

Ergonomic Work Facility Design for Appearance & Packing Line H3CR Operators at PT Omron Indonesia

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PT Omron Manufacturing of Indonesia, an electronics sector company established on February 13, 1933, faces issues in its production department. Operator complaints due to poorly adjusted ergonomic work facilities hinder their ability to meet production targets. Using the Nordic Body Map method, the author investigated muscle complaints to identify the most affected muscles, which will guide the redesign of work facilities. Additionally, the REBA method was employed to assess the urgency of this redesign, incorporating anthropometric and user-centered design (UCD) methods to better tailor the facilities to user needs.

Keywords: Nordic Body Map, Rappid Entire Body Assesment, Anthropometry, User Centered Design

INTRODUCTION

To establish a successful business, it is essential to have high-quality supporting factors. This includes elements within the scope of the company. Among these supporting factors, there is a concept known as the 5Ms, namely Man (human resources), Machines, Materials (raw materials), Methods or strategies, and Money. These factors are interconnected, with a very close relationship and equally important to consider. Humans are one of the factors affecting work productivity, encompassing quantity, educational and cultural backgrounds, abilities, attitudes, age, and gender (Alzaelani dan M. Dzikron 2022). Humans, as the primary source and driving force in producing or creating something, play a crucial role in any business process.

According (Lestary dan Chaniago 2018) to in their research, the most important asset a company has is its human resources because they have an impact on the company's survival. Thus, humans are a strategic factor in all organizational activities. The sustainability of human resources needs to be considered so that the quality of the products produced can be of good quality (Meina *et al.*) Organizations must recognize the potential of their workforce due to the increasingly competitive business environment. Having employees with high performance will increase the company's productivity level and thus, enhance the company's profits (Nurfadlika dan Adinata 2023).

Unfortunately, according to the International Labour Organization (ILO), it is estimated that there are approximately 340 million occupational accidents and 160 million victims of work-related diseases worldwide every year (Situngkir *et al.* 2021). Obviously, with these figures of workplace accidents, it is proof that there are still causes of the high number of accidents and diseases due to work that generally occur due to the work environment. The work environment encompasses everything surrounding the worker that can affect them in performing the tasks assigned to them (Kepemi *et al.* 2005). The work environment in a company will demonstrate that a person working will produce a good output if they are compatible with the company and its work (Abu *et al.* 2022).

The work environment referred to includes the facilities and infrastructure provided by an organization, known as work facilities. According to (Sugiharto 2013), incorrect work methods and facilities cause complaints about the physical condition of operators. Complaints that often occur are musculoskeletal disorders (MSDs) or injuries to the musculoskeletal system, work risk factors causing Musculoskeletal Disorders (MSDs) (Abu *et al.* 2022). Musculoskeletal complaints are issues related to skeletal muscle parts that are experienced by an individual, ranging from very mild to very severe pain. If muscles are subjected to static loads repeatedly and over a long period of time, this can lead to

complaints such as damage to joints, ligaments, and tendons. (Mahardika dan Pujotomo 2014). Of course, to have good work facilities cannot be separated from the ergonomic standards that must be met. Musculoskeletal disorder is an ergonomic issue frequently encountered in the workplace, particularly relating to the strength and endurance of humans in performing their tasks. (Amri *et al.* 2016). Therefore, work facilities must be adapted to human limitations.

Ergonomics is one of the physical parameters related to the body posture of workers at the workplace. Improper work posture is one of the potential risk factors for accidents and diseases in workers at the workplace (Qutubuddin *et al.* 2013). In another study according (Hamdy dan Zalisman 2018), to on-ergonomic working conditions result in less optimal body posture, inefficiency, low quality, and a person may experience health disorders such as dizziness (motion), low back pain, skeletal muscle disorders, and unavoidable hearing loss. It can be concluded that Ergonomics is the alignment or matching between humans, or what can be referred to as the user, with objects and also the activities or tasks they perform, thereby creating a synchronization that results in comfort in using those objects (Leonardo *et al.* 2018).

In 2018, the World Health Organization (WHO) declared that musculoskeletal complaints are the second highest cause of disability worldwide, with lower back pain being a major contributor to global disability. The prevalence of musculoskeletal diseases in Indonesia based on diagnosis or symptoms is 24.7% (Abdillahtulkhaer *et al.* 2022). Data from the Central Bureau of Statistics (BPS, 2018) shows that 26.74% of the population aged 15 and over who work experience health complaints and disorders. From the data of the Ministry of Health, there were 40,694 cases of occupational diseases. One such occupational disease is musculoskeletal complaints caused during work processes that are not ergonomic (Wiranto *et al.* 2019)

PT Omron, as a manufacturing company that employs a considerable number of workers, produces products such as electronic items and automation equipment. As a manufacturing company, PT Omron must be able to produce according to the targets set for each day. Therefore, this presents a unique challenge for all elements of the company, including the production department, which has the role and responsibility to process a product directly. The work frequency starts from Monday to Friday (5 workdays) with a total of 8 working hours per day and 40 hours per week.

After initial observations, an unusual body posture was discovered while operators were performing their tasks on the H3CR production line. The author conducted interviews with the operators involved, and the results revealed complaints about body parts, which led to unmet production targets on the H3R production line. Discomfort while working can impact the performance potential of the worker. This can be analyzed from various factors in the workplace, one of which is assessing ergonomic risks to determine if further action is needed (Ida *et al.* 2010). This issue was caused by work facilities that had not been adjusted to ergonomic principles. Given these findings, the background prompted the author to investigate the ergonomic risks occurring to operators at the Final Check APP and Packing on line 3 H3CR in the IAB Department, resulting from the discovered unnatural body postures during work tasks.

METHODS

The solution methods to be used are classified into two, aimed at identifying problems using the Nordic Body Map (NBM) and REBA methods. The Nordic Body Map method will be used to locate muscle issues and determine which part experiences the most pain. The REBA method is an assessment tool used to measure the importance of the action being taken, employing a likert scale for evaluation. Furthermore, to design work facilities, the author utilizes the study of anthropometry and the user-centered design (UCD) method.

1. The Nordic Body Map

Nordic Body Map is the most frequently used questionnaire to identify discomfort among workers, and this questionnaire is often utilized because it is standardized and neatly organized by observing and analyzing the body map. Through this questionnaire, it is possible to estimate the type and level of skeletal muscle complaints experienced by workers (Hamdy dan Zalisman 2018). The

NBM (Nordic Body Map) method, in its application, uses a worksheet in the form of a body map and is a very simple, easy-to-understand, affordable, and time-efficient method. Observers can directly ask respondents about which skeletal muscles are experiencing discomfort or pain by pointing directly at each skeletal muscle as listed in the "Nordic Body Map" questionnaire worksheet. (Roberta Zulphi Surya *et al.* 2021)

2. Rapid Entire Body Assessment (REBA)

Rapid Entire Body Assessment (REBA) is a method in the field of ergonomics used to assess the working posture of operators, which includes the posture of the neck, back, arms, wrists, and legs (Hunusalela *et al.* 2021). The application of this method to prevent or reduce the risk of injuries associated with specific positions (particularly skeletal muscles). (Nova dan Hariastuti 2021). The outcome obtained is in the form of a decision level that indicates the urgency of the required action (Suaib 2023).

3. Anthropometry

The term anthropometry comes from "anthro," meaning human, and "metri," meaning measure. Anthropometry is the science that concerns the measurements of the human body, especially body dimensions. Anthropometry will broadly be used as ergonomic considerations in the design process of products or work systems that will require human interaction. Humans generally differ in terms of body shape and size dimensions (Santoso *et al.* 2014). There are two options in designing work systems based on anthropometric data (Latar 2016) namely; tailored to the body of the worker in question (individual design), which is ergonomically best and suitable for the user/worker population.

4. User Centered Design (UCD)

User Centered Design (UCD) is a method that focuses on the needs of potential users in the stages or process of system design. These needs include comfort and satisfaction when the user utilizes the system product that is to be designed (Zen *et al.* 2022)). The concept of UCD is applied based on the needs and interests of the users, focusing on creating a system that can be used and understood effectively. This method is utilized for interactive system development, centering on user needs, usability, tasks, and design workflows (Aura 2021). The goal of User-Centered Design (UCD) is more than just creating useful products (Amrullah *et al.* 2016). The method used is the User Centered Design (UCD) approach method. Based on the User Centered Design (UCD) method, there are four stages as follows:

1) Plan the human centered process

The researcher conducted a literature study by reading, understanding journals, reference books, and other media related to data processing in general to support existing theories. Therefore, in this design, it reinforces the use of anthropometry methods to support research using the user-centered design (UCD) method, which can meet user desires.

2) Specify the Context of Use

At this stage, the target users are determined.

3) Specify User and Organizational Requirement

At this stage, the researcher identifies the details of user needs through interview techniques.

4) Product Design Solutions

This stage is the design solution phase. It will be made in the form of a design prototype.

5) Evaluations Design Against User Requirement

This stage is the evaluation phase of the design that has been created.

RESULTS AND DISCUSSION

1. Nordic Body Map

The Nordic Body Map questionnaire, designed to assess musculoskeletal symptoms, was systematically distributed to three operators working in the appearance and packing sections of the H3C production line. This questionnaire has been widely used by ergonomic experts to evaluate the severity of disorders in the musculoskeletal system and is recognized for its validity and reliability Following

the completion of the questionnaire, the collected data were meticulously processed and organized. Presented below are the detailed results from this data collection effort.

Table 1 The Nordic Body Map Questionnaire

No	Location	Operator											
		Erma			Wulan				Widia				
		TS	SS	S	SK	TS	SS	S	SK	TS	SS	S	SK
0	Upper neck pain / stiffness		2					3		1			
1	Lower neck pain		2					3		1			
2	Left shoulder pain				4		2				2		
3	Right shoulder pain			3							2		
4	Left upper arm pain	1						3			2		
5	Back pain			3		1					2		
6	Right upper arm pain			3					4	1			
7	Waist pain			3		1				1			
8	Buttock pain		2					3			2		
9	Bottom pain	1						3			2		
10	Left elbow pain	1					2			1			
11	Right elbow pain	1				1				1			
12	Left forearm pain			3		1					2		
13	Right forearm pain		2						4			3	
14	Left wrist pain			3			2						
15	Right wrist pain			3				3		1			
16	Left hand pain	1					2			1			
17	Right hand pain		2						4	1			
18	Left thigh pain	1						3		1			
19	Right thigh pain	1				1				1			
20	Left knee pain	1				1						3	
21	Right knee pain	1				1					2		
22	Left calf pain		2			1						3	
23	Right calf pain		2				2					3	
24	Left ankle pain		2				2				2		
25	Right ankle pain		2			1				1			
26	Left foot pain		2			1						3	
27	Right foot pain		2				2					3	
Total Individual Score		56			61				48				

Table 2 Likert Scale

Skala Likert	Total Individual Score	Risk Level	Level of Improvement
1	23 – 49	Low	No improvement has been found
2	50 – 70	Moderate	Action may be required in the future
3	71 – 90	High	Immediate action is required
4	92 - 122	Very High	Comprehensive action is needed as soon as possible

The recapitulation of the analysis using the Nordic Body Map method is as follows:

- The operator with the highest score is Operator 2 (Wulan) with a total score of 61, followed by Operator 1 (Erma) with a total score of 56, and Operator 3 (Widia) with a total score of 48.
- From the results obtained, Operator 2 with a score of 61 falls into the Likert scale category level 2, which means 'Moderate' and 'action may be required in the future'.
- The second operator has the most complaints in the back area, with a given score of 4 for the arm and hand sections, indicating a pain level category of 'Very Painful' (VP). Based on the analysis above, Operator 2 (Widia) will be chosen by the researcher for further study to design work facilities in the form of production tables.

From the analysis above, operator 2 (Widia) will be the respondent chosen by the author to conduct further research on designing and creating a work facility in the form of a production table.

2. Rappid Entire Body Assement (REBA)

The assessment of work posture is conducted using the REBA method. The REBA method is utilized to evaluate the work posture positions including the body, legs, upper arms, lower arms, and wrists in standing workers. (Apriyan Trio Afandy et al. 2023). The REBA method comprises three assessments classified with a table.

The REBA method includes three assessments classified by tables. Table A assesses the neck, back, and legs. Table B assesses the arms and hands. Finally, Table C determines the final REBA score. These results can serve as a reference for improving workplace facilities.

Based on the observations and field documentation collection on the Final Check App and packing operators, the next steps involve scoring and analysis using the REBA method. Here is the analysis and the steps carried out according to the REBA method standards.

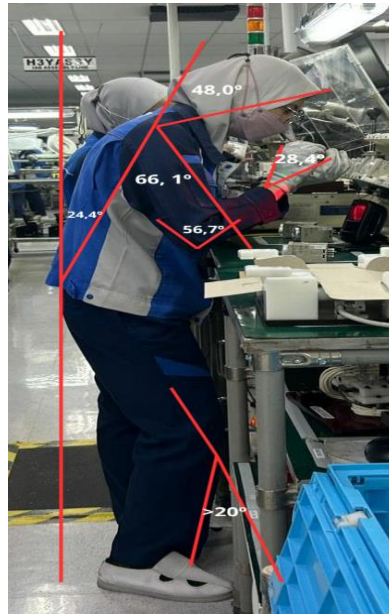


Figure 1 Work Posture of App Operator and Packing Line H3CR

Table 3 results of the REBA assessment

No	Factor	Movement	Adjust	Score
Group Posture A				
1	Local Neck Position	Forming an angle of 48.8°	1	3
2	Locate Trunk Position	Forming an angle of 24.4°	-	2
3	Legs	Angle Between 30° - 60°	1	2
4	Look – up Posture Score in Table A			
5	Add Force/Load Score	Load<11bs		0
6	Score A, Find Row in Table C			5
Group Posture B				
7	Locate Upper Arm Position	Forming an angle of 66.1°	-	3
8	Locate Lower Arm Position	Forming an angle of 56.7°	-	2
9	Locate Wrist Position	Forming an angle of 28.4°	-	1
10	Look –up Posture Score in Table B			
10	Add Coupling Score	Well fitting handle & mid power grip; good		0
12	Score B, Find Column in Table C			
13	Step 13 : Activity score	Repetead small range addition { more than 4x per minute }		1
REBA Score				7

The activities of the final check app and packing operators are carried out over an 8-hour work period, resulting in an additional score of +1. Therefore, the total REBA score for the final check app and packing activities is 7. The REBA method standard classifies a score of 7 as work with medium risk, necessitating future corrective action.

3. Anthropometry

Anthropometric data encompasses a comprehensive range of measurements and information, including the identity details of the operator, such as age, gender, and physical characteristics, along with the critical concept of design planning. This concept integrates the specific body dimensions—such as height, reach, and seated torso length—of the operators, which are essential for creating a custom-designed production table. These measurements are meticulously gathered and analyzed to ensure that the production table not only fits the physical requirements of the workforce but also enhances comfort and efficiency in the workplace, thereby aligning with ergonomic best practices to support optimal work conditions and productivity.

Table 4 User Identity

Identity	Versatility
Name	Wulan
Age	21
Gender	Female
Height	173 cm
Weight	51 kg

Design Concept

a) Table Height

The height of the table during work activities. If too low, it can cause the body to stoop while working. Such body posture can lead to pain in the waist muscles, back, and pain in the muscles of the neck and shoulders. The table height is derived from the Standing Elbow Height.

b) Table Length

The length of the work table used does not always employ the maximum arm reach and span possible. Besides, this adjustment can provide a comfortable and safe working posture and position. The table length is obtained from the Length of Arm Reach Forward.

c) Table Width




The width of the table used must be in accordance with the arm reach and span. So that employees are able and quite freely to adjust their bodies. To obtain a more comfortable working posture and position, the table width is derived from the forward arm reach.

Anthropometry Calculation

The body dimensions used for the table design are Elbow Height for table height, Arm Span Length for table width, and Forward Arm Reach for table width. Below are the anthropometric dimensions that will be used in the workplace facility improvements in the form of tables at the final check and app workstation, along with their sizes and allowances.

Table 5 Operators Body Dimension

No	Need	Explanation
	Part Workstation	Table Height
1	Anthropometric Dimensions and Their Use	The vertical distance from the floor to the lowest point at the right corner is 109 cm.

No	Need	Explanation
	<p data-bbox="443 197 587 215">DIMENSI TINGGI SIKU</p>  <p data-bbox="491 607 624 636"><i>Allowance</i></p> <p data-bbox="459 723 660 752">Final Dimension</p>	<p data-bbox="794 521 1453 719">The allowance is focused on the accessories used by the operator. Regarding the anthropometric dimension of elbow height, the accessory that has an impact is Shoes. The height of the production operator's shoes in department IAB reaches 2 cm, therefore the allowance is a positive allowance of 2 cm.</p> <p data-bbox="794 723 1091 752">$107 \text{ cm} + 2 \text{ cm} = 109 \text{ cm}$</p>
2	<p data-bbox="371 792 746 857">Anthropometric Dimension and Their Use</p> <p data-bbox="475 869 635 920">DIMENSI PANJANG RENTANG TANGAN KE DEPAN</p>  <p data-bbox="491 1290 624 1319"><i>Allowance</i></p> <p data-bbox="467 1357 647 1386">Dimensi Akhir</p> <p data-bbox="459 1395 660 1424">Part Workstation</p>	<p data-bbox="1042 759 1201 788">Tablel Width</p> <p data-bbox="794 792 1453 891">The distance from the top of the right shoulder (acromion) to the tip of the middle finger of the right hand, with the right elbow and wrist straight, is 71 cm.</p> <p data-bbox="794 1256 1453 1355">The allowance provided for the table width takes into account the storage of machines and work tools placed on the table, thus the given allowance is 4 cm.</p> <p data-bbox="794 1357 1062 1386">$71 \text{ cm} + 4 \text{ cm} = 75 \text{ cm}$</p>
3	<p data-bbox="371 1426 746 1491">Anthopometric Dimension and Their Use</p> <p data-bbox="467 1503 647 1554">DIMENSI PANJANG RENTANGAN TANGAN KE SAMPING</p>  <p data-bbox="491 1944 624 1973"><i>Allowance</i></p> <p data-bbox="459 2011 660 2040">Final Dimension</p>	<p data-bbox="1042 1393 1201 1422">Table Length</p> <p data-bbox="794 1621 1453 1720">The maximum distance from the tip of the middle finger of the right hand to the tip of the middle finger of the left hand is 150 cm.</p> <p data-bbox="794 1912 1453 2011">Since the operator does not use any specific accessories that affect body dimensions, there is no allowance given.</p> <p data-bbox="794 2013 1091 2042">$150 \text{ cm} + 0 \text{ cm} = 150 \text{ cm}$</p>

Details of the components that will be adjusted in the final check app and packing workstation involve a workbench that has been tailored to the operator's body anthropometry. This also aligns with the findings from the worksheet analysis of work posture assessment using the Rapid Entire Body Assessment (REBA) method previously conducted, where a final score of 7 was obtained. This score indicates that the operator's work posture for the final check app and packing process, when performing activities, is still not in accordance with ergonomic principles.

4. User Centered Design (UCD)

a) Plan The Human Centered Process

Below are several journals used by the author as references to previous research in designing the production table.

Table 6 Reference Journal

No	Peneliti	Judul	Objek Penelitian	Tempat Penelitian
1	Susi Eliyana, Yoga Puji Raharjo, Chris Calik (2023)	Perancangan Meja Kerja Dengan Menerapkan Aspek Ergonomi Dan Fitur Untuk Meningkatkan Efisiensi Kerja Seorang Desainer Perancangan Meja Kerja Yang	Desainer	-
2	Atik Kurnianto, Yoga Andrian (2020)	Ergonomis Untuk Membantu Proses Repair Stripping Mirrors Dengan Metode Rula	Pegawai Reppair Stripping Mirros	-
3	Agung Kristanto, Dianasa Adhi Saputra (2011)	Perancangan Meja dan Kursi yang Ergonomis pada Stasiun Kerja Pemotogan Sebagai Upaya Peningkatan Produktivitas	Operator	Industri Barokah Jaya

b) Specify Of Use

This work facility design, in the form of a production table, is used to meet the needs of users (final check appearance and packing operators at the H3CR line) at PT Omron Manufacturing Of Indonesia.

c) Specify User and Organizational Requirement

1) Specify User

Based on the interview results with the source (operator), what is needed by the operator is a work table that fits or is suitable for their body height.

2) Organizational Requirement

Based on interview results with the company's field supervisor, the company needs ergonomic work facilities that comply with Law Number 1 of 1970 concerning Occupational Safety.

d) Product Desain Solutions

The following is a design of the work facility in the form of a production table that has been adjusted to meet the needs of the operator.

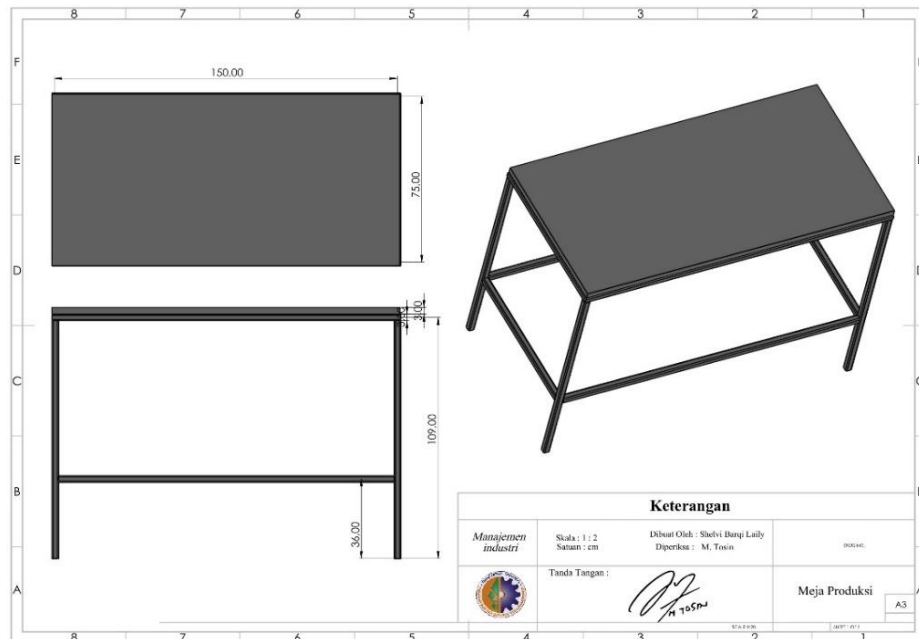


Figure 2 Production Table Design

e) Product Design Against Requirement

At this stage, an evaluation of the design outcomes that have been created is conducted. Based on the results of the Nordic Body Map data processing, with the highest final score being 61, this category falls under "Action may be required later," and the Rapid Entire Body Assessment with a total final score of 7, this category falls into the medium risk work category, indicating that corrective actions may need to be taken in the future. Therefore, the author hopes that this design can be used by the company to make improvements to the work facilities in the form of production tables in the future. The evaluation provided is in the form of validation from the company, indicated by a signature on the design outcomes created by the author.

CONCLUSION

Based on ergonomic calculations using anthropometric methods that have been adapted to the operator's body to create an ergonomic production table facility, the resulting production table dimensions are 150 x 75 cm in length and width, with a leg length of 109 cm that has been validated.

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