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Working Station Model Based on Mathematic Model of Anthropometry for Embroidery Workers

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Abstract

BACKGROUND: Often, the embroidery craftsmen do their work by ignoring the unbalance of their anthropometric size with the size of the tables and chairs used. This condition causes not ergonomic sitting position when they are working that will trigger variety of subjective complaints of craftsmen, especially in muscles and joints.

AIM: Conducted development research using 4D model (devine, design, develop, and disseminate) based on anthropometry size to build chair and table as more ergonomic work station for embroidery craftsmen.

METHODS: The first three stages are done by analyzing the compatibility of anthropometry of the body with the size of work station used by mathematical approach and laboratory scale test. The acceptance level of craftsmen on the prototype of work station model measures by technology accepted model that conducted on a public scale.

RESULTS: The result of this research is the establishment of more ergonomic prototype of work station model for embroidery craftsmen and based on the result of public scale examination of 180 embroidered craftsmen showed that 63% of respondents stated less subjective complaints of muscle and joint disorders at the shoulders, 71% subjective complaints of muscle and joint disorders in the upper arm, and respondents stated reduced subjective complaints of muscle and joint disorders in the 56% after using a new work station model.

CONCLUSION: However, it is still necessary to make improvements to the prototype of the work station model to be more ergonomic and to suppress the emergence of subjective complaints of muscle disorders and joints of embroidery craftsmen.

Introduction

Embroidery craft is one of the superior products from Tasikmalaya which is famous and has a wide market share. Most of the embroidery crafts in Tasikmalaya are in the form of home industries, absorbing a large number of workers, especially those of the productive age [1]. Based on data from the Department of Industry in 2013, the center of Tasikmalaya embroidery industry spreads in 24 villages from 12 subdistricts. This industry is able to absorb the workforce of 31,765 people with 17,000 details coming from Tasikmalaya City and the rest coming from Tasikmalaya Regency. The workers are spread over 2708 business units.

Kawalu subdistrict is listed as the region that has the most entrepreneur of handicraft business, namely, 87.7% of total embroidery crafters in Tasik. The region that has the largest business unit in Kecamatan Kawalu is Tegalsari Village which produces high-quality embroidery such as Turatex, Purnama, Ciwulan, Haryati, and Flower Tanjung. Its total production reaches 7.2 million pieces per year with its production value has reached the figure above Rp. 500 billion [2].

The working station currently used by most craftsmen is a sewing machine placed on a flat table with a non-ergonomic wooden bench [3]. The wooden bench in question is a separate part of the sewing machine table and is not equipped with a backrest or armrest and has a fairly hard seat [4]. This state of work station forces craftsmen to form a variety of working angles that do not fit comfortably for a sitting position [5].

The design of desks and chairs and other work stations should be tailored to the anthropometry size of the user's body [6]. According to Widana (2018), anthropometry is the measurement of body dimensions or other physical body characteristics that are relevant to the design of something that people wear [7]. On the other hand, Mularidaran (2019) explains that an ergonomic work station will encourage users to adapt, resulting in the emergence of erroneous working positions [8]. The position will be done continuously and become a bad habit (bad habit) of someone during activity [9].

The attitude of craftsmen and the work station model that is uncomfortable and safe for the body often creates various problems for the body. Problems experienced by the craftsmen related to the physiological adaptation of the body that has reached the maximum limit so that there is a change of work system of the body forced to adjust the conditions of work station and work organization. If this situation

continues, it will appear various physical complaints, especially the emergence of pain in muscles and joints.

Research Methods

Research activity

This research was conducted for 3 years in 3 stages. The first stage carried out in the first year is collecting data and information either from the owner's embroidery company or from embroidery workers as a prototype design material or a more ergonomic workstation model. The second stage carried out in the second year was the improvement of the model work station through laboratory experiments and the implementation of the work station model at the embroidery company in Kawalu sub-district, Tasikmalaya City. The third stage carried out in the third year is acceptance analysis using a modified technology acceptance model (TAM) sequentially used to determine the level of user acceptance of the model of work station created.

Methods

The type of research is development research with 4D model (devine, design, develop, and disseminate). The research stages are as follows:

a. The devine stage is done through direct observation of the job execution process to obtain data about the anthropometry size of the craftsman body, the size of the work station used and the subjective complaints of muscle and joint disorders experienced. This process is done with the approach method 5W + 1H consisting of the questions What, Who, When, Why, Where, and How.
b. Design stage is done by changing the various body sizes and the size of the work station into several angle sizes when working position. Furthermore, the angle of work position associated with the emergence of subjective complaints of muscle and joint disorders in craftsmen is analyzed. From the analysis result, it is made adjustment of design of work station model in the form of sketch of work station model able to form ideal working position angle.
c. Develop stage is done by building a work station for embroidery craftsmen based on sketches of designs that have been made
d. The disseminate stage is done through TAM approach to measure public acceptance of technological innovation. This stage is done through two ways of testing are:
   1. Laboratory scale test to analyze work station model based on ergonomic principles involving 15 craftsmen as comparison. The results of this stage allow for a design change from the work station that has been created.
   2. A public scale test involving a larger number of craftsmen to measure the level of public acceptability based on the safety level and the artist's sense of comfort associated with the subjective complaints of muscle and joint disorders they experience.

Results

The devine stage

Result of analysis of validity and reliability of indicator to latent variable of anthropometry measure using CFA shows that there are 10 of 12 body size that can be used as parameter to represent anthropometry variable of craftsman, as shown in Table 1.

Table 1: Results of confirmatory analysis of body size parameters as anthropometric indicators

Body size	Rho value	p value
Standing height	0.113	0.320
Long range	0.721	0.000
Shoulder height	0.174	0.298
Shoulder wide	0.492	0.010
Buttock wide	0.773	0.000
Sitting height	0.756	0.000
Sitting elbow height	0.751	0.000
Sitting buttock height	0.862	0.000
Sitting knee height	0.771	0.000
Sitting upper leg length	0.458	0.008
Sitting lower leg length	0.442	0.007
Range of eyes to object	0.762	0.000

The result of the analysis on the measurement of the work station both table and chair using CFA shows that some parameters that become indicator for ergonomics of work station are shown in Table 2.

Table 2: Results of confirmatory analysis of table-chair parameter size as an ergonomic indicator of work station

Work station size	Rho value	p value
Table height	0.713	0.000
Table wide	0.274	0.041
Table length	0.892	0.000
Foot support height	0.473	0.003
Chair height	0.872	0.000
Chair wide	0.673	0.000
Seat height	0.776	0.000
Seat mat	0.795	0.000

Both measurements are then converted into angles formed by the body of the craftsmen while their work. The angle becomes an indicator of anthropometrical balance of the craftsmen body with the ergonomics of the table and chair as the working station their used. Table 3 shows the magnitude of the angle formed when the embroidery craftsman works.

Table 3: Results of confirmatory analysis of the corner of the embroidery artist when working

Body angel parameter	Angel size (°)	*Rho* value	p value
Angles formed between the toes with the soles of the feet	100–105	0.172	0.253
Angles formed between the sole of the foot with the lower leg	90–110	0.092	0.200
Angle formed between the lower leg with the upper leg	90–110	0.080	0.187
Angles formed between the upper legs with the buttocks	60–80	0.758	0.000
Angles formed between the back with the neck	155–180	0.443	0.048
Angles formed between the neck with the head	155–180	0.401	0.037
Angle that is formed upper arm with shoulder	25–90	0.728	0.000
Angles formed between the upper arm and the forearm	110–160	0.625	0.000
Angle formed between the forearm with the palm of the hand	165–180	0.023	0.183
Angles formed between the palms of the hands with the fingers of the hand	165–180	0.018	0.200

Furthermore, the results of confirmatory analysis of the appearance of subjective complaints of muscle and joint disorders in the embroidery craftsmen are shown in Table 4.

Table 4 shows that significant subjective complaints of muscle and joint disorders occur only in the body of the neck, shoulders, armpits, back, waist, and buttocks. The priority of handling based on the strength of the relationship. The body of embroidery craftsmen on the armpit, waist, and buttocks is the most risk parts of the body affected muscle and joint disorders.

Table 4: Results of subjective complaints confirmation complaints of muscle and joint disorders

Work station size	Rho value	p value
Complaints pain in the head	0.171	0.200
Complaints pain in the neck	0.475	0.041
Complaints pain in shoulders	0.595	0.016
Complaints pain in the armpits	0.683	0.000
Complaints pain in the arm section	0.422	0.159
Complaints pain in the wrist	0.476	0.162
Complaints pain in the hinges of hands	0.092	0.428
Complaints pain in the back	0.485	0.026
Complaints pain in the waist	0.682	0.000
Complaints Pain in the buttocks	0.667	0.000
Complaints pain in knee section	0.418	0.148
Complaints pain in the ankle	0.182	0.200
Complaints pain in the toes of the feet	0.081	0.420

Further data processing using path analysis to anthropometry data of craftsmen body, table and chair size (work station), and subjective complaints of muscle and joint disorders indicate that there are several anthropometry parameters of craftsmen body and work station size that can be used as an indicator of cause the appearance of subjective complaints of muscle and joint disorders in the embroidery craftsmen (Table 5).

Table 5: Result of path analysis of interlatent liaison relationships

S. No	Model of relationships	Rho value	p value
1.	Anthropometric size→Subjective complaints	0.628	0.000
2.	Ergonomic work station→Subjective complaints	0.841	0.000

The result of the analysis can then be formulated the relationship between anthropometry size of craftsmen and an ergonomic work station with the emergence of subjective complaints as muscle and joint disorders in embroidery craftsmen by mathematically formulation:

$$SC = 0.68\ AS + 0.84\ EWS$$

Where, SC is subjective complaint, AS is anthropometric size, and EWS is ergonomic work station.

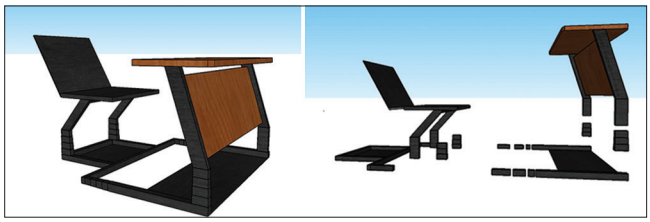

Figure 1: The design of work station for embroidery craftsmen

The design stage

The next stage is to determine the design of table and chair that is recommended to be used as work station by embroidery craftsmen. Work station is made based on the results of the analysis in the previous stage by considering the amount of angles that become indicators of the ergonomic equilibrium of working station.

The design of the table and chair should be adjusted to the anthropometric size of the craftsmen who have different quantities. Therefore, it is necessary to made the flexibility of chair height and the flexibility of distance of the table with the chair to occur an ergonomic balance between the craftsmen with their work station and the emergence of comfort when their used (Figure 1).

Table and chair which made as a work station is tied each other or not separate as common embroidery work station. However, there are regulators to change the position of the chair forward and back so that the worker can easily adjust the distance between the table with the seat as comfortable as possible which implies the formation of safe angles on the buttocks, waist, and knees (Figures 2-4).

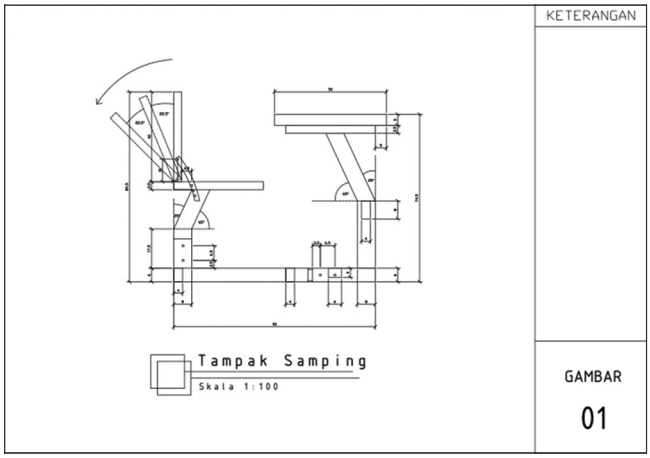

Figure 2: Engineering sketch, side view of working station for embroidery craftsman

In addition, the height of chairs can also be up-down so that it can adjust to the height of each worker sitting. This also implies the formation of an ideal angle on the neck, back, knees, ankles, armpits, and shoulders. Therefore, researchers are trying to make chairs that can be adjusted at an angle so that craftsmen can lean back while working (Figures 5 and 6).

The last thing to take into consideration is the foam laminated by the fabric on the seat mat and the chair back so that the worker can sit comfortably. The design of work stations made from metal material so it is durable and easily formed (Figures 7 and 8).

The design is subsequently converted into a technical or engineering sketch to facilitate the creation of a more ergonomic work station.

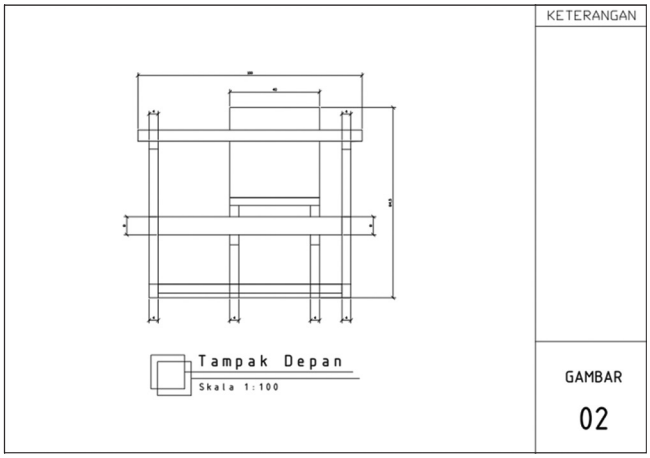

Figure 3: Engineering sketch, front view working station for embroidery craftsman

The develop stage

Stage of the development of work station done after reviewing result of mathematical analysis which subsequently poured in design of work station. A working station prototype is made available to each craftsman with different anthropometric sizes. Forms of work station can be described into several parts, among others:

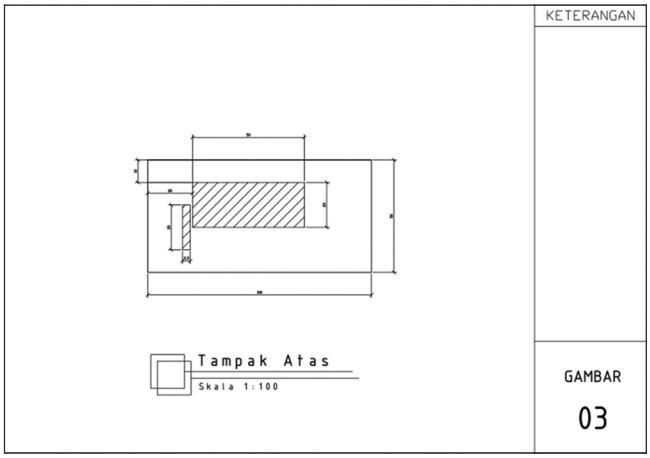

Figure 4: Sketch technique, top view work station for embroidery craftsman

Figure 5: Structure of frame embroidery working stations

1. The basic frame of metal
2. Table mat made of melamine plywood material
3. Seats for backrest and pads made of fabric and foam.

Discussion

Results of research show that the daily work position of the craftsmen is form an angle position that tends not to be ergonomic. This is due to an imbalance between the size of the worker's anthropometry and the size of the working station used. The angle that is formed tends to be taper or <90°. The angles that should be concerning when their in sitting position are as follows: (1) The angle formed between thighs with the buttocks, (2) the angle formed by the upper arm with the shoulder, and (3) the angle formed between the upper arm and the forearm. This is in line with the opinion of Blackler (2018) explains that the angle

Figure 6: Embroidery working table matter

Figure 7: Seat backrest and pad of embroidery working stations

formed in the sitting position is strongly influenced by the size of the length of the legs both up and down with seat height [10]. When the worker sits there is an angle formed between the chest and the height of the work table. it depends on the height of the worker.

Taper angle will make the muscle clamped blood vessels that exist around it so that the lumen of blood vessels becomes narrower and blood flow becomes slower. This condition makes the supply of nutrients and oxygen decreased. The muscles that are actively working will change the energy system used slowly from aerobic to aerobic. Mul (2015) explains that it can happen when the muscle lacks oxygen supply and the energy source used glucose as an ATP provider [11]. This simple sugar molecule will be transformed through a series of enzymatic chemical reactions in the muscle cytoplasm into pyruvic acid. Furthermore, the pyruvic acid molecule will be altered according to the oxygen condition of the muscle. If the level of oxygen deprivation in the muscle is not too high, then pyruvate can be converted back into glucose and glycogen, but if the condition of oxygen deprivation in the muscle lasts long, then the pyruvic acid will be converted into lactic acid [12]. Therefore, continuous muscle contraction over a long period of time can lead to increased production of lactic acid that appears as a by-product of anaerobic muscle energy usage.

Figure 8: Prototype working stations embroidery

Produced lactic acid will enter and flow inside the blood vessels [13], [14].

Joyner (2015) explains that when blood lactate acid concentration increases with continuous muscle contraction over long periods then blood viscosity will increase and blood flow becomes slower, especially in joints [15]. Lactic acid that has a high enough density is difficult to escape in the joints, resulting in accumulation of lactic acid in the joints that will cause pain [16], [17]. This is in line with the results of research showing that the emergence of subjective complaints of muscle and joint disorders experienced by the craftsmen more felt in the armpit, waist, and buttocks that are part of the body with a pointed angle as they work.

Therefore, it is appropriate to construct a working model for embroidery craftsmen aim to improving these pointed angles by modifying their work station models which considering an ergonomic equilibrium.

Conclusions and Suggestion

Conclusions

1. Subjective complaints of muscle and joint disorders result from an imbalance between the anthropometric size of the embroidery craftsmen body and the size of the work station that they use. The contribution of anthropometric size of craftsmen and the size of work station to the occurrence of subjective complaints of muscle and joint disorders, respectively, by 68% and 84%.
2. It should be need to make a model of work station for embroidery craftsmen by considering the size of their anthropometry and the size of their work station that forms a more gentle seating angle, especially on the shoulders, armpits, waist, and buttocks.

Suggestion

It should be needs to be socialized to embroidery craftsmen and a kind of workers that work with similar work station and similar work position to pay more attention to the balance of their body size with the size of their work station such as the size of chairs and tables used.

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