapitulation is carried out by grouping the results of each operator's observations on each work activity, so that the pattern of results of each activity can be observed more systematically. Thus, the difference in risk characteristics in each activity can be seen more clearly before the discussion of the relationship between the parameters used in this study is carried out.

Table 4. A Summary of Actual Data Patterns by Activity

Activities	RULES Representative	RULA Pattern	REBA Average	REBA Pattern	HR Average	HR Pattern	RPE Average	Categories RPE
Polishing	5.83	Height; The Majority of the *Action Levels* 3–4	6	*Medium Risk*	91.5 bpm	Relatively lowest	5.67	Medium
Lifting	3	Medium; *Action Level* 2	3.17	*Low–Medium Risk*	97.0 bpm	Relatively moderate	5.83	Medium
Laying	6	Height; *Action Levels* 3–4	6.33	*Medium-High Risk*	106,3 bpm	Relatively most height	6	Medium

The summary in Table 4 is the basis for discussing the relationship between the level of occupational posture risk obtained from RULA and REBA and physiological responses based on *Heart Rate* and workload perception based on Borg RPE. This presentation makes it easier to identify activities that show a higher tendency to ergonomic risk compared to other activities.

Preparation of Ergonomics Improvement Proposals

Ergonomics improvement proposals are made after priority activities are determined through mapping the results of RULA, REBA, *Heart Rate* and Borg RPE. This supporting data includes the characteristics of *manual handling*, the dimensions of work facilities, operator anthropometry, and information from brief interviews. Although supporting data is not used in the order of priority of activities, it is still used as a basis for considering proposed improvements that are more in line with actual working conditions.

Based on supporting data, the moved product weighs about ±8 kg, the moving distance is about 2-4 meters, the initial height of the transfer is about ±60 cm, and the final height of the laying is about ±16 cm. The dimensions of the facility show the height of the table is about ±55 cm and ±80 cm, the laying height is about ±16 cm, and the working range distance is about ±50 cm. Operator anthropometric data shows a standing elbow height of 101-108 cm and a forehand reach of 54-58 cm. Complete anthropometric data and supporting data are presented in the appendix.

Table 5. Proposed Ergonomics Improvements Based on Priority

Priority Activities	**Key Findings**	**Supporting Data**	**Proposed Improvements**

Laying	Laying activities are a priority Mainly because the results of the mapping of the RULE, REBA, *Heart Rate*, and Deposit RPE. Activities This involves lowering the product to a low area such as *Pallet* so that the posture The body becomes bent over	The weight of the product is about 8 kg, the moving distance is about 2-4 meters, the laying height is approximately 16 cm, while the height of the standing elbow The operator is in the range of 101-108 cm. This product is placed on a pallet so that after the process is completed it can be moved using handlift/handpallet for inspection or packing.	Repairs are directed at the adjustment of supporting facilities *pallets, not on the elimination of use Pallet*. Proposals that can be given in the form of use *Pallet stand*, lift table, *Scissor Lift Table*, or similar aids to make it high *Pallet* can be approached working height, so that the laying process is more comfortable. Once the product is finished being assembled, *Pallet* can still be moved using *handlift or handpallet*. This proposal was chosen because does not change product transfer flow using *Pallet* as a means of transportation, but only changes the altitude area Placement to make it more in-house common sense in the workplace.

Polishing	This gluing activity indicates a postural risk in the upper body because the operator needs to hold *Nozzle* directly Continuous for Work process. The operator must also maintain the position of the hands, wrists, arms, and body for the results to be Experience Stay precise. In the condition In other words, the operator can experience bowing, bowing posture, and Reach in the future.	The height of the workbench used depends on the condition of the machine that is ready to be used. Can be on machines that use a table ±55 cm or ±80 cm. Distance The reach is ±50 cm forward, while the process of gluing the operator's hand reach forward is on average in the range of 54-58 cm. *Nozzle* always held during Immersion activities take place and conditions hose *Nozzle* hanging in the area work. From the results Interview Related Immersion	Improvements can be made by positioning the product closer to the operator to reduce forward range. In addition, it can Consider the use of assistive devices such as *fixture*, *jig*, *Stopper*, or product support to make the product position more stable during gluing process. Hose *Nozzle* also can be styled using a hose hanger, a retainer hose, or *Tool Balancer* so that the hose pull does not overloading the operator's hands. Objectives of Recommendations This is to help the operator maintain a more stable posture without compromising the rigor of the drilling process. Height of the working area Recommended made more consistent and adapted to the characteristics of the job so that the operator does not have to bend, bend or reach excessively. The recommendations should applied without changing the quality of production because it does not change the

		process this, complaints occurred in wrists, arms, shoulders, and waist as well as obstacles must be in maintaining a working position during	process of the design or product specifications.

Lifting	Lifting activities involve Manual transfer of products from the workbench to the pallet. Although the product is Observed to weigh about 8 kg or more, this activity should be taken into account as it is carried out in the absence of special handles and distances Transplant Can change based on position *Pallet* empty around the area *center epoxy*.	The product weighs about ±8 kg, the moving distance about 2-4 meters, high The beginning of the lift is about ±60 cm and the end height is about ±16 cm. No grip Specifically for products, so that The operator lifts it by holding its sides. Work area still allows use Tools such as *Handlift*/*Hand pallet*, and Tools other moves.	Repairs can be made by reducing manual moving distances, for example by placing *Pallet* empty closer to the workbench before The process begins. In addition, the use of trolleys, pushtables, or hand pallets can be considered to assist when moving products when pallets are far away. Since the product does not have a special handle, the operator needs to be directed to lift the product as close to the body as possible, avoiding twisting movements and ensuring a stable grip position before moving. The aim of this proposal is to reduce the burden of manual moving without the main workflow using pallets as the product moving medium. This proposal makes use of the relocation facility existing in an industrial environment so that the implementation is more possible than changing the overall working method.

Based on Table 5, the proposed improvements are made based on the results of the ergonomic analysis and actual working conditions at the *epoxy center*. Therefore, the recommendations given do not change the main production flow or the use of *pallets* as a medium to move products, but are more directed at adjusting work facilities, setting work areas, and implementing tools that can be applied by the company. With this approach, the proposals given are expected to be more realistic to be implemented compared to changes in the overall work process.

Based on the proposed improvements listed in Table 4.17, the simulation of the reassessment of RULA and REBA is based on the posture of representative proposals for gluing, lifting, and laying activities.

Table 6. Comparison of Actual Score and Improvement Simulation Score

Activities	**RULES Actual**	**REBA Actual**	**RULES Simulation**	**REBA Simulation**	**Remarks**

Polishing	5,83	6	3	2	The proposed posture simulation showed that the risk of posture decreased
Lifting	3	3,17	3	3	Lower risk and more conditions Controlled
Laying	6	6,33	3	3	Simulation of the proposed posture Produce
Polishing	5,83	6	3	2	The proposed posture simulation shows that posture risk Downhill
Lifting	3	3,17	3	3	Lower risk and more conditions Controlled
Laying	6	6,33	3	3	Simulation of the proposed posture Produce

The simulation results show that proposed improvements can reduce the risk of posture, especially in gluing and laying activities. However, these results are still conceptual because they have not been applied directly in actual working conditions. Therefore, implementation and field evaluation can be carried out in future research to test the effectiveness of the proposals that have been prepared.

CONCLUSION

A work posture analysis using RULA and REBA showed that each job had a different level of ergonomic risk. The activity with the highest level of posture risk is laying, followed by gluing activities. While lifting activities have a relatively lower level of risk. The use of *Heart Rate* and Borg RPE complemented the results of the work posture assessment by demonstrating the physiological response and perception of the operator's workload. The pattern of results shows that laying activity causes the highest heart rate response and Most operators on workload perception are in the weight category. These results show that the ergonomic risk assessment becomes more comprehensive when the RULA and REBA results are read together with *the Heart Rate* and Borg RPE. Based on the results of the analysis, it shows that ergonomics improvement proposals are prepared by taking into account the characteristics of each work activity. Use supporting facilities for laying activities such as *pallet stands* or *scissor lift tables* to adjust the height of the laying area. In gluing activities, improvements are directed to the adjustment of the working position and the use of product support aids and nozzle hoses. Meanwhile, in lifting activities, the proposal is focused on reducing the distance of the transfer and the use of moving aids. Posture simulations based on the proposal show the potential to reduce the level of posture risk, especially in gluing and laying activities.

This study has limitations, including observations were made on six operators with one observation on each operator only. *Heart Rate* data is only used to describe the relative pattern of interactivity heart rate response and is not used for formal physiological workload calculations. Therefore, future research is expected to use more subjects and make repeated observations, as well as more comprehensive physiological measurements

Suggestions

The results of the study show that laying activities have the most prominent ergonomic risk patterns, the Company must prioritize improvements to these activities. To avoid the operator lowering the product to a position that is too low, companies may consider adjusting the height of the product placement or the use of auxiliary tools such as *pallet* stands, lift tables, *scissor lift tables*, or other auxiliary tools. For gluing activities, companies can consider setting the product closer to the operator, adjusting the *nozzle* and hose, and using aids such as *fixtures*, *jigs*, *stoppers*, or product supports to make the operator's work posture more stable. For lifting activities, companies can consider placing the laying area closer to the workbench and using moving aids.

For further research, it is recommended that the proposed ergonomics improvements be implemented and retested to see if the improvements have an impact on RULA, REBA, *Heart Rate*, and Borg RPE. Follow-up research may also consider the use of more specific techniques to assess manual moving operations, increase the number of operators observed, and include different types or weights of different products. Thus, the results of further research can provide a better picture of how effective ergonomics improvements are in the work area of *an epoxy center*.

BIBLIOGRAPHY

Afonso, M., Gabriel, A.T. and Godina, R. (2022). Proposal of an innovative ergonomic SMED model in an automotive steel springs industrial unit. *Advances in Industrial and Manufacturing Engineering*, 4, p.100075. doi:https://doi.org/10.1016/j.aime.2022.100075.

Anwar, A., Murugan, A.S., Recchia, A., Kim, E. & Urbanic, J. (2024). Investigating musculoskeletal risks in manual mushroom harvesting: An ergonomic field study in Canadian farms. *Social Sciences & Humanities Open*, [online] 10 p.101049.

doi:https://doi.org/10.1016/j.ssaho.2024.101049.

Arias, O., Groehler, J., Wolff, M. & Choi, S.D. (2023). Assessment of Musculoskeletal Pain and Physical Demands Using a Wearable Smartwatch Heart Monitor among Precast Concrete Construction Workers: A Field Case Study. *Applied Sciences*, 13(4), p.2347. doi:10.3390/app13042347.

Balogh, D., Cui, X., Mayer, M., Niels Koehncke, D., R. & Lang, A.E. (2025). Reliability and agreement during the Rapid Entire Body Assessment: Comparing rater expertise and artificial intelligence. *PLoS ONE*, [online] 20(5), pp.e0323262–e0323262. doi:https://doi.org/10.1371/journal.pone.0323262.

Bent, B., Goldstein, B.A., Kibbe, W.A. & Dunn, J.P. (2020). Investigating sources of inaccuracy in wearable optical heart rate sensors. *npj Digital Medicine*, 3(1). doi:10.1038/s41746-020-0226-6.

Bustos, D., Cardoso, F., Rios, M., Vaz, M., Guedes, J., José Torres Costa, J., Santos Baptista & Fernandes, R.J. (2022). Machine Learning Approach to Model Physical Fatigue during Incremental Exercise among Firefighters. *Sensors*, 23(1), pp.194–194. doi:https://doi.org/10.3390/s23010194.

Chaiklieng, S., Youngwilai, A. & Boocock, M.G. (2025). The effectiveness of an ergonomics program to reduce musculoskeletal disorders in high voltage overhead powerline workers. *International Journal of Industrial Ergonomics*, 110, p.103819. doi:https://doi.org/10.1016/j.ergon.2025.103819.

Dartey, A. F., Abonie, U. S., Banson, A. N., & Akortiakumah, J. B. (2024). Ergonomic challenges of mortuary attendants in Ghana: an exploratory study. *International Journal of Occupational Safety and Ergonomics*, *30*(4), 1283–1287.

Dhonny, M.A. & Mahbubah, N.A. (2025). Evaluation of the risk of musculoskeletal injury based on the Rula and Reba method in the Freight Forwarding Operator at Pt Dcf. *Sigmateknik*, 8(2),pp. 237–249. doi:https://doi.org/10.33373/sigmateknika.v8i2.8497.

Gao, G., Ng, S.S.M., Man, S.S. and So, B.C.L. (2025). Ergonomic risk assessment methods for work-related musculoskeletal disorders among healthcare workers: A systematic review. *Journal of Safety Research*, 95, pp.189–196. doi:10.1016/j.jsr.2025.10.001.

Gobbo, S., Bullo, V., Favro, F., Pavan, D., Doro, B., Bortoletto, A., De Palma, G., Sala, E., Mattioli, S., Di Blasio, A. & Bergamin, M. (2025). Strength and Perceived Effort in Repetitive Upper-Limb Tasks: An OCRA Method Analysis of 900 Workers. *La Medicina del Lavoro*, [online] 116(4), p.16856. doi:https://doi.org/10.23749/mdl.v116i4.16856.

Gómez-Galán, M., Díaz-Pérez, M., Rubio-Romero, J.-C. and Callejón-Ferre, Á.-J. (2025). Association between musculoskeletal symptoms and psychosocial factors in tropical crop workers of Spain using standardized Nordic questionnaire and Mini Psychosocial Factors method. *International Journal of Industrial Ergonomics,* 105, p.103672. doi:https://doi.org/10.1016/j.ergon.2024.103672.

González-Alonso, J., Martín-Tapia, P., González-Ortega, D., Antón-Rodríguez, M., Díaz-Pernas, F.J. and Martínez-Zarzuela, M. (2025). ME-WARD: A multimodal ergonomic analysis tool for musculoskeletal risk assessment from inertial and video data in working places. *Expert Systems with Applications*, 278, p.127212. doi:https://doi.org/10.1016/j.eswa.2025.127212.

Heydar Pradika Sukma & Chandra Dewi Kurnianingtyas (2022). Analysis of Work Posture and Manual Handling on the Material Transport Activities of Indonesian Traditional Market Workers. *International Journal of Industrial Engineering and Engineering Management*, 4(2), pp.65–74. doi:https://doi.org/10.24002/ijieem.v4i2.5921.

Joshi, M. & Deshpande, V. (2021). Study of association between OWAS, REBA and RULA with perceived exertion rating for establishing applicability. *Theoretical Issues in*

Ergonomics Science, 23(3), pp.313–332. doi:10.1080/1463922x.2021.1958951.

Kartika, C. & Mukhtar, A. (2023). The application of Rula and REBA in overcoming the fatigue of BOTTOM roll machine operators. *HEURISTIC/Heuristic*, pp.13–24. doi:https://doi.org/10.30996/heuristic.v20i1.8867.

Kee, D. 2022. Comparison of LEBA and RULA Based on Postural Load Criteria and Epidemiological Data on Musculoskeletal Disorders. *International Journal of Environmental Research and Public Health*, 19(7), p.3967. doi:https://doi.org/10.3390/ijerph19073967.

Kusumadewi, I., Budiman & Taufiqur Rohman, R. (2025). Ergonomic Work Facility Design Using Anthropometric Data. *Journal of Mechanical and Manufacture*, 4(1), pp.23–33. doi:https://doi.org/10.31949/jmm.v4i1.12570.

Lawrensa, B., Widodo, L., & Doaly, C. O. (2023). Analysis of Physical Workload Ergonomics in Workers Using Cardiovascular Load, Reba, and Nordic Body Map Methods. *Serina Journal of Science, Engineering and Medicine*, *1*(2), 247–258.

Li, K., Cardoso, C., Moctezuma-Ramirez, A., Abdelmotagaly Elgalad and Perin, E.C. (2023). Heart Rate Variability Measurement through a Smart Wearable Device: Another Breakthrough for Personal Health Monitoring? *International Journal of Environmental Research and Public Health*, 20(24), pp.7146–7146. doi:10.3390/ijerph20247146.

Manohar, B.A., Devaraj, J., Maheswaran, C. and Pugalenthi, S. (2025). Performance Evaluation of Rapid Entire Body Assessment Using AI-Assisted Ergonomic Analysis in Dentistry. *Biomimetics*, 10(4), p.239. doi:https://doi.org/10.3390/biomimetics10040239.

Naranjo, J.E., Mora, C.A., Bustamante Villagómez, D.F., Mancheno Falconi, M.G. & Garcia, M.V. (2025). Wearable Sensors in Industrial Ergonomics: Enhancing Safety and Productivity in Industry 4.0. *Sensors*, 25(5), p.1526. doi:https://doi.org/10.3390/s25051526.

Nelfiyanti, N., Almanda, D., Ahyadi, H., Robbani, M. I., Setiawan, A., & Daruki, D. (2023, October). Application of REBA and RULA Methods to Determine MSD Risk Categories in Furniture Measurement Workers. In *the Proceedings of the National Research Seminar of LPPM UMJ.*

Oakman, J., de Wind, A., van den Heuvel, S. G., & van der Beek, A. J. (2017). Work characteristics predict the development of multi-site musculoskeletal pain. *International archives of occupational and environmental health*, *90*(7), 653–661.

Ogedengbe, T.S., Abiola, O.A., Ikumapayi, O.M., Afolalu, S.A., Musa, A.I., Ajayeoba, A.O. & Adeyi, T.A. (2023). Ergonomics, Postural Risk Assessment and Observational Techniques in the 21st Century. *Procedia Computer Science*, [online] 217, pp.1335–1344. doi:https://doi.org/10.1016/j.procs.2022.12.331.

Özkan Ayvaz, Bedia Özyıldırım, Halim İşsever, Gözde Öztan, Muhammed Atak & Sevda Özel (2023). Ergonomic risk assessment of working postures of nurses working in a medical faculty hospital with REBA and RULA methods. *Science Progress*, 106(4). doi:https://doi.org/10.1177/00368504231216540.

Putri, M.V.P., Nugraha, W.N. & Safitri, K.N.S. (2024). Assessing High-Risk Manual Handling Activities for Musculoskeletal Disorders (MSDs) in PT DNL Warehouse Using Rapid Entire Body Assessment (REBA) and Manual Handling Assessment Chart (MAC) Tools. *JOURNAL OF INDUSTRIAL ENGINEERING,* 14(3), pp.171–184. doi:https://doi.org/10.25105/jti.v14i3.19987.

Pradipta Sitompul, K., Zufarshidqi, A., Bintang Utama, D. & Imdam, I.A. (2025). Reducing the risk of musculoskeletal disorder through the design of painting desk aids using the REBA method. *Metrics: Journal of Science and Technology*, 25(02), pp.83–88. doi:https://doi.org/10.25170/metris.v25i02.5870.

Primasari, M.S. & Kurnianingtyas, C.D. (2022). Analysis of Work Posture and Manual Material Handling in Material Transfer Activities at BP Lathe Workshop. *PASTI Journal (Industrial Systems and Engineering Research and Applications)*, 16(2), p.124. doi:https://doi.org/10.22441/pasti.2022.v16i2.001.

Pratama, B. W. N., Herlianti, R., & Ikatrinasari, Z. F. (2024). Ergonomic Workbench Design with Anthropometric Method in the Inspection Process of Checking Green Tire Output at Company X. *Performance: Scientific Media of Industrial Engineering*, *23*(2), 141–150.

Rahmawati, N., Indrawan, P., Kartinawati, A., Dardanella, D., Pangestu, F.J., Rafandita, A., Zidan, A., Masithoh, C.D., Anggraeni, D., Yunanto, D.H., Ocsadira, K.F. & Nainggolan, N.S. (2025). Evaluation of Work Posture Using RULA and REBA Methods and Ergonomic Intervention Design in a Brownies SME in Bogor. *G-Tech: Journal of Applied Technology*, 9(4), pp.2091–2098. doi:https://doi.org/10.70609/g-tech.v9i4.8065.

Rezki, A.S., Maksum, A.H., Herwanto, D. & Rahmat, M.T. (2023). Work Posture Risk Analysis with Nordic Body Map, RULA, and REBA Methods in the Manual Process of Material Handling in Soy Sauce Factories. *Journal of Industrial Engineering and Systems Media*, 7(2), p.86. doi:https://doi.org/10.35194/jmtsi.v7i2.2677.

Simon, S., Dully, J., Dindorf, C., Bartaguiz, E., Walle, O., Ilsemarie Roschlock-Sachs & Fröhlich, M. (2024). Inertial Motion Capturing in Ergonomic Workplace Analysis: Assessing the Correlation between RULA, Upper-Body Posture Deviations and Musculoskeletal Discomfort. *Safety*, 10(1), pp.16–16. doi:https://doi.org/10.3390/safety10010016.

Suarjana, I.W.G., Pomalingo, Moh.F., Palilingan, R.A. and Parhusip, B.R. (2022). Ergonomic Work Facility Design Using Anthropometric Data to Reduce Load Physiological. *Scientific Journal of Industrial Engineering*, [online] 10(2), pp.109–117. doi:https://doi.org/10.24912/jitiuntar.v10i2.17755.

Thamsuwan, O., Galvin, K., Palmandez, P. & Johnson, P.W. (2023). Commonly Used Subjective Effort Scales May Not Predict Directly Measured Physical Workloads and Fatigue in Hispanic Farmworkers. *International Journal of Environmental Research and Public Health*, 20(4), p.2809. doi:10.3390/ijerph20042809.

Unegbu, H. and Yawasa, D.S. (2025). Ergonomic Redesign of Farm Tools to Reduce Musculoskeletal Disorders among Nigerian Farmers. *Journal of Agricultural Engineering*, 14(6), pp. 2297–2315. doi:https://doi.org/10.23960/jtepl.v14i6.2297-2315.

Varghese, A., Panicker, V.V. & George, J. (2025). Posture Assessment of Rubber Tappers: A Comparative Analysis of OWAS, REBA, RULA, and PERA Methods. *La Medicina del lavoro*, [online]116(3),pp.15875–15875. doi:https://doi.org/10.23749/mdl.v116i3.15875.

Zeny Fatimah Hunusalela, Surya Perdana & Galuh Krisna Dewanti (2021). Analysis of Operators' Work Posture Using RULA and REBA Methods at Juragan Convection Jakarta. *IKRA-ITH Technology*, 6(1), pp.1–10. doi:https://doi.org/10.37817/ikraith-teknologi.v6i1.1656.