

Anthropometry–Kansei for ergonomic assistive device design

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Abstract

Manual work using non-ergonomic tools at the packaging station causes workers to bend over for long periods. This condition can increase the risk of Musculoskeletal Disorders (MSDs), thereby reducing worker productivity. The objectives of this study were to determine the greatest pain complaints from workers, design ergonomic aids to reduce MSDs complaints, and analyze worker responses to the ergonomic aids created. The methods used included worker anthropometric measurements, percentile determination, statistical tests to ensure data usability, and Kansei Engineering to identify worker interest in the tool. Results and discussion, popliteal length, popliteal height, and hip width are the dimensions used to design the tool. All dimensions were tested statistically. In the data sufficiency test, all data were declared valid, the data reliability test was declared reliable, and the data normality test stated that the data were normally distributed. The percentile used was the 50th percentile. Worker responses to the tool were evaluated using Kansei Engineering using nine Kansei words. All Kansei words were declared valid with values (0.407-0.850) exceeding the r-table value, and the reliability test (0.707-0.791) was declared greater than the Cronbach Alpha limit (5%), so all Kansei words were reliable. In conclusion, the ergonomic aids for packaging workers have a length of 43.65 cm, a height of 44.40 cm, and a width of 33.35 cm, while the evaluation of the aids produced seven descriptors with the highest scores, namely comfortable to use (0.940), safe to use (0.935), light (0.911), easy to use and move (0.913), simple design (0.920), flexible to use (0.951), and very functional when used in the workplace (0.938).

Keywords:

Anthropometry, design, Kansei Engineering, manual work, musculoskeletal disorders.

1 Introduction

The increasing demand for rubber can be seen in the increasingly advanced automotive industry, which has also led to a growing need for rubber in vehicle tire production. Despite current technological advancements, the role of humans in the production process remains essential. In fact, many industries still employ manual labor [1], un-ergonomic work facilities or tools. Manual work performed in unnatural postures can cause pain and, if done continuously, can lead to Musculoskeletal Disorders (MSDs) [2][3]. MSDs are muscle disorders that have a major impact on workers, namely causing pain, soreness, numbness, tingling, swelling, stiffness, trembling, sleep disturbances, and burning sensations [4]. This is also experienced by workers at PT ABC.

PT. ABC is a company operating in the rubber processing sector, processing raw rubber into crumb rubber. The production process at this rubber factory consists of five work stations: purchasing and receiving raw materials, pre-cleaning, milling, crushing into crumbs, and packaging. During the production process, many manual activities are performed by workers [5]. Observations were carried out at workstations that have manual activities; the results of the observations were identified using Ergofellow 3.0 software, which obtained workers' postures that were often bent or unnatural for workers at each production station, resulting in a score of 9-12 with a high risk level [6][7] so that this work posture can trigger muscle complaints in workers [8]. Identification is carried out first at the raw material purchasing station (Fig 1).



Fig. 1. Posture of workers in the raw materials purchasing section.

Fig. 1 shows the activity during the rubber loading and unloading process with the worker's body posture in a sitting position with the arms slightly bent at an angle of 29.88° and the legs slightly hanging at an angle of 115°. A static sitting posture for 8 hours of work can cause muscle complaints [9] in the worker's body. The pre-cleaning station is the initial inspection work on the material (Fig 2).

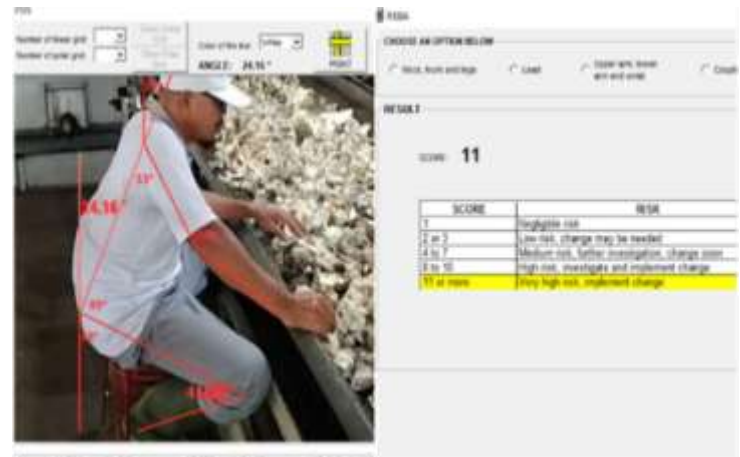


Fig. 2. Pre-cleaning section workers' body posture.

Fig. 2 shows a worker's posture while sitting in a chair with the body slightly bent and the legs bent at a 41.08° angle. This bent leg position is maintained for 8 hours of work. This causes musculoskeletal complaints in workers due to their non-ergonomic posture [10]. The milling station is a station that separates the fruit bunches (Fig 3).

Fig. 3 shows that the worker's body posture in this activity is bent at an angle of 52.37° and 54.78°. The worker's legs are also bent at an angle of 30.33° and 35.88°. The worker's body posture is bent, lowered, and squatted, with hands raised, and these activities are carried out repeatedly for a long time, which can make workers susceptible to musculoskeletal complaints [11]. The crumbling station is the process of processing raw rubber lumps into small, clean granules (Fig. 4).

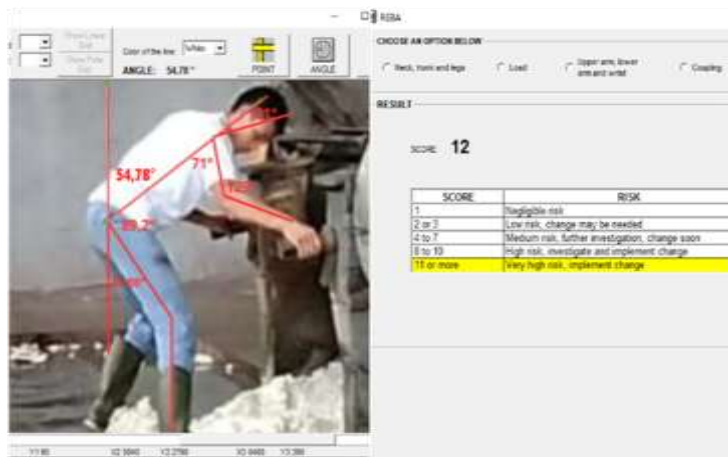


Fig. 3. Body posture of milling workers.

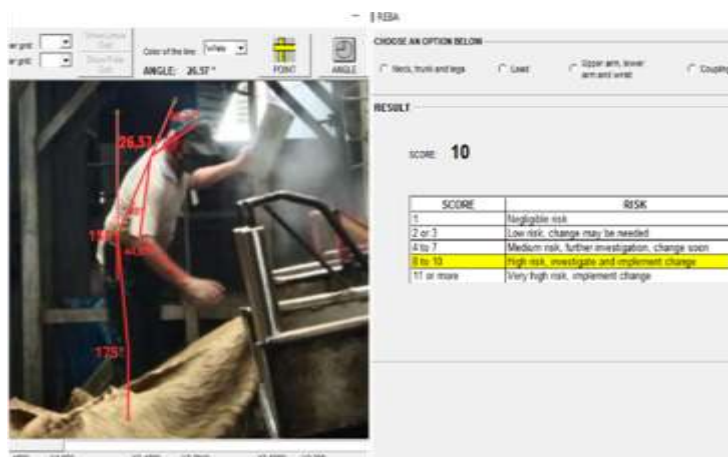


Fig. 4. Body posture of crumbing section workers.

Fig. 4 shows a worker's hunched posture, with their arms bent at a 44.87° angle. Workers perform this process repeatedly for extended periods of time, making them susceptible to muscle complaints [12]. The packing station is the job of wrapping products (Fig 5).

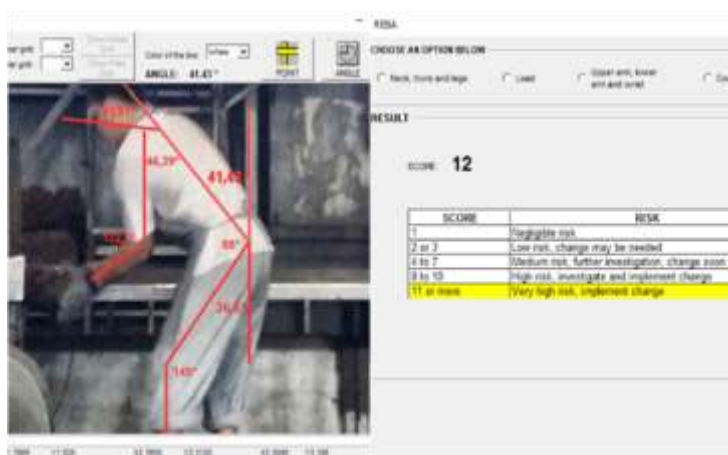


Fig. 5. Body posture of packing workers.

Fig. 5 shows the body posture of workers in the packaging section during the weighing process. Bale weighing is the process of weighing bales to ensure they meet the required weight of 35 kg. To obtain a weight of 1 bale of 35 kg, workers must carry out manual material handling activities, namely lifting 2 bales from the oven-dried bale to be weighed, if the bale weight exceeds the specified weight. If specified, workers will cut the bale using a manual cutting tool, namely a large knife. This activity is carried out repeatedly with a body posture bent at 41.43° , a twisting body posture, standing, looking down, and arms raised for a long time. This can trigger complaints of musculoskeletal disorders in workers [13].

Work postures that humans often use when doing work include standing, sitting, squatting, bending, walking, and so on [14]. This work posture is carried out depending on the existing work system conditions [15]. If the work system conditions are unhealthy, it will cause work accidents, because workers do unsafe work [16]. One of them is that workers will experience musculoskeletal disorders [17].

The ergonomic aids are carried out based on anthropometric methods, namely, the size of the tool is adjusted to the worker's body size [18]. After the ergonomic aids are made, worker responses to the aids are carried out using the Kansei Engineering method. So the purpose of this research is to determine the biggest pain complaints from workers, design ergonomic aids to reduce MSDs complaints, and analyze worker responses to the ergonomic aids made.

2 Method

2.1 Sample

The sample in this study was workers who performed manual work at 5 work stations, totaling 41 people with an age range of 24–64 years and male gender. The object of this study was complaints of musculoskeletal disorders experienced by workers while doing their work, while the type of research conducted was descriptive with a quantitative approach, namely research that describes all research results based on numerical data [19].

2.2 Questionnaire distribution procedure

Questionnaires were distributed to 41 workers who carried out work manually at 5 work stations. The Standard Nordic Questionnaire (SNQ) contains 28 questions regarding pain complaints experienced by workers while doing their work [20], as shown in Table 1.

Table 1. Standard Nordic questionnaire

No.	Pain complaints	No pain	A bit painful	Pain	Very painful
0	Upper neck				
1	Lower neck				
2	Left shoulder				
3	Right shoulder				
4	Left upper arm				
5	Back				
6	Right upper arm				
7	Waist				
8	butt				
9	hips				
10	Left elbow				
11	Right elbow				
12	Left forearm				
13	Right forearm				
14	Left wrist				
15	Right wrist				
16	Left hand				
17	Right hand				
18	Left thigh				
19	Right thigh				
20	Left knee				
21	Right knee				
22	Left calf				
23	Right calf				
24	Left ankle				
25	Right ankle				
26	Left Foot				
27	Right foot				

Table 1 shows the contents of the SNQ questionnaire, which was assessed to determine the level of pain experienced by each worker at each workstation. The level of complaints was divided into four categories: no pain (weighted 1), some pain (weighted 2), pain (weighted 3), and very pain (weighted 4) [21]. Work stations

that have a high risk will be proposed for the design of ergonomic aids to reduce muscle complaints felt by workers [22].

2.3 Tool design procedure

The tool design procedures carried out are: measurement of workers' body dimensions, statistical test and percentile determination.

2.3.1 Measurement of workers' body dimensions

Measuring body dimensions is needed for ergonomic tool design proposals. The result is a tool design that can be used comfortably by the entire population, with dimensions adjusted to anthropometric data. Anthropometry is a natural measurement of the human body, both in static (actual size) and dynamic (adjusted to work) activities [23][24] also stated that anthropometry is a collection of numerical data relating to the physical characteristics of a human body, such as size, shape, and strength, as well as the application of data for product design. Measurements for each dimension are different; the three-dimensional measurement methods used are shown in Table 2.

Table 2. Dimensional measurement




Dimension	Measurement
 Popliteal butt	Measure the horizontal distance from the outer edge of your buttocks to the inner bend of your knee. Your thigh and lower leg should form a right angle.
 Popliteal height	Measure the vertical distance from the floor to the bottom of the thigh.
 Hip width	The subject sits upright; measure the horizontal distance from the outermost part of the right hip.

Table 2 shows that each dimension has a different measurement, such as the popliteal buttock dimension, which is the horizontal distance from the outer edge of your buttocks to the inner bend of your knee. Your thigh and lower leg should form a right angle.

2.3.2 Statistical test

The data validity test calculation is carried out to determine whether the measurement data that has been obtained from the measurements is sufficient or not. The data sufficiency test is performed using the Eq. (1).

$$N' = \left\lceil \frac{\left[\frac{k}{s} \sqrt{Nx \sum X_i^2 - (\sum X_i)^2} \right]^2}{\sum X_i} \right\rceil \quad (1)$$

It is known that k indicates the level of confidence, s indicates the degree of accuracy, X_i indicates the data, and N indicates the number of data, while N' indicates the number of observation data. If the data is not valid, then the measurement is carried out again [25]. Data is said to be valid if $N' < N$, and vice versa, data is said to be valid if $N' > N$.

The aim of the data reliability test is to ensure that the data collected from the measurement results can be used as a research sample [26]. To obtain data reliability testing, three stages are carried out: (1) finding the average (Eq. (2)); (2) determining the standard deviation (Eq. (3)); (3) reliability testing: the reliability testing determines whether the data is reliable or not (Eq. (4)-Eq.(5)).

$$Me = \frac{\sum x_i}{n} \quad (2)$$

$$\sigma = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n}} \quad (3)$$

$$UCL = \bar{x} + k \cdot \sigma \quad (4)$$

$$LCL = \bar{x} - k \cdot \sigma \quad (5)$$

It is known that UCL is the Upper Control Limit, LCL is the Lower Control Limit, mean is the average, and σ is the standard deviation. Data is said to be reliable if the data (X_i) is between the UCL and LCL and vice versa; if the data exceeds the UCL or the data is less than the LCL, then the data is considered unreliable.

Normality test is a test carried out to assess the distribution of data in a group of data or variables [27]. This normality test is conducted using the Kolmogorov-Smirnov method and using the Statistical Package for the Social Sciences (SPSS) software. Data is said to be normally distributed if the resulting data must be greater than Cronbach's alpha (5%).

2.3.3 Percentile determination

A percentile is a measurement that determines the ergonomic size of a tool. Percentiles are used to match the human dimensions of the tool to be designed [28], so that humans can use the designed tool without experiencing pain complaints or prolonging the occurrence of pain complaints. The determination of percentiles includes percentile 1 (P1) to percentile 99.5 (P99.5) (Table 3). Table 3 shows some percentiles used to design the tool.

Table 3. Percentiles

Percentile	Formula
99.5	$x + (2.58 \cdot \sigma)$
99	$x + (2.32 \cdot \sigma)$
97.5	$x + (1.95 \cdot \sigma)$
97	$x + (1.88 \cdot \sigma)$
95	$x + (1.65 \cdot \sigma)$
90	$x + (1.28 \cdot \sigma)$
80	$x + (0.84 \cdot \sigma)$
75	$x + (0.67 \cdot \sigma)$
70	$x + (0.52 \cdot \sigma)$
50	x
25	$x - (0.67 \cdot \sigma)$
20	$x - (0.84 \cdot \sigma)$
10	$x - (1.28 \cdot \sigma)$
5	$x - (1.65 \cdot \sigma)$
3	$x - (1.88 \cdot \sigma)$
2.5	$x - (1.95 \cdot \sigma)$
1	$x - (2.32 \cdot \sigma)$

2.4 Kansei Engineering procedure

Kansei Engineering [29] is a technology that combines Kansei (feelings and emotions) with engineering disciplines [30]. This field focuses on the development of products that provide human satisfaction through technology, analyzing human emotions, and transforming them into products [31]. The steps in data processing for the Kansei Engineering method are: (1) data coding and tabulation: the Kansei questionnaire responses from all respondents were scored using a Likert scale (e.g., 1–5), then tabulated in a worksheet (rows = respondents, columns = each Kansei word); (2) descriptive statistics: the mean, standard deviation, and distribution of scores were calculated for each Kansei word to obtain an initial overview of respondents' perceptions of the designed assistive device [32]; (3) Kansei item validity testing: each Kansei word was tested for validity using an item-total correlation (Pearson). An item is declared valid if the correlation coefficient is significant

($r_{\text{calculated}} > r_{\text{table}}$ or $p < 0.05$), and therefore may be used in subsequent analyses (4) Kansei scale reliability test: the internal consistency of all Kansei items was tested using Cronbach's alpha. An alpha value ≥ 0.70 indicates that the Kansei instrument is reliable and suitable for use as a single scale; (5) factor analysis feasibility test [33]: the suitability of the data for factor analysis was checked using the Kaiser-Meyer-Olkin (KMO) value and Bartlett's significance test. Data were considered suitable for factorization if the KMO value was > 0.5 and the Bartlett's test was significant ($p < 0.05$); (6) factor analysis and naming of Kansei dimensions: factor analysis was used to reduce several Kansei words into several emotional factors/dimensions. Kansei words with high factor loadings on the same factor were then used to name these dimensions (e.g., comfort & safety, ease of use, functionality, etc.); (7) determining key Kansei attributes and design implications: the dimensions and Kansei words with the greatest contribution are designated as key Kansei attributes. These attributes then serve as the basis for determining the final elements and specifications of the ergonomic aid design, ensuring that the tool is not only physically ergonomic but also meets user perceptions and expectations [34].

3 Results and discussion

3.1 Assessment of complaint levels of Musculoskeletal Disorders (MSDs)

The SNQ questionnaire is used to determine the level of pain complaints related to musculoskeletal symptoms experienced by workers while performing their jobs. The general section of the SNQ consists of 27 questions with four response indicators: no pain, some pain, pain, and extreme pain [35]. The SNQ questionnaire data were collected manually at each workstation, and only severe pain complaints were examined at each station. There are five workstations: raw material purchasing, pre-cleaning, milling, crumbing, and packing. The results of the questionnaire on workers showed that the packing workstation caused the most pain complaints (Fig 6).

Fig. 6 shows that at the packing station, all respondents who completed the questionnaire stated that all posture points experienced severe pain, with the highest score being 80%, which is a high-risk level. Of the 28 complaint points, only two complaint points were not very painful, namely the upper neck and buttocks. Therefore, to reduce these complaints, an ergonomic aid was designed using anthropometric methods.

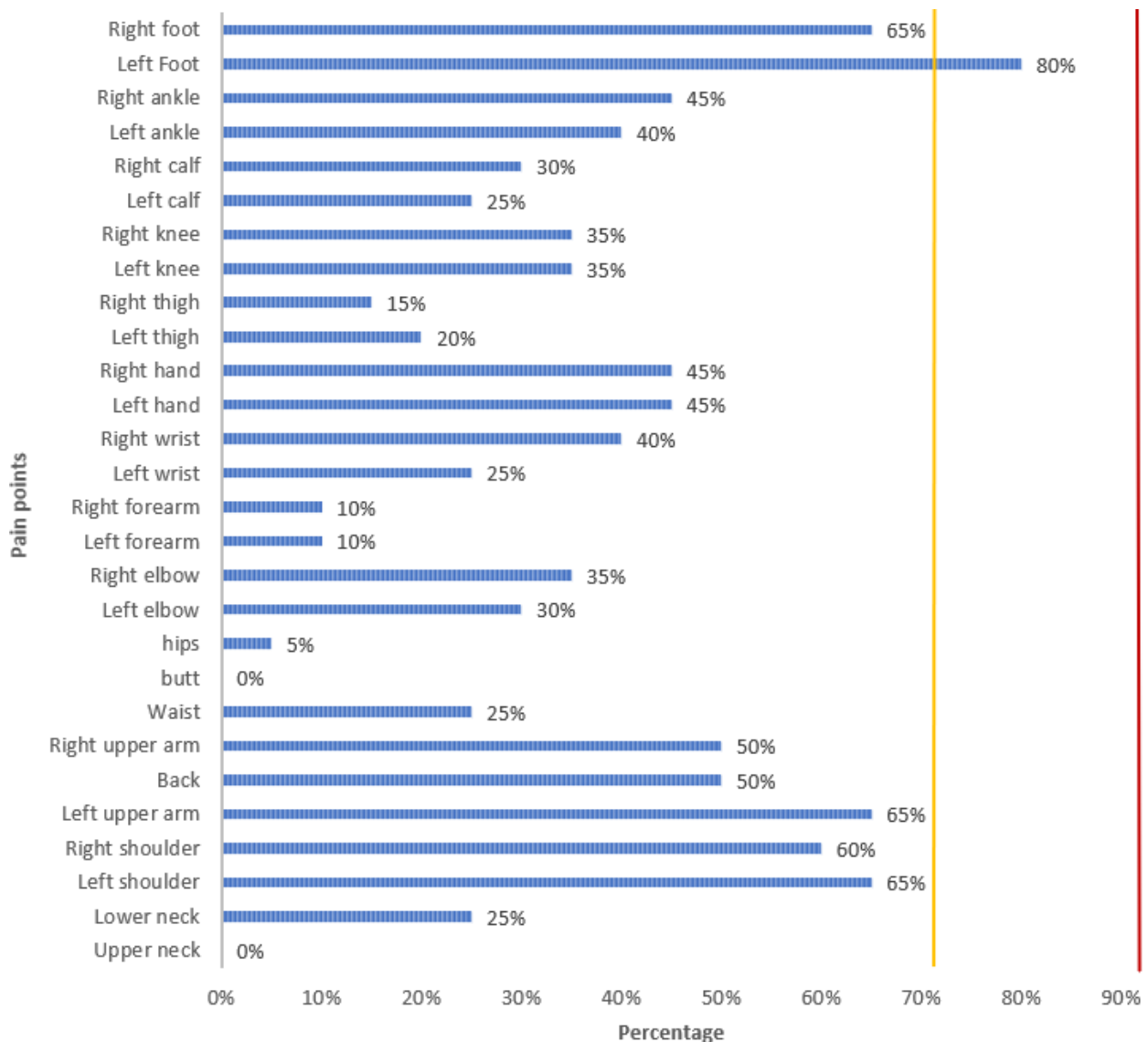


Fig. 6. MSDs for packing station workers.

3.2 Anthropometric measurements

Anthropometric methods were used to design assistive devices that could reduce pain complaints among workers [36][37] at the packing station. Three dimensions are used in the design of this ergonomic assistive device, as these three dimensions support the designed assistive device: popliteal buttocks, popliteal height, and hip width. Measurements for these three dimensions are shown in Table 4.

Table 4 shows the three dimensions used to design ergonomic aids, such as the popliteal butt dimension, which is used to determine the length of the ergonomic aid. Several steps to obtain the design of ergonomic aids in anthropometry are by conducting statistical tests and determining percentiles. The statistical tests carried out are data validity tests, data reliability tests, and data normality tests [38].

Table 4. Three-dimensional design of ergonomic

Body dimension	Utility
Popliteal butt	Used to determine the length of the tool
Popliteal height	Used to determine the height of the tool
Hip width	Used to determine the width of the tool

3.2.1 Data validity test

Data validity tests were carried out for the three dimensions used. An example calculation for the popliteal buttock dimension is:

$$N' = \left[\frac{\frac{k}{s} \sqrt{N \times \sum Xi^2 - (\sum Xi)^2}}{\sum Xi} \right]^2$$

$$N' = \left[\frac{2}{0.05} \sqrt{20 \times 38.253 - 762.129} \right]^2 = 6.153$$

The results of the data adequacy test showed that the popliteal buttock dimension data N' (6.153) < N 20; thus, the adequacy test for the popliteal butt dimension is valid. A summary of the data adequacy test is shown in Table 5.

Table 5. Data validity test recapitulation

Body dimensions	N'	N	Information
Popliteal butt	6.153	20	Valid
Popliteal height	5.470	20	Valid
Hip width	8.383	20	Valid

Table 5 shows that all dimension data are declared valid, as evidenced by the data results being smaller than the total number of data.

3.2.2 Data reliability test

Data reliability tests were carried out for the three dimensions used in designing the aids (Fig. 7). Fig. 7 shows that all dimensional data, namely popliteal butt dimensions, popliteal height dimensions, and hip width dimensions, are stated to be reliable because all data from the three dimensions are between the UCL and LCL control limits.

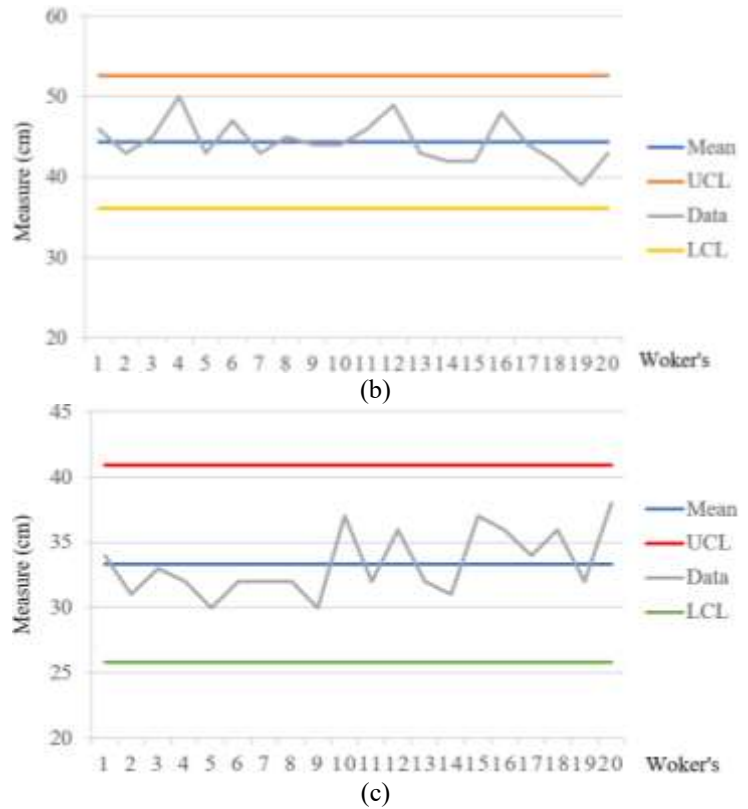
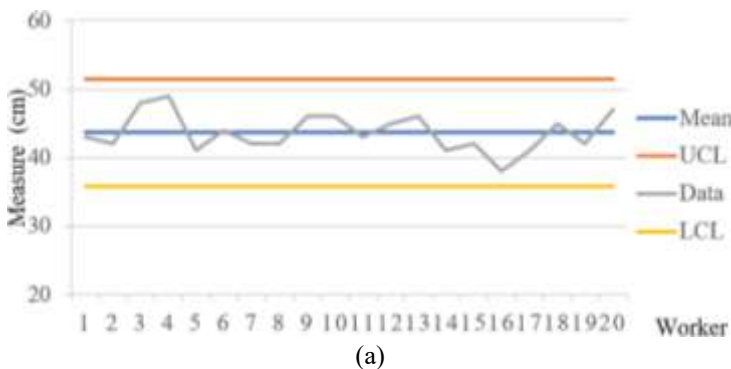


Fig. 7. Summary of data reability test. (a) Popliteal butt dimensions recapitulation, (b) popliteal height dimensions recapitulation, (c) hip width dimensions recapitulation.

3.2.3 Data normality test

The data normality test is used to see whether the data obtained is normally distributed or not [39]. Kolmogorov-Smirnov normal distribution test on the body dimensions of popliteal buttocks, popliteal height, and hip width using IBM SPSS Statistics 25 software as shown in Fig. 8.

	Popliteal Buttock	Popliteal Height	Hip Width	
N	20	20	20	
Normal Parameters ^{a,b}	Mean	43.65	44.40	33.35
	Std. Deviation	2.777	2.664	2.477
Most Extreme Differences	Absolute	.174	.160	.257
	Positive	.174	.160	.257
	Negative	-.120	-.134	-.158
Statistical Tests	.174	.160	.257	
Asymp. Sig. (2-tailed)	.115c	.195c	.001c	

a. Test distribution is Normal.
 b. Calculated from data.
 c. Lilliefors Significance Correction.

Fig. 8. Normality test recapitulation.

Based on Fig. 8, it shows a recapitulation of the data normality test using the Kolmogorov-Smirnov method using SPSS software. The results obtained for the popliteal buttock dimension data were 0.174, the popliteal height dimension data were 0.160, and the hip width dimension data were 0.257. The test results show that the three-dimensional data is greater than 0.05, so it can be concluded that the three-dimensional data normally distributed.

3.2.4 Percentile determination

A percentile is a value that indicates the proportion of individuals in a population whose body dimension is less than or equal to that value [40]. The percentile values commonly used in anthropometric calculations are the 1st, 2.5th, 5th, 10th, 15th, 25th, 50th, 75th, 85th, 90th, 95th, and 97th percentiles. In this study, the 50th percentile (P50) was used because workers had almost the same body posture [41] (Table 6).

Table 6. Percentil

Dimensions	Percentile	Percentile value results (cm)
Popliteal buttock	50	43.65
Popliteal height	50	44.40
Hip width	50	33.35

Table 6 presents the 50th percentile values for the three anthropometric dimensions used in this study. The results indicate that the workers had a bench length of 43.65 cm, a bench height of 44.40 cm, and a bench width of 33.35 cm (Fig. 9).

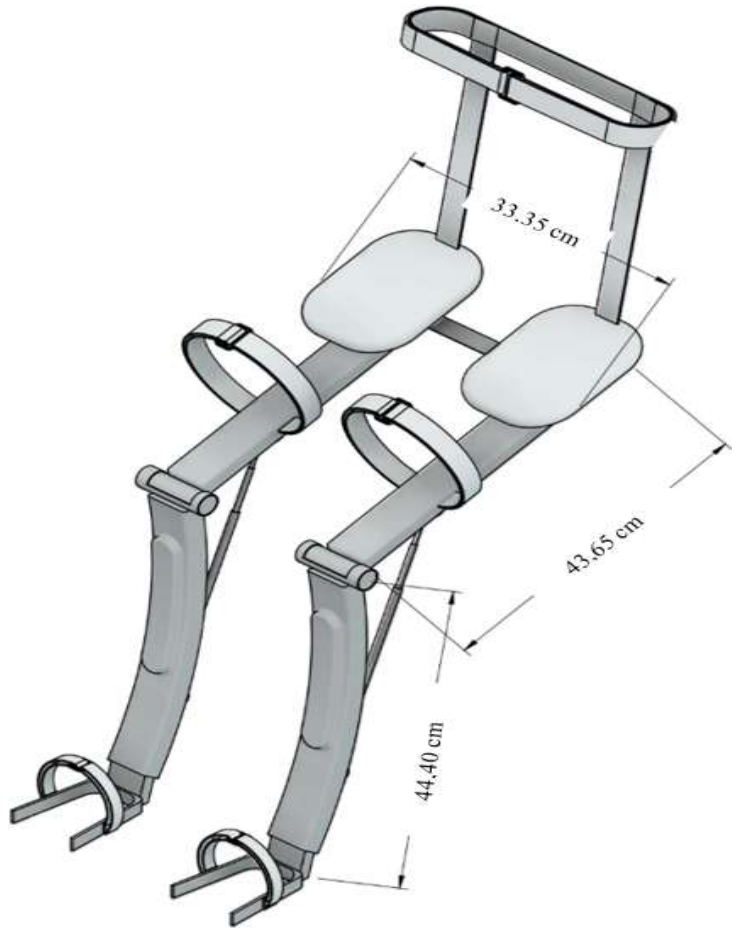


Fig. 9. Ergonomic sit-stand support device.

Fig. 9 shows an ergonomic sit-stand support device specifically designed for packaging workers in the rubber industry. The main structural dimensions of this device are based on the 50th percentile anthropometric values of the operators, namely a popliteal-buttock length of 43.65 cm, a popliteal height of 44.40 cm, and a hip width of 33.35 cm. These values are used to determine the thigh support length, the vertical distance between the footrest and the seating surface, and the width of the upper frame. This device enables a stable sit-stand posture, reduces lower-limb fatigue, and improves comfort during prolonged packaging activities.

3.2.5 Kansei engineering

The Kansei Engineering method in this study aims to analyze workers' responses to the ergonomic aids created. In the Kansei Engineering method, the first step is to determine the Kansei words used as questionnaire attributes. In this study, nine Kansei words were used, and each Kansei word was tested for data validity Table 7.

Table 7 shows that the kansei words from the validity test yielded 9 valid kansei words, where the calculated r value was > the r value in the table; for example, 0.417 > 0.374. The criteria used to determine the level of reliability are the Cronbach's alpha level, with 9 attributes (Table 8).

Table 8 is declared reliable if $r\alpha > r\text{table}$. In this case, the r table value is 0.374. The r alpha value can be seen as (P1 0.791),

(P2 0.789), (P3 0.793), (P4 0.718), (P5 0.707), (P6 0.762), (P7 0.729), (P8 0.749), and (P9 0.745). This value is greater than the r table.

Table 7. Validity test Kansei Engineering

Kansei word	r value	r table	Information
Comfortable to use	0.417	0.374	Valid
Safe to use	0.416	0.374	Valid
The tool is unique	0.407	0.374	Valid
The material is light	0.788	0.374	Valid
The tool is light	0.850	0.374	Valid
The tool is easy to use and move	0.545	0.374	Valid
The design is simple	0.741	0.374	Valid
Flexible when used	0.632	0.374	Valid
Very functional to use while working	0.657	0.374	Valid

Table 8. Reliability test

Attributes	Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Cronbach's alpha if item deleted
P01	34.1333	5.430	0.229	0.791
P02	34.1000	5.403	0.244	0.789
P03	34.1667	5.454	0.218	0.793
P04	34.1667	4.489	0.688	0.718
P05	34.4000	4.524	0.786	0.707
P06	34.6333	5.275	0.412	0.762
P07	34.3667	4.723	0.637	0.729
P08	34.6667	5.195	0.530	0.749
P09	34.7000	5.045	0.545	0.745

3.2.6 Determining Kansei word components

This analysis uses SPSS Statistics 23 software and obtained 3 matrix components from 9 collected Kansei words. In the matrix components, 3 components can be seen that have been formed, determined from the highest value greater than ≤ 0.05 , which has the highest value and is formed, namely comfortable when used, safe to use. The tool is unique, as shown in Table 9.

Table 9. New factor component matrix

	Component		
	1	2	3
Comfortable to use		0.919	
Safe to use		0.912	
The tool is unique		0.557	
The material is light	0.643		
The tool is light	0.792		
The tool is easy to use and move	0.777		
The design is simple	0.630		
Flexible when used	0.845		
Very functional to use while working	0.825		

Table 9 shows the determination of new components, where a Kansei word is considered valid if its value is greater than 0.05. In this component, there are variables with values less than 0.05 that do not belong to any component. Therefore, factor analysis must be repeated, and factor rotation should be performed using the varimax method or another appropriate method until no component contains values ≤ 0.05 . Factor rotation using the varimax method with Kaiser normalization was conducted, resulting in a new grouping of factors formed in accordance with the appropriate extraction method criteria. The results of the determination of the new components or factors are in Table 10.

Table 10 shows that the factor rotation yields three new components: (1) component one, operational efficiency, consists of three Kansei words: the tool is easy to use and maneuver, flexible in use, and highly functional for work; (2) component two, perception or satisfaction, consists of four Kansei words: the tool is unique, the material is lightweight, the tool is lightweight and the

design is simple; (3) component three, information comprehension, consists of two Kansei words: comfortable in use and safe to use.

Table 10. Rotated component matrix

	Rotated component matrix		
	Component		
	1	2	3
Comfortable to use			0.940
Safe to use			0.935
The tool is unique		0.438	
The material is light		0.503	0.484
The tool is light	0.911		
The tool is easy to use and move	0.913		
The design is simple	0.920		
Flexible when used	0.951		
Very functional to use while working		0.938	

Extraction method: principal component analysis.
 Rotation method: varimax with Kaiser normalization.^a
 a. Rotation converged in 4 iterations.

3.2.7 Determination of Kansei items and categories

The results of the ergonomic sit-stand support device aids show that elements can be grouped into three main types: material, design, and form. Each of these elements consists of two categories, as shown in Table 11.

Table 11. Tool elements and categories

Element	Categories
Material	Plat stainless Webbing canvas
Design	Unique Character
Form	Flexible Long

Table 11 shows the specifications of the ergonomic tool design based on worker preferences, as: (1) the tool is made of a stainless steel plate, which serves as the main frame due to its strength, rust resistance, and easy cleaning. It is ideal for work environments requiring high durability. This material ensures safety and makes the tool lightweight. Meanwhile, canvas webbing is a thick fabric with high tensile and friction resistance, providing comfort during use; (2) the tool's design has a distinctive character. This tool is expected to increase work motivation, and its uniqueness reflects its simple design; (3) the tool is flexible and long, a shape that conforms to Kansei vocabulary, giving the impression of being easy to use and maneuver, flexible in use, and highly functional (Fig 10).



Fig. 10. Ergonomic sit-stand support prototype.

Fig. 10 shows an ergonomic sit-stand support prototype designed to assist workers when lifting and carrying loads, such as during industrial packing processes.

4 Conclusions

Based on the results and discussion, the conclusions can be drawn: (1) the greatest pain complaints were found among workers at the packing station, with a score of 80% at the high level; (2) the ergonomic design of the assistive device used was 43.65 cm long, 44.40 cm high, and 33.35 cm wide; (3) the ergonomic design of the assistive device was appropriate and well-accepted by workers, with strong potential to reduce the risk of MSDs, with the highest scores being comfortable to use (0.940), safe to use (0.935), lightweight (0.911), easy to use and move (0.913), simple design (0.920), flexible use (0.951), and highly functional in the workplace (0.938).

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