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Development of work tool design in household sewing businesses based on participatory ergonomics principles

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Abstract

Household sewing businesses as a small industry still use simple tools, especially work chairs. The work chair used does not suit the worker's posture. This has the impact of making workers less comfortable in carrying out sewing business. Apart from that, it causes musculoskeletal complaints in workers such as back pain. Work chair models that do not suit the worker's posture are often referred to as non-ergonomic work tools. This can be overcome with participatory ergonomic applications, namely the role of workers as users. The method uses anthropometric data, namely measuring the dimensions of the worker's body according to the tools used. Anthropometric data from workers is then calculated using percentiles, and the results are applied to the dimensions of work equipment, in this study, in the form of work chairs. By using Percentiles 5 (P5), 50 (P50), and 95 (P95), the dimensions of the new work chair are obtained. Minimum chair height 36.76 cm and maximum height 40.34, cushion or seat length 43.2 cm, backrest width 45.26 cm, cushion or seat width 45.17 cm, backrest height 51.40 cm, backrest height arm 15.89 cm, armrest width 9.88 cm, and armrest length 27.60 cm. The design of work chairs is based on anthropometric data according to workers' needs and has an impact on comfort when used at work.

Keywords: Work chair design, sewing, anthropometry, participatory, ergonomics

1. Introduction

Sewing as a side business to increase income can be done at home. This business can also help develop the small industrial sector and add value to society. On the other hand, sewing requires skill, precision, and work tools that suit the worker's needs. Apart from sewing machines, something that allows workers to work comfortably is a work chair. Most household sewing businesses and small industries still use makeshift work chairs. This creates an unnatural working posture and is contrary to ergonomic principles. To overcome this, input or participation from workers as users is essential regarding work equipment needs.

Ergonomics, a science that harmonizes work tools with workers, aims to ensure that the work is effective, comfortable, safe, healthy, and efficient. Households and small businesses require the application of ergonomic principles so that workers are comfortable at work so that productivity and occupational health can be increased. Worker participation through input regarding the work carried out is essential. Lighter physical workload, manual tasks that can be redesigned more effectively, and more accessible procurement of work tools are benefits of implementing a participatory approach [1, 2]. Ergonomic applications are essential so workers do not experience work disturbances such as additional workload, fatigue, and musculoskeletal complaints due to unnatural working postures. Unnatural working postures cause increased levels of fatigue, musculoskeletal complaints, and the risk of muscle injury, which results in additional workload, health costs, and reduced productivity [3, 4, 5, 6].

Ergonomic application through participatory methods to harmonize work tools with workers as users. Several studies on the application of participatory ergonomics to small farmers through the use of anthropometric data of workers designing work tools such as metal liquid pouring tools, mangosteen harvesters, drying chambers, solar energy hybrid dryers, show that the level of musculoskeletal complaints has decreased and productivity has increased [7, 8, 9, 10]. The most effective way to create more human-centered jobs and reduce the incidence of work-related musculoskeletal disorders and risks to safety and health is to redesign manual tasks through the principles of participatory ergonomics. [11, 12, 13]. In the IEA, it is explained that ergonomics (or human factors) is a scientific discipline that deals with understanding interactions between humans and other elements of a system and a profession that applies principles, theories, methods, and data to design to optimize overall system performance and human welfare [14]. Ergonomics and human factors are a scientific discipline that optimizes overall system performance and human well-being simultaneously in different work contexts [15]. Sewing work using a simple work chair is often done by people in household businesses. This affects the working posture of workers less naturally and causes discomfort at work. As shown in Figure 1 regarding work chairs used in sewing businesses.

Fig 1: Types of work chairs in a sewing business

Based on initial observations made at one of the household sewing businesses, it was found that workers who used work tools, as in Figure 1, experienced low back pain. Ergonomically, this is one of the musculoskeletal complaints experienced by workers. Musculoskeletal complaints often occur in workers if their work posture is unnatural due to the work tools being used that are not ergonomic. Complaints among workers, such as pain in the legs, arms, and hands and tension in the neck, wrist, waist, and back, are caused by manual work. This condition influences the decline in performance so that work productivity decreases [16]. An increased risk of work injury occurs due to exposure to risk factors for musculoskeletal disorders [17]. The work tools used in the job must produce a natural working posture for the worker. Work must be adapted to human abilities and limitations to improve the results achieved, which is the principle of fitting the task to the man in ergonomics [18]. There is an increased risk of injury to the musculoskeletal area due to incorrect and unusual work postures [19].

Based on the above, improvements were made to work chairs for sewing businesses based on an ergonomic review, namely, worker participation. This is by recommendations from the Occupational Safety and Health Administration (OSHA) to prevent sources of disease by carrying out ergonomic measures, namely technical engineering, such as the design of workstations and work tools. From the participatory ergonomic application, it is hoped that workers can do their work effectively, comfortably, safely, healthily, and efficiently. So that occupational safety and health is maintained, as well as increasing productivity.

2. Materials and methods

The research was conducted in a convection business with five employees. The design of work tools is only carried out on the worker's chair. The chair design is based on anthropometric data of workers doing sewing work. Anthropometric data measurements are carried out according to requirements for creating worker chairs. Work disruptions and accidents can be reduced by using anthropometric databases to design appropriate workplaces and equipment [20]. Worker participation approach through measuring anthropometric data as an application of ergonomic principles. This is an effort to reduce the occurrence of musculoskeletal complaints in workers.

The worker measurement tool uses the Nordic Body Maps (NBM) questionnaire, percentile table, and steel meter. Materials for making chairs include a welding machine, grinder, drill, hollow iron measuring 4 cm x 4 cm x 1.8 cm, hollow iron measuring 4 cm x 2 cm x 1.8 cm, 2 cm multiplex, pile bolts, and clamps bicycle. The worker's anthropometric data is calculated using percentiles to apply to the dimensions of the work chair. Anthropometric data based on the worker's sitting position includes popliteal height (A), distance between the popliteal buttocks (B), shoulder width (C), hip width (D), shoulder height (E), elbow height (F), hand width, and length. Hand as presented in Figure 2. Anthropometric data is used for various purposes, such as workplace design, work facilities, and product design, to obtain appropriate measurements based on the dimensions of human body parts that will be used to create work tools [21].

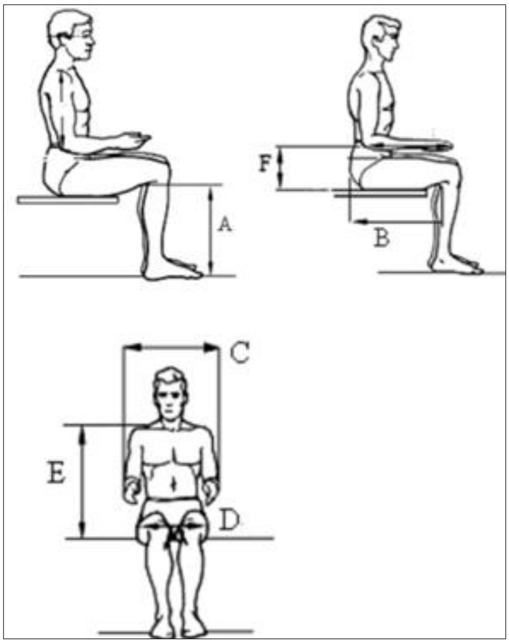

Fig 2: Measurement of anthropometric data of workers in a sitting position

The flow of anthropometric data in designing a work chair is determining body dimensions, determining the user population, calculating percentile values for each predetermined body dimension, and applying tool design. This study used the 5th, 50th, and 95th percentiles. Percentiles were calculated based on Equations 1 to 3.

$$P5 = \overline{X} - (1.65 \text{ x } \delta) \quad (1)$$

$$P50 = \overline{X} \quad (2)$$

$$P95 = X + (1.65 \text{ x } \delta) \quad (3)$$

P5 is the 5th percentile, P50 is the 50th percentile, P95 is the 95th percentile, $\overline{X}$ is the average value of the data, X is the data, and δ is the standard deviation. Standard deviation is calculated using Equation 4.

$$\delta = \sqrt{\frac{\sum_{i=1}^{n}(X_i - \overline{X})}{n-1}} \quad (4)$$

n is the number of samples and X_i shows samples 1, 2, and so on.

3. Results and discussions

The results of measuring anthropometric data of workers engaged in sewing business and percentile applications can be shown in Table 1.

Table 1: Chair dimensions based on worker anthropometric data

No	Data type	P 5 (cm)	P 50 (cm)	P 95 (cm)	Description
1.	Popliteal height	36.76		40.34	chair height
2.	Popliteal buttock distance		43.20		seat length
3.	Shoulder width		45.26		backrest width
4.	Hip width			45.17	seat width
5.	Shoulder height		51.40		backrest height
6.	Elbow height	15.89		21.59	armrest height
7.	Hand width			9.88	armrest width
8.	Hand length		27.60		armrest length

The application of participatory ergonomics produced results as shown in Table 1; namely, chair height was measured from the worker's popliteal height using the 5th percentile (P5) and 95th percentile (P95). This is done so that the chair can be used by workers with an adjustable height; namely, the lowest dimension is 36.76 cm (P5), and the highest is 40.34 cm (P95). Applying P5 and P95 to chair heights allows workers to adjust their work posture as desired, thereby providing comfort. The 5th and 95th percentile applications accommodate a fairly wide range of populations because the design can be adjusted based on user needs [22]. The 50th percentile calculates the distance between the popliteal buttocks so workers with short or long legs can reach the backrest. This dimension is used to design the length of the cushion or seat and has dimensions of 43.20 cm. The height and length of the cushion or seat are as shown in Figure 3.

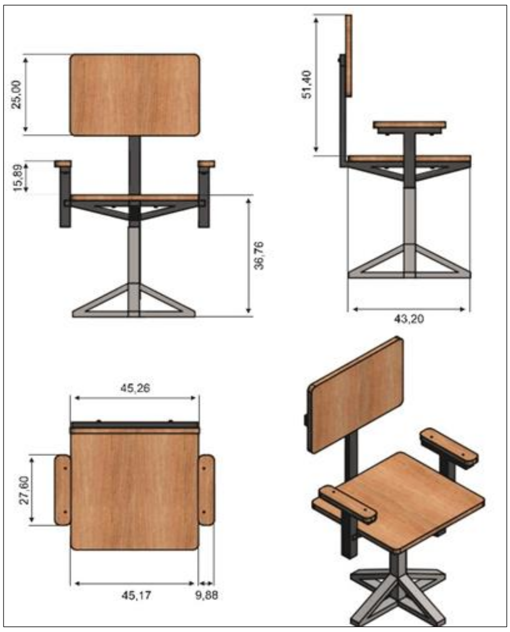

Fig 3: Chair design for a sewing business based on worker anthropometric data

Based on Figure 3, it can also be shown regarding the width of the backrest, width of the cushion or seat, height of the backrest, height of the armrests, width of the armrests, and length of the armrests. Each has dimensions in sequence, namely 45.26 cm, 45.17 cm, 51.40 cm, 15.89 cm, 9.88 cm, and 27.60 cm. The use of percentile variations in designs, such as in Figure 3, so that the work chair suits the worker's body as the user. Using the 95th percentile (P95) indicates that 95% of users will be at or below that measure. The 95th percentile indicates the largest user size. The use of percentile 5 (P5) indicates the smallest user size. Percentile 50 (P50) indicates that the work tool design can be used for various body sizes of users or workers. The work chair design, as in Figure 3, results from participation from sewing workers, namely through anthropometric data from these workers. With the new design resulting from the application of participatory ergonomics, it is hoped that it will provide comfort to workers as users. The design shown in Figure 3 can replace the worker's chair as in Figure 1. This will change the working posture from an unnatural one to an ergonomic one. Decreased productivity as a result of the emergence of musculoskeletal complaints due to unergonomic work postures [23]. With the application of participatory ergonomics, harmony is achieved between humans or workers and work stations and tools.

4. Conclusion

Application of participatory ergonomic principles as an effort to include workers as users of a work tool design. Work tools are designed to produce harmony with the user. This impacts natural working posture and is often referred to as ergonomic working posture. User participation through anthropometric data, namely the user's body dimensions, which are adjusted to the work tools used. From the worker's anthropometric data, percentiles are then applied to obtain the measurements of the ergonomic work tools the worker uses. Ergonomic work tools can reduce musculoskeletal complaints, fatigue, and increase comfort and productivity.

5. Compliance with ethical standards

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6. Disclosure of conflict of interest

The authors declare no conflict of interest.

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