Musculoskeletal analysis of a stand screen-printing table design using the nordic body map questionnaire

Y. Herlambang

Telkom University, Bandung, Indonesia

ABSTRACT: In the screen-printing process the factor of dependence on operators is very high. However, there are a variety of problems such as decreased body resistance or fatigue to potential musculoskeletal injuries or complaints that can make the process difficult. The research method used is the ergonomics approach using the Checklist measurement in the form of the Nordic Body Map Questionnaire to interpret musculoskeletal complaints. The data obtained will be used for the preparation of formulas that are suitable for the development of a new screen-printing table design that is in accordance with the characteristics of small industries and has better comfort with low levels of physical complaints. The most common complaints were in the lower body region, such as calves and ankles due to frequent standing and walking in the printing process. Development of a new work equipment design is needed by considering the unbalanced load reduction on the operator's body, and the development of the temporary transport system when the operator moves from the work point.

Keywords: printing table, musculoskeletal, Nordic body map questionnaire, stand work posture

1 INTRODUCTION

Screen-printing techniques in Indonesia have been widely used by the public (Bandi 2004) including various creative industries such as the fashion industry, publishing and printing, advertising, crafts, and design. This research is expected to explore the role of the operator in the production process that can affect the level of productivity. The design has advantages in the simplicity and visibility of the work system, however the shortcomings surround a guide system that does not have good accuracy, a calibration and registration process that still relies on operator feeling, low efficiency of transportation distance, set-up time efficiency, and efficient use of space. Fatigue, potential musculoskeletal injuries, or physical complaints are all possible negative characteristics of using screen-printing equipment.

The method used tried to understand the role of the operator in the production process that can affect the level of productivity and kind of work posture and body parts that interact when using an existing design. This was analyzed using the ergonomics study approach with the Nordic Body Map to assess which parts of the body have complaints when using the existing design so that later designs would have a low level of human error and can be mastered easily, quickly, and well by other screen-printing operators. The data to be obtained is whether the design of this standing screen-printing operator is ergonomic enough so that it can increase productivity or would it illuminate the primary physical problems that inhibit productivity.

2 METHOD

2.1 *Research method*

The research to be conducted is qualitative research. Qualitative research is a method for exploring and understanding the meaning of individuals or groups of people ascribed to social or humanitarian

problems. This process requires important efforts, such as asking questions to collect specific data from participants, analyzing data inductively, and interpreting the meaning of the data obtained. The results of this study are usually flexible (Creswell 2010).

The qualitative research strategy to be used is the case study approach: the research strategy carefully investigates a program, event, activity, process, or group of individuals. Cases are limited by time and activity, and researchers gather complete information using various data collection procedures based on a predetermined time (Stake in Creswell 2010).

The objective type of this research is explanatory, trying to explain the effect the different screen-printing table designs used by operators had on the level of fatigue or physical complaints. It is expected that this research will explain the effectiveness of screen-printing design when used by several operators with different competencies and different work pose habits, related to musculoskeletal complaints and the quality of printing results. The approach taken is to use an experiment with a quasi-experimental design type, where the control group in the form of non-equivalent is determined based on the competence of the operator and puts forward a screen-printing table design factor.

2.2 *Nordic Body Map*

The Nordic Body Map is a tool in the form of a questionnaire that is most often used to find discomfort or pain in the body (Kroemer et al. 2001). This questionnaire was developed by Kourinka in 1987, then in 1992 Dickinson modified it. Respondents who filled out the questionnaire were asked to give a sign of the presence or absence of disturbance in the body area (Kroemer et al. 2001). The Nordic Body Map is intended to find out in more detail the parts of the body that experience interference or pain when working. Although this questionnaire is subjective (Santoso et al. 2014), it is standardized and valid enough to be used.

2.3 *Posture of work*

Work pose is human posture when interacting with work tools/equipment. A good work pose is one that makes it possible to carry out work effectively and with minimal muscle effort. The posture of not doing movement or work is standing, lying down, squatting, and sitting (Pheasant 1991). Workers' positions and work poses when carrying out activities in the workplace affect the physiological response of the workers. An unnatural/physiological work pose is the cause of various disorders in the musculoskeletal system (Manuaba 1998). To overcome these problems, it is necessary to know the criteria for an ideal work pose in carrying out an activity or work, such as muscles that work statically or very little (Pheasant 1991; Palilingan et al. 2012b). In carrying out tasks, using one's hands is carried out easily and naturally. Changing or dynamic work poses are better than relaxed static work poses, and a relaxed static work pose is better than a tense static work pose.

According to Pheasant (1991), there are seven basic principles in overcoming posture while working: prevent forward inclination of the neck and head; prevent forward inclination in the body; prevent the use of upper limbs in a raised state; prevent body rotations in an asymmetrical (twisted) pose; joints should be in the range of one-third of the maximum movement; and if you use muscle power, it should be in a position that results in maximum strength.

2.4 *Data procedures*

The data collection process will be carried out in the following ways:

1. Literature Study
2. Interview
3. Observation of activities
4. Questionnaire

Data collection used a questionnaire and the interview method to obtain data about complaints when using a screen-printing table design and then measuring the dimensions of the product and the dimensions of the user's body with the anthropometric measurement method with sitting work attitude and reach of the hands and feet when in a standing position.

3 RESULT AND DISCUSSION

3.1 *Modular table design data*

The design of the modular table with a permanent guide system commonly called the banting table system is the development of a long table system. The printing table generally uses a wooden frame (the) with a length of 200 cm, width of 70 cm, and height of 80 cm, and table surface uses 6 mm plywood, equipped with a drying rack at the bottom table.

The base material is in the form of sheets of boards in the form of smaller pieces with a size of about 50 x 40; generally, the ratio is one sheet of wide board cut into 16 parts, with each board having a permanently attached guide system, having a thickness of boards 6–10 mm, and a gluing system to the base of the material using table glue or glue sticker.

This table has a screen registration system that is permanently installed with wood material attached to the rail as well as the frame which is also with wood material, the register system uses two earring screws that refer to the stopper with wooden frame rails as a support on the base of the material.

Figure 1. Modular table workstation.

3.2 *Modular table activity*

In the flow diagram map, it can be seen how the trajectory used in the production process uses a unit board table, the design of the fixed unit table requires the operator to walk from one material to the next and rotate again to do the next process, even though the distance is closer than the long table design.

3.3 *Nordic Body Map data*

Assessment of musculoskeletal complaints with the Nordic Body Map questionnaire four Likert scale. The assessment steps are as follows.

1. Preparation
2. Procedures

Figure 2. Modular table activity.

- a. Before starting the work each subject was given a Nordic Body Map questionnaire and subjects were asked to fill in themselves by putting grass marks (✓), on items that corresponded to the perceived complaint, then the results were collected.
- b. After finishing work, each subject was given a Nordic Body Map questionnaire again and the subjects were asked to fill in themselves by giving a sign of grass (✓), on items that corresponded to the perceived complaint, then the results were collected.
3. Recording
4. The data collection that is processed consists of six respondents using the Nordic Body Map technique, and the data obtained are arranged into a table to see the level of complaints. Explanation of the level of complaints is classified into 4 options: the body part that has been given the number does not hurt (choose 1), a little sick (choose 2), sick (choose 3), and very sick (choose 4).
5. The number of samples measured is as many as six people, the data taken is the data after the sample is finished working for one working day or eight working hours by using a standing desk.

If seen from Table 1, the average score for complaints is 76, with the highest score with a score of 84 originating from operator V, and the lowest score being 65 derived from operator W. There are 3 operators with a score above 80 and 3 with a below average score, so the range from lowest to highest is 17.

When viewed from the score per skeletal muscle obtained, an average score of the total per body part is 16.3, with the lowest score of 9 and with the highest score of 21, and there are 15 body parts with complaints above the average, namely: Left Upper Arm, Back, Right Upper Arm, Right Wrist, Right Hand, Left Thigh, Left Foot, Right Leg, Waist, Left Wrist, Right Thigh, Left Calf, Right Calf, Left Ankle, and Right Ankle.

Then if we filter again, there are 7 parts of the body with the highest score of 3 complaints, totaling a total of 20 and/or more, namely: Waist, Left Wrist, Right Thigh, Left Calf, Right Calf, Left Ankle, and Right Ankle.

Some of them have complaints about the thigh because they use thigh pressure toward the front in the print process to press the screen to hold the register, then complain of the waist due to standing too long for many processes, and some complain of the left wrist because of the registration process and the movement of their boards supporting the screen with the left hand dominant because the right hand holds the squeegee.

Table 1. Nordic body map data.

NO	OTOT SKELETAL	SKOR PER OPERATOR					
		Z	Y	X	W	V	U
0	Leher atas	2	3	2	2	3	3
1	Tengkuk	2	2	2	2	3	2
2	Bahu kiri	2	3	2	2	2	2
3	Bahu Kanan	2	3	2	2	2	2
4	Lengan Atas Kiri	3	3	3	2	3	3
5	Punggung	3	4	3	2	4	2
6	Lengan Atas Kanan	3	3	3	2	3	3
7	Pinggang	3	3	4	3	3	4
8	Pinggul	2	2	2	1	2	2
9	Pantat	1	2	2	1	2	2
10	Siku Kiri	2	2	1	1	2	1
11	Siku Kanan	2	2	1	1	2	1
12	Lengan Bawah Kiri	2	2	3	2	3	3
13	Lengan Bawah Kanan	2	2	3	2	3	3
14	Pergelangan Tangan Kiri	3	3	4	4	3	3
15	Pergelangan Tangan Kanan	3	3	3	3	3	3
16	Tangan Kiri	2	3	3	2	2	3
17	Tangan Kanan	3	3	3	2	3	3
18	Paha Kiri	3	3	3	3	4	3
19	Paha Kanan	4	3	3	4	4	3
20	Lutut Kiri	3	3	3	2	3	2
21	Lutut Kanan	3	3	3	2	3	2
22	Betis Kiri	3	4	4	3	4	3
23	Betis Kanan	3	4	4	3	4	3
24	Pergelangan Kaki Kiri	3	4	3	3	4	3
25	Pergelangan Kaki Kanan	3	4	3	3	4	3
26	Kaki Kiri	3	3	4	3	3	3
27	Kaki Kanan	3	3	4	3	3	3
TOTAL SKOR PER-OPERATOR		73	82	80	65	84	72
RATA-RATA SKOR OPERATOR		76					

Generally, it is seen that there are more body parts that are in pain compared to those that are not sick. Most complaints are on the lower body such as calves and ankles due to frequent standing and walking back and forth in the printing processing (process) to each board, drying, and collecting printed materials. Some have complaints about their thighs because they use high pressure toward the front in the printing process to press the screen so that it meets the register; some complain about the waist due to standing for too long in a standing position in many processes, and some complain about the left wrist because of the registration process and the displacement of their boards supporting the screen with the dominant left hand because the right hand holds the racket.

4 CONCLUSION

There are limitations of Small and medium-sized enterprises (SMEs) in filter printing in the mastery of simple technology, one of which is using a type of unit board table with a standing work position. This position causes musculoskeletal complaints when working against the operator. In the production process, there are two processes that require a major operator role, namely the process set-up and printing process, starting from the preparation of paint, installation of printing

materials, printing of basic colors, second layer/subsequent layers, drying, walking to the storage of printed materials, all mostly done while standing or running 8 hours each day.

The priority in the development of this proposed design is to reduce musculoskeletal complaints in the body with regard to Waist, Left Wrist, Right Thigh, Left Calf, Right Calf, Left Ankle, and Right Ankle. Development of a new work equipment design is needed to consider the unbalanced load reduction on the operator's body, and the development of the temporary transport system when the operator moves the work point so that it does not have an ill impact especially on the operator's hand. In addition, this new design attempts to reduce the standing required in the printing process thereby lessening the stress on the operator's body.

REFERENCES

- Creswell, J.W. 2010. *Research Design: Pendekatan Kualitatif, Kuantitatif, dan Mixed*. (diterjemahkan oleh: Achmad Fawaid). Yogyakarta: Pustaka Pelajar.
- Herlambang, Y. et al. 2015. *Penerapan Micromotion Study Dalam Analisis Produktivitas Desain Peralatan Kerja Cetak Saring*. Jurnal Teknologi Informasi dan Komunikasi (Tematik) PPM PLB. Bandung, 2:26–34.
- Kroemer, K. et al. 2001. *Ergonomic, how to design for ease and efficiency*. 2nd edition. Prentice Hall, New Jersey.
- Pheasant, S. 1991. *Ergonomics, Work and Health*. London: Macmillan Academic Profesional Ltd.
- Manuaba, I.B.G. 1998. *Ilmu Kebidanan, Penyakit Kandungan dan KB*. EGC. Jakarta.
- Santoso, et al. 2014. *Perancangan Metode Kerja untuk Mengurangi Kelelahan Kerja pada Aktivitas Mesin Bor di Workshop Bubut PT. Cahaya Samudra Shipyard*. Profesiensi, 2(2):155–164.
- Sobandi, B. 2004. *Model Pembelajaran Kewirausahaan Sablon dalam Menumbuhkan Minat Wirausaha Santri di Kecamatan Cisalak Kabupaten Subang*. Bandung: Universitas Pendidikan Indonesia.
- Tusianti, E. et al. 2019. *Analisis Hasil SE2016 Lanjutan Potensi Peningkatan Kinerja Usaha Mikro Kecil*. Jakarta. Badan Pusat Statistik.