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Analysis of Work Posture and Physical Workload on Musculoskeletal Disorders Among Welders Using the NBM, REBA, and SNI 7269:2009 Methods

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ABSTRACT

Welding workers at a workshop fabrication metal do preparation materials, welding, grinding, and cleaning welding crust with position changing body follow location object work. Conditions This can cause complaint muscles and skeleton as well as risk posture work. Research This aim identify musculoskeletal disorders (MSDs) complaints, assessing risk posture, counting burden Work physical, and determine priority repair ergonomics on three welders. Research use approach descriptive quantitative through observation, interviews, Nordic Body Map (NBM) questionnaire, documentation posture, and recording duration activity. Complaints analyzed using NBM, risk posture assessed with Rapid Entire Body Assessment (REBA), whereas need energy counted referring to SNI 7269:2009. The results show the highest NBM score was NS at 55, followed by NY at 50 and KM at 38. Back, neck top and arms on left become part body with score complaint The largest REBA score was recorded at 9 in NS (risk high) and 11 in KM and NY (very high risk). Total workload based on calculation summary reached 240,515 kcal /hour on NS, 251,127 kcal /hour on KM, and 248,536 kcal /hour on NY; all of them including category moderate. The results show that more complaints tall No always in line with risk posture or need more energy big. Improvement needs prioritized on KM and NY postures through adjustment tall object work, support, and reach tools. Research This provide base practical for choose action ergonomics based on three types mutual assessment complement, although effectiveness proposal repair Not yet tested.

Keywords: *Ergonomics, Musculoskeletal Disorders, Nordic Body Map, Rapid Entire Body Assessment, Workload Physique.*

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INTRODUCTION

Work welding in the workshop fabrication metal need accuracy and position a suitable body with location connection. Workers often must adapt position neck, back, legs and arms so that they can see as well as reach welded parts. Condition the found in three workers in the workshop fabrication metal that becomes object research, namely NS, KM, and NY. Observation covers preparation work, welding, grinding and cleaning welding crust during approximately 300 minutes per worker. Activity welding use up the longest time, namely 100.165 minutes on NS, 120.754 minutes on KM, and 112.555 minutes on NY. Interview early also found complaint No comfortable on some part body. However, long time workers maintain position bow or bow down Not yet known in a way sure. Condition This show the need inspection ergonomics for now part the body that experiences complaints, level risk posture and load Work physique during welding.

Problem the important Because position lack of work Good can cause stress on muscles and joints, especially when ongoing repetitive or in long time. [1] studied 128 welding workers in Zimbabwe and found that 78% of respondents report painful back below. Research it also shows connection between risk posture and complaints muscle. [2], via study term long-term study of welding and electrical workers in Canada, found that time Work with arm shoulder height or more related with improvement risk shoulder pain. Meanwhile that, [3] show that arrangement shoulder, elbow and wrist angles hand need noticed for reduce discomfort in welding above head. Third study This show that problem ergonomics welders do not only relate with the weight work, but also with method body positioned moment Work.

Evaluation risk ergonomics has done through various approach, but every method give different information. [1] used questionnaire complaint muscle together method evaluation posture for identify factor risks to welding workers. [4] compares OWAS, RULA, and REBA methods as well find that results evaluation can different although used in the same job. Research it also shows that RULA has deeper relationship strong with a number of size burden posture and complaints muscle compared to REBA. Furthermore, [5] combined REBA, OWAS, and

modeling digital humans for evaluate design place Work welding. Simulation results show that use table work that can customized potential lower risk posture. Studies This help recognize danger posture, but No everything enter need energy Work as part from evaluation worker in a way comprehensive.

Other research is starting develop evaluation ergonomics become action improvement. [6] found that use welding tools with design ergonomic can reduce load on part muscles and reduce feelings of discomfort comfortable in testing limited. [7] also reported that adjustment place work accompanied by training ergonomics give results Better compared to training only to workers industry casting metal. However, the results second study the No can direct applied to all workshop Because type work, equipment, and conditions the workers different. On the other hand, [8] have using NBM, REBA, and SNI 7269:2009 for research complaint muscles, posture, and load work in industry know. Research the prove that third method has used together, but context his job different from welding. Therefore that, the implementation third methods in welding work are necessary assessed based on characteristics activities and conditions place researched work.

Based on study previous, gap research gap lies in the need for compare complaint muscle, risk posture, and needs energy in a way directly on each welder as base determine priority repair ergonomics. Research [1] more emphasize complaints and factors risk, whereas [5] focuses on assessment posture and simulation repair place work. Research [8] have use third method, but carried out in industry know and be directed for test connection intervariable. In the workshop fabrication the metal being studied, not yet available evaluation integrated which shows whether worker with the highest complaints also have risk posture and needs the greatest energy. Novelty study This lies in the comparison third indicator at the level individual for compile order priority repair ergonomics welder. Novelty This nature application and analysis in context research, not creation method new.

Study This aim for identify location and score musculoskeletal disorders (MSDs) complaints using the Nordic Body Map (NBM), determining level risk posture Work using Rapid Entire Body Assessment (REBA), as well count burden Work physique in kcal /hour based on SNI 7269:2009 on three welders. Third result method Then compared to for determine workers and conditions necessary work get attention more previously. Research This give contribution in the form of mapping problem ergonomics based on complaint body, risk posture, and needs energy in One framework assessment. In terms of practical, the results can help manager workshop determine priority adjustment tall object work, use buffer, settings range equipment, and distribution activity work. Research This nature descriptive so that No intended for prove connection cause and effect or success action repairs that have not been done implemented.

MATERIALS AND METHODS

Research Design

Study This use approach descriptive quantitative for identify musculoskeletal disorders (MSDs) complaints, assessing risk posture work, and measure burden Work physical on workers welding in a metal fabrication workshop. Research involving three welding workers with NS, KM, and NY codes. Assessment done use three mutually exclusive methods complement, namely the Nordic Body Map (NBM) for identify complaints on the part body, Rapid Entire Body Assessment (REBA) for evaluate risk posture work, and SNI 7269:2009 for count burden Work based on need energy. The third result method compared to in a way descriptive for determine priority repair ergonomics. Research limited to observation condition work and preparation recommendations, without do intervention direct.

Data Collection Techniques

Data collection was carried out through observation direct, interview, NBM questionnaire, documentation posture work and record keeping time activity. Observation covers four activities main, namely preparation work, welding, grinding and cleaning welding crust [4], [9], [10]. The NBM questionnaire was used for take notes complaints felt workers, while documentation posture used as base evaluation position neck, trunk body, legs, arms top, arm bottom and wrist hands. Besides that, duration data worker activity and weight used for count need energy based on SNI 7269:2009. All data is grouped based on each worker so that the results third method can compared to [2], [11].

Work Posture Documentation and Angle Measurement

Table 1. Posture Work and Measurement Corner Body Welder Worker

			GROUP A			GROUP B		
Worker	**Activity**	**Name**	**Neck**	**Trunk**	**Legs**	**Upper Arm**	**Lower Arm**	**Wrist**
1.		NS	49º	31º	37º	31º	122º	31º

2.		KM	80º	37º	144º	31º	93º	48º
3.		NY	70º	34º	139º	31º	63º	45º

Data Analysis Methods

a. Work Activities and Observation Time

Analysis activity Work done with grouping work based on type activities and duration implementation. Time each activity noted in unit minutes, then added up for get total time observations of each worker [8], [12]. This data used for identify activities that require the longest time and become base calculation burden Work physical. Duration activities are also used for give description about necessary activities get attention in evaluation ergonomics. However, time implementation something activity No direct considered as duration exposure posture risky Because position body can change during work ongoing [13], [14].

b. Musculoskeletal Complaints Assessment Using NBM

NBM method is used for identify complaint muscles and skeleton based on part the body that is felt No comfortable by workers. Data obtained from answer questionnaire, then score every part body added up for get score complaints of each respondent. Calculation total NBM score is performed use Equality [15], [16].

$$S_{NBM,i} = \sum_{j=1}^{n} s_{ij} \tag{1}$$

Description: S_ NBM,i is the total NBM score of workers ith, while s_{ij} is score complaint worker i-th in the section body to -j.

Besides score individual, done calculation percentage contribution score complaint every part body to amount all over NBM scores of respondents. Percentage the used for identify part body that has amount score the highest complaints, as shown in Equation [7], [17].

$$P_j = \left(\frac{\sum_{i=1}^{n} s_{ij}}{\sum_{i=1}^{n} S_{NBM,i}} \right) \times 100\% \tag{2}$$

Description : P_j is percentage contribution score complaints on the part body to -j.

Percentage This show proportion score complaint to the total NBM score, not percentage workers who experience complaints. Assessment results used for determine part the body needs get attention in repair ergonomics [18], [19].

c. Work Posture Risk Assessment Using REBA

Evaluation posture Work done use REBA method with evaluate position body worker based on documentation activity welding. Assessment shared become two group, namely Group A which includes neck, trunk body, and legs, and Group B which includes arm top, arm bottom and wrist hand. Angle every part body used for determine score posture in accordance REBA provisions. Group A scores were obtained through Table A with consider factor burden or style, whereas score Group B obtained through Table B with notice quality handle coupling [20], [21]. Both score the combined through Table C and added with score activity for get mark end of REBA as Equation (3).

$$S_{REBA} = C(A, B) + S_{aktivity} \tag{3}$$

Description: S_REBA is score end of REBA; A is score Table A after adjustment burden or style ; B is score Table B after adjustment ; C (A, B) is score combination based on Table C; and S_activity is score addition based on characteristics activity Work.

Final score used for determine level risks and needs action improvement. Scores of 8–10 include risk height required repair in time close, whereas score 11–15 included very high risk that requires action immediately. Assessment done to posture recorded work in documentation research. The results used for determine priority repair based on level risk posture of each worker [13], [22], [23].

d. Physical Workload Assessment Based on SNI 7269:2009

Evaluation burden Work physique done based on SNI 7269:2009 concerning evaluation burden Work according to need calories based on expenditure energy. Measurement done with consider type activity, position body, duration work, and the worker 's weight. Each activity grouped based on characteristics movement and position Work for determine mark need energy in accordance table standard [24], [25]. Energy value activity Then multiplied with duration for obtain total energy during observation. Average load Work counted use Equation (4).

$$\text{Average Workload} = \left[\frac{\sum_j (e_j \times t_j)}{\sum_j t_j}\right] \times 60 \quad (4)$$

Description : BK_rerata is the average load Work activity (kcal /hour), e_j is need energy activity to -j (kcal / min), and t_j is duration activity to -j (minutes). Factor 60 is used for change unit need energy from kcal / minute become kcal /hour. The sum of $e_j \times t_j$ shows the total energy activity in kcal.

Next, the average load Work added with mark basal metabolism (MB) for get burden total work using Equation (5).

$$BK_{total} = BK_{average} + MB \quad (5)$$

Basal metabolism is calculated based on worker 's weight, with coefficient 1 kcal /kg/hour for men and 0.9 kcal /kg/hour for women. The results of the load total work then compared to with SNI 7269:2009 category, namely Work light of 100–200 kcal /hour, work currently more from 200–350 kcal /hour, and work heavy more from 350–500 kcal /hour. Observation activity referring to the provisions standards that require recording at least four hours in One day work and hourly average calculations [5], [26].

e. Integrated Ergonomic Assessment and Improvement Prioritization

Analysis integrated done with compare NBM, REBA, and load results Work physical on each workers [3]. The NBM results are used for identify location as well as level reported complaints, REBA is used for determine level risk posture work, while SNI 7269:2009 is used for know need energy during work. Third results served in matrix comparison based on identity workers. The value of third method No added up become One score because each measures different aspects [27], [28].

Priority repair determined with prioritize posture that has level the highest REBA risk, then consider part body with score NBM's biggest complaint as well as characteristics activity work. Analysis results used for compile recommendation in the form of adjustment height and position object work, settings range equipment, use appropriate supports, as well as arrangement variation activities and time rest. Recommendations arranged based on identified and unresolved risks tested its effectiveness. Therefore that, the result study interpreted in a way descriptive without conclude connection cause and effect between posture, load work, and MSDs complaints [1], [29].

RESULTS

Observation done to four activity main welding workers, namely preparation work, welding, grinding and cleaning welding crust. Duration every activity noted for now distribution time the most work and activities carried out. Observation results third worker presented in Table 1.

Table 1. Duration of Welding-Related Work Activities

Activity	NS	KM	NY
Preparation Work	79,483	73,846	75,325
Welding	100,165	120,754	112,555
Grinding	71,276	62,419	64,875
Cleaning weld crust	49,076	42,638	47,685
Amount activity	300,000	299,657	300,440

Welding is activity with duration longest in all workers, namely 100,165 minutes on NS, 120,754 minutes on KM, and 112,555 minutes on NY. Activity This covers 33.39%–40.30% of time observation, with proportion highest at KM. Meanwhile that, cleaning welding crust requires shortest time. Difference duration show that distribution activity third worker No The same even though the total time observation approaching 300 minutes. The duration welding need noticed Because work This can involving position the body is maintained for reach connection. However, the duration activity Not yet show how long does the worker is at in posture risky so that required REBA assessment.

Musculoskeletal Complaints Based on NBM

Complaint muscles and skeleton identified use Nordic Body Map (NBM) questionnaire for now level discomfort felt every worker. Answer score added up so that obtained comparison complaint between NS, KM, and NY. Summary results evaluation presented in Table 2.

Table 2. Nordic Body Map Scores Among Welders

Worker	NBM Score	Order of complaints
NS	55	1 (highest)
NY	50	2
KM	38	3 (lowest)
Total	143	

NS obtained highest NBM score of 55, followed by NY at 50 and KM at 38. A difference of 17 points between NS and KM shows existence difference level reported complaints during work. Although is at in environment same work, third worker No feel discomfort with same level. Difference the can related with variation position body, type activity, or length of work, but the cause Not yet can be confirmed from NBM score only. Therefore that, the result This become base for recognize workers who need get attention and determination part body that needs inspection more carry on.

Analysis to be continued with identify part body that has amount score complaint biggest. Assessment This help determine location necessary complaints prioritized in repair ergonomics. Distribution score combination from third worker shown in Table 3.

Table 3 Distribution of Musculoskeletal Complaint Scores

Parts of body	Total score	% of 143 NBM points
Back	10	6.99
Neck on	9	6.29
Arm on left	8	5.59
Neck lower	7	4.90
Left shoulder	7	4.90
Waist	7	4.90
Butt	7	4.90

Back own amount score complaint highest by 10 points (6.99%), followed by neck on by 9 points (6.29%) and the arm on left by 8 points (5.59%). Seven part the listed body contributed 55 of 143 points or 38.46% of all over NBM score. Back and neck complaints can relate with position bow or bow down when see welded joints, whereas complaint arm Possible relate with activity holding and directing equipment. Findings This direct attention to the settings tall object work and reach tools. However, the percentage the is part of the total score complaints, not amount workers who experience pain, and relationships with posture Not yet tested in a way direct.

Work Posture Risk Assessment Using REBA

Risk posture Work checked through measurement corner six-part body used in REBA assessment. Measurement done based on documentation position worker during welding for see difference posture between respondents. Angle data acquired body presented in Table 4.

Table 4. Measured Body Segment Angles During Welding Activities

Worker	Neck	Torso	Foot	Upper arm	Forearm	Wrist
NS	49°	31°	37°	31°	122°	31°
KM	80°	37°	144°	31°	93°	48°
NY	70°	34°	139°	31°	63°	45°

Difference position the body is most visible at an angle neck and legs. Angle The NS neck was recorded at 49°, while KM reached 80° and NY 70°. stem body closer together, namely 31°–37°, while arm on all over worker recorded 31°. In the section wrist hand, KM shows corner the biggest of 48°, followed by NY 45° and NS 31°. Variations This show that worker use position different bodies when do welding. Large angle need checked to position neutral and point reference the measurement Because No all corner can direct interpreted as greater risk height. Determination level danger still need REBA calculation in general complete.

Angle data body furthermore used as base evaluation risk posture through REBA method. Final score grouping level risk and determine how much fast action repair need carried out. The results of the assessment of each worker presented in Table 5.

Table 5. REBA Scores and Work Posture Risk Classifications

Worker	Final REBA	Risk level	Priority of action
NS	9	Tall	Repairs scheduled soon
KM	11	Very high	Immediate action

Worker	Final REBA	Risk level	Priority of action
NY	11	Very high	Immediate action

M and NY are both get REBA score 11 which includes very high risk, while NS gets score 9 with category risk high. The results placing KM and NY as priority main Because assessed posture need action immediately. NS also requires repair although level the urgency lower. Difference score This show that work on type same job No always produce level risk same posture. Adjustment position object work, use buffers, and settings range equipment can become choice improvement. However, the score the Still need inspection to details Group A, Group B, and factor additional REBA before stated fully verified.

Physical Workload Based on SNI 7269:2009

Besides position body, needs energy during Work counted based on SNI 7269:2009 for know category burden Work physical. Calculation using total energy activity, duration observation, and basal metabolism of each worker. Summary results calculations and grouping shown in Table 6.

Table 6. Physical Workload Assessment Based on SNI 7269:2009

Worker	$\Sigma(e_i \times t_i)$ (kcal)	Time (minutes)	Average (kcal/hour)	BK MB (kcal/hour)	Total (kcal/hour)	BK Category
NS	902,576	300,000	180,515	60	240,515	Currently*
KM	959,539	299,657	192,127	59	251,127	Currently*
NY	964.09325	300,440	192,536	56	248,536	Currently*

KM has burden highest total work of 251,127 kcal/hour, followed by NY at 248,536 kcal /hour and NS at 240,515 kcal /hour. All three is at in category moderate, with difference highest and lowest only 10,612 kcal / hour. Interestingly, NY has total energy activity the biggest of 964.09325 kcal, but burden total work KM taller after enter basal metabolism. This is show that duration, needs energy activity, and basal metabolism affect mark end. Category currently No means work free from risk Because need energy different with pressure on the muscle's consequence position body. Although calculation summary has in accordance in a way arithmetic, details energy every activity Still required for ensure accuracy its classification.

Integrated Interpretation and Scientific Discussion

The results of NBM, REBA, and SNI 7269:2009 were compared for get description condition ergonomics every worker. Third method give information different about complaint body, level risk posture, and needs energy work. Comparison the summarized in Table 7 as base determine priority repair.

Table 7 Integrated Assessment of Musculoskeletal Complaints, Postural Risks, and Physical Workload

Worker	NBM	REBA	Total BK (kcal/hour)	Main meaning	Posture priority order
NS	55 (highest)	9 (high)	240,515 (medium)	Top complaint; risky posture	After posture score 11
KM	38 (lowest)	11 (very high)	251,127 (medium)	Highest posture risk; highest energy	Priority 1 with NY
NY	50	11 (very high)	248,536 (medium)	Highest postural risk; 2nd order complaint	Priority 1 with KM

Comparison third method show that score complaint No always follow level risk posture. NS has highest NBM score as much as 55, but his REBA score more low than KM and NY. On the contrary, KM noted lowest complaints as much as 38, but own REBA score 11 and load highest total work of 251,127 kcal /hour. NY also experienced risk very tall posture although need its energy Still classified as moderate. Difference This can happen because NBM records complaints felt workers, REBA assesses position body moment observed, while SNI measures need energy. With thus, thirdly method need used together so that the decision repair No only depend on one value. Priority First given to KM and NY based on risk posture, while NS complaints remain need attention.

Proposed Ergonomic Improvements

Recommendation repair arranged based on problem main thing found through evaluation complaints, posture, and load work. Every action directed at the source risk certain as well as equipped indicators that can used for evaluate the result. Plan repair ergonomics presented in Table 8.

Table 8. Proposed Ergonomic Interventions and Evaluation Indicators

Problem observed	Action targets	Testable proposals	Evaluation indicators
REBA 11 on KM and NY	Posture when reaching for the joint	Set the height of the workpiece; use a stable jig/support	REBA before–after for the same posture and activity
Complaint back and neck	Reduces hunching/bowing	Bring the weld line within a comfortable viewing and reach	NBM score of back/neck area and body angle

Problem observed	Action targets	Testable proposals	Evaluation indicators
		range.	
Complaint arm on left	Reduce static arm positions	Adjust the grip, tool position, and arm support for safety.	NBM arm and REBA Group B scores
Welding 100–121 minutes / observation	Limiting exposure to long postures	Vary tasks and include short, safe breaks.	Duration of each posture and activity records
Energy data per activity is incomplete	SNI category validation	Repeat activity logs, body position, and energy calculations	Total BK and searchable categories

Most urgent fixes directed at the KM and NY postures through adjustment tall object Work as well as use stable support for reduce need bow or reach too far away. Complaints back and neck handled with repair position welded joints, whereas arrangement handle and location equipment intended for reduce burden position arm. Variation tasks and breaks It is also proposed that workers No maintain same position too long. Success action need checked through change REBA score, NBM complaints, and duration posture risky before and after repair. Measurement energy every activity must also be equipped for ensure SNI results. All action the Still in the form of proposal so that the benefits Not yet can stated proven before done testing.

DISCUSSION

Research result show that back, neck top and arms on left is part body with score complaint the biggest, while posture Work produce REBA score 9–11 indicating risk tall to very high. Findings This in line with [1], who reported complaint back bottom at 78% of 128 welding workers as well connection between risk posture and complaints muscles. [2] also found that Work in position squat and lift arm until shoulder height or more related with increasing risk painful back and shoulders in welders. Similar results reported [18], with the welding worker's REBA score reaches 11–12 so need action repair soon. [3] reinforces findings the through testing shoulder, elbow, and wrist positions influential hands to discomfort during welding. Meanwhile that, [19] found connection between duration position arm lifted or body bending and raising complaint muscles in workers maintenance house. Similarities results the show that position body need get attention in welding work. However, research This Not yet prove that observed posture become reason direct complaint worker.

Although study This find risk posture height, relationship between position body and complaints muscle No always same in research others. [25] no find connection meaningful between score risk posture and MSDs complaints in 45 workers cleanliness ($p = 0.903$), but find connection with factor psychosocial. [9] also concluded that duration and magnitude corner bow No show consistent relationship with painful back on review four research involving 2,013 workers, although certainty the proof Still low. From the side measurement, [4] reported that RULA in various study own deeper relationship strong with indicator burden posture and MSDs compared to REBA. [21] even find that level the same REBA risk No always show size burden the same joint. Besides The Cochrane review by [23] shows that repair ergonomics Not yet Of course produce change meaning in pain arms, neck, and shoulders are compared maintenance usual. Difference the No cancel results study this, but show that REBA scores, NBM complaints, and needs energy No may considered as the same size. Therefore, the observation posture repeated, examination factor others, and testing before and after repair required for ensure benefit action ergonomics.

Study This combines NBM, REBA, and SNI 7269:2009 for determine priority repair, but Not yet test change condition Work after action done. [6] expands approach the with test design ergonomic welding tools and find decline burden muscles in three from eight the observed muscles, accompanied by reduced pain and increased accuracy Work. [10]step more Far through intervention on 132 workers industry metals, including welders, and show repair score risk posture as well as corner body after arrangement place Work during three months. Meanwhile that, [5] combined REBA, OWAS, and modeling digital humans for evaluate design place Work welding; simulation table work that can arranged show decline category risk posture squat from very high become medium. Third study the give direction development for findings this, namely change results identification risk become design improvements that can be made tested. for KM and NY workers, priority can give on adjustment tall object work and use buffer, while complaint back, neck, and arms need evaluated through NBM, REBA, and load measurements Work before as well as after repair. With Thus, the contribution study can develop from mapping risk going to proof effectiveness repair ergonomics.

CONCLUSION

Study This show that condition ergonomics three welders in the workshop fabrication metal own difference level complaint muscle, risk posture and load Work physical. The Nordic Body Map (NBM) assessment shows score complaint the highest in NS at 55, followed by NY at 50 and KM at 38, with complaint largest on the back, neck top and arms on left. The results of the Rapid Entire Body Assessment (REBA) show that NS has score 9 with risk high, while KM and NY gained score 11 with very high risk so that need repair immediately. Meanwhile that, assessment burden Work based on SNI 7269:2009 produces values of 240,515 kcal /hour in NS, 251,127 kcal

/hour in KM, and 248,536 kcal /hour in NY, all of which including category currently based on calculation summary. Differences the show that complaint more muscles tall No always followed risk posture or need more energy big. Therefore that, repair ergonomics prioritized on posture KM and NY work through adjustment tall object work, use buffer, settings range equipment, as well as management activities and time rest. Third integration method give more basic complete for identify problems and determine priority repair ergonomics. However, research This limited to three workers and not yet test effectiveness proposed action so that required measurement advanced before and after repair.

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CONFLICT OF INTEREST
The authors declare no conflicts of interest related to this study.

DATA AVAILABILITY STATEMENT
The article reports the Nordic Body Map scores, REBA scores, and physical workload estimates for each participant using participant codes. Requests for additional de-identified data may be directed to the corresponding author, subject to participant confidentiality.

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DECLARATION OF AI TOOL USAGE
AI tools were used solely to improve sentence structure in the manuscript.

REFERENCES

[1] E. Chiboyiwa, F. Ncube, and P. Erick, "Risk factors for work-related musculoskeletal disorders among welders in the informal sector under resource constrained settings," *WORK*, vol. 72, no. 1, pp. 239–252, 2022, doi: 10.3233/WOR-205275.

[2] N. Cherry, J. Beach, and J.-M. Galarneau, "The relation of musculoskeletal disorders to ergonomic work demands in welders and electrical workers: a prospective Canadian cohort study," *Ann. Work Expo. Heal.*, vol. 69, no. 6, pp. 626–640, 2025, doi: 10.1093/annweh/wxaf029.

[3] M. D. Alam and I. A. Khan, "Optimization of ergonomic parameters in overhead arc welding using grey relational analysis," *J. Biomech.*, vol. 189, p. 112823, 2025, doi: 10.1016/j.jbiomech.2025.112823.

[4] D. Kee, "Systematic Comparison of OWAS, RULA, and REBA Based on a Literature Review," *Int. J. Environ. Res. Public Health*, vol. 19, no. 1, p. 595, 2022, doi: 10.3390/ijerph19010595.

[5] S. A. Tasik, R. Maulidya, I. W. Utami, D. M. Safitri, N. Rahmawati, and A. N. Habyba, "Integrating ergonomic intervention and digital human modelling for posture improvement in welding tasks," *J. Ind. Serv.*, vol. 11, no. 2, pp. 278–299, 2025, doi: 10.62870/jiss.v11i2.31507.

[6] C. Pilat, C. Weyh, T. Frech, K. Krüger, E. Schubert, and F.-C. Mooren, "An ergonomic welding torch reduces physical load response and improves welding quality in novices: A pilot study," *Int. J. Occup. Saf. Ergon.*, vol. 28, no. 4, pp. 2370–2376, 2022, doi: 10.1080/10803548.2021.1989199.

[7] R. Esmaeili, M. Shakerian, S. V. Esmaeili, M. Jalali, A. B. Pouya, and A. Karimi, "A multicomponent quasi-experimental ergonomic interventional study: long-term parallel four-groups interventions," *BMC Musculoskelet. Disord.*, vol. 24, p. 107, 2023, doi: 10.1186/s12891-023-06220-4.

[8] H. R. Denavia and J. D. Saptadi, "The Relationship Between Work Posture, Workload, and Sex with Musculoskeletal Disorder (MSDs) Complaints in Workers at Tofu Factories in Piyungan District," *Period. Occup. Saf. Heal.*, vol. 3, no. 2, pp. 9–16, 2025, doi: 10.12928/posh.v3i2.11654.

[9] A. Maillard, T. Pasche, P. Coenen, and G. Christe, "The association between trunk flexion and low back pain in blue-collar workers: A systematic review," *WORK*, vol. 84, no. 1, pp. 42–51, 2026, doi: 10.1177/10519815251397391.

[10] S. M. Hosseini, M. A. Lahoori, and Z. R. Kahaki, "The Effectiveness of Ergonomic Intervention in Work-related Postures and Upper Crossed Syndrome of Metal Industry Workers," *Med. Lav.*, vol. 116, no. 4, p. 16165, 2025, doi: 10.23749/mdl.v116i4.16165.

[11] C. T. J. Hulshof *et al.*, "The prevalence of occupational exposure to ergonomic risk factors: A systematic review and meta-analysis from the WHO/ILO Joint Estimates of the Work-related Burden of Disease and Injury," *Environ. Int.*, vol. 146, p. 106157, 2021, doi: 10.1016/j.envint.2020.106157.

[12] A. Umyati, A. S. Mariawati, and P. Peti, "Work posture analysis and complaint risk using Nordic Body Map

(NBM) and Rapid Entire Body Assessment (REBA) methods," *J. Ind. Serv.*, vol. 9, no. 2, pp. 179–186, 2023, doi: 10.36055/jiss.v9i2.22004.

[13] Y. A. Dewanto, A. C. P. Oloan, M. D. Arifin, and K. A. Nugraha, "Ergonomic Analysis of Welding Postures on Productivity and Weld Quality Using the REBA Method," *Int. J. Mar. Eng. Innov. Res.*, vol. 10, no. 3, pp. 1007–1014, 2025, [Online]. Available: https://journal.its.ac.id/index.php/ijmeir/article/download/8734/7349/20939

[14] C. Greggi *et al.*, "Work-Related Musculoskeletal Disorders: A Systematic Review and Meta-Analysis," *J. Clin. Med.*, vol. 13, no. 13, p. 3964, 2024, doi: 10.3390/jcm13133964.

[15] G. Sudibyo and Z. F. Ikatrinasari, "Analisis Postur Kerja Menggunakan Metode Ovako Work Posture Analysis System (OWAS) Dan Rapid Entire Body Assessesment (REBA) Pada Pekerja Welder Workshop Lembaga Penyiaran," *J. PASTI (Penelitian dan Apl. Sist. dan Tek. Ind.*, vol. 18, no. 1, pp. 88–102, 2024, doi: 10.22441/pasti.2024.v18i1.009.

[16] A. S. Rezki, A. H. Maksum, D. Herwanto, and M. T. Rahmat, "Analisis Risiko Postur Kerja dengan Metode Nordic Body Map, RULA dan REBA pada Proses Manual Material Handling Pabrik Kecap," *J. Media Tek. dan Sist. Ind.*, vol. 7, no. 2, pp. 86–94, 2023, doi: 10.35194/jmtsi.v7i2.2677.

[17] B. Demissie, E. T. Bayih, and A. A. Demmelash, "A systematic review of work-related musculoskeletal disorders and risk factors among computer users," *Heliyon*, vol. 10, no. 3, p. e25075, 2024, doi: 10.1016/j.heliyon.2024.e25075.

[18] G. A. F. Rozaqi, A. W. Rizqi, and H. Hidayat, "Analisis Tingkat Risiko Keluhan Musculoskeletal Disorder (MSDs) Pada Pekerja Welder Di PT XYZ Dengan Metode REBA dan OWAS," *INTECOMS J. Inf. Technol. Comput. Sci.*, vol. 7, no. 6, pp. 2096–2106, 2024, doi: 10.31539/intecoms.v7i6.12583.

[19] F. K. Lohne, K. Xu, M. S. Fimland, J. Palarea-Albaladejo, and S. Redzovic, "Association between musculoskeletal pain and exposures to awkward postures during work: a compositional analysis approach," *Ann. Work Expo. Heal.*, vol. 68, no. 5, pp. 522–534, 2024, doi: 10.1093/annweh/wxae027.

[20] S. Anwer, H. Li, M. F. Antwi-Afari, and A. Y. L. Wong, "Associations between physical or psychosocial risk factors and work-related musculoskeletal disorders in construction workers based on literature in the last 20 years: A systematic review," *Int. J. Ind. Ergon.*, vol. 83, p. 103113, 2021, doi: 10.1016/j.ergon.2021.103113.

[21] C. Brandl, A. Bender, T. Schmachtenberg, J. Dymke, and P. Damm, "Comparing risk assessment methods for work-related musculoskeletal disorders with in vivo joint loads during manual materials handling," *Sci. Rep.*, vol. 14, no. 1, p. 6041, 2024, doi: 10.1038/s41598-024-56580-7.

[22] M. Muharam and M. A. Puspasari, "Designing Welding Workstations to Reduce the Risk of MSDS (Musculoskeletal Disorders)," *J. Indones. Sos. Teknol.*, vol. 5, no. 9, 2024, doi: 10.59141/jist.v5i9.3314.

[23] P. Mehta *et al.*, "Ergonomic interventions for treating work-related complaints of the arm, neck or shoulder in adults," *Cochrane Database Syst. Rev.*, vol. 2026, no. 10, p. CD014644, 2026, doi: 10.1002/14651858.CD014644.pub2.

[24] A. D. Susanto, "Evaluasi Postur Kerja Operator Bottom Tube – Welding dengan Analisis REBA di PT XYZ," *JUS TEKNO (Jurnal Sains dan Teknol.*, vol. 9, no. 1, pp. 90–94, 2025, [Online]. Available: https://journal.sttdb.ac.id/index.php/justekno/article/view/132

[25] S. O. G. Tewal, D. V. D. Doda, and H. I. S. Wungouw, "Hubungan Musculoskeletal Disorders (MSDs) dengan Psikososial dan Postur Kerja Menggunakan REBA pada Pekerja Cleaning Service," *e-CliniC*, vol. 13, no. 3, pp. 348–352, 2025, doi: 10.35790/ecl.v13i3.61404.

[26] C. Ruengdech, S. Howimanporn, T. Intarakumthornchai, and S. Chookaew, "Implementing a Risk Assessment System of Electric Welders' Muscle Injuries for Working Posture Detection with AI Technology," *Int. J. Online Biomed. Eng.*, vol. 20, no. 4, pp. 84–95, 2024, doi: 10.3991/ijoe.v20i04.46465.

[27] K. D. Lestari and H. Hendra, "Postur Kerja dan Gangguan Otot Rangka Akibat Kerja Pada Juru Las," *J. Ergon. Indones. (The Indones. J. Ergon.*, vol. 8, no. 1, pp. 1–10, 2022, doi: 10.24843/JEI.2022.v08.i01.p01.

[28] B. I. Putra and M. R. Khatamy, "Revolutionizing Welding Ergonomics to Mitigate Musculoskeletal Risks," *Indones. J. Innov. Stud.*, vol. 25, no. 4, 2024, doi: 10.21070/ijins.v25i4.1187.

[29] B. S. Nasional, "SNI 7269:2009: Penilaian beban kerja berdasarkan tingkat kalori menurut pengeluaran energi," Badan Standardisasi Nasional, Jakarta, Indonesia, 2009. [Online]. Available: https://pesta.bsn.go.id/produk/by_ics/116