Ergonomic Assessment of Sewing Machine Operators to Minimize Musculoskeletal Disorders

Etika Muslimah[1], *Devira* Ulfa Permatasari[1] , *Munajat* Tri Nugroho[1], *Suranto* Suranto[1], *Indah* Pratiwi[1], *Siti* Nandiroh[1]

[1]Industrial Engineering Department, Muhammadiyah Surakarta University, Indonesia

Abstract. Garment industry sewing involves 8 hours of sitting in an unnatural, uncomfortable position that can lead to muscle pain and injuries. This study aims to evaluate complaints and risks of MSDs in sewing work in the garment industry. Identify complaints using the Nordic Body Map (NBM) and Assessment of Repetitive Task (ART) methods. Based on the results of identification with NBM of sewing operators, it was found that the body parts where complaints occurred were the waist at 89%, the right calf at 61%, the buttocks at 53%, and the back at 50% from a total of 36 sewing operators. The results of analysis using the Assessment of Repetitive Task (ART) method show that all sewing operators experience musculoskeletal disorders in the moderate level exposure category so that further review of the sewing workstation is needed. The recommended improvement is in the form of improving posture to reduce the complaints felt. Relevance for industry: this study focuses on sewing work-related factors and other risk factors, which will help researchers to better understand the risk of MSDs in the garment industry. These risk factors must be considered when creating and implementing ergonomic aspects to prevent and reduce musculoskeletal discomfort.

1 Introduction

Sewing machines are an essential equipment in the clothing business. Sewing machine operators play an important role in the creation of clothes and textile goods. They are performing tasks that demand repetitive limb movements, particularly the hands, wrists, shoulders, and lower back. As a result, this employment is regularly employed to treat major musculoskeletal health conditions among operators.

Labor-related Musculoskeletal Disorders (MSDs) are a common workplace health concern among sewing, ironing, and packaging workers, and they can be caused by the manual and repetitive nature of the garment industry's labor [1]. The same working posture can result in symptoms in specific areas of the body. Sewing work is an example of a repetitive and time-consuming activity. Employees are more likely to acquire Musculoskeletal Disorders (MSDs) because they maintain the same posture for extended periods of time at work [2]. Work done over a long length of time and consistently will result in serious physical ailments. [3]. If the muscles are subjected to a steady load over a lengthy

period of time, it might cause workers to complain about joint, ligament, and tendon injury. Muscles are subjected to persistent and repetitive loads over time, which can result in symptoms such as joint, ligament, and tendon damage [4]. Musculoskeletal disorders (MSDs) are complaints in the skeletal muscles that range from very mild to quite painful [5]. Physical ergonomics considerations include a load-postural combination, position activity, difficult work posture, lifting large loads, manual material handling (MMH), walking or standing.standing for long periods of time, working long shifts, looking necks, monotonous or repeated work, poor work. The cause of Work Related Musculoskeletal Disorders (WMSDs), particularly Low Back Pain (LBP) [6].

The other side, research said that WMSD is the leading cause of missed workdays, higher expenses, and job disruption in developing nations [7]. MSDs in tailors occur due to the use of non-ergonomic work equipment, lengthy periods of sitting with painful postures on the neck, back, and legs, repetitive, stationary movements, and irregular working hours [8]. The aim of this study is to present an evaluation of the prevalence of musculoskeletal disorders (MSDs) among sewing operators using them as well as the impact of MSDs on their performance, using Nordic Body Map (NBM) and Assessment Repetitive Task (ART) methods. The ART method is especially relevant for the analysis of repetitive work, various studies are useful. One of the studies was an assessment of dentists in India. According to the study, new improved ergonomic methodologies such as ART may be beneficial in determining risk factors responsible for prevalent MSDs in dentistry[9,10].

2 Methods

The study was conducted using structured operator interviews at work sites and questionnaire surveys. The study involved 36 suture operators who agreed to take part and had MSD experience in various parts of the body. Operators demographic information, work-related details, and NBM questions about MSDs were gathered via a questionnaire. Demographic datas are age, gender, education and job experience. The NBM sheet recorded MSDs symptoms at the region of body.

Data collected from NBM questionnaires and ART method assessment sheets by sewing machine operator workers through interviews and direct observation regarding the problems currently being experienced. The participants were asked to identify where they had felt discomfort, pain, or ache in their job [11].The NBM method data required in filling out the NBM questionnaire based on interviews conducted with sewing machine operator workers is data on body parts experiencing complaints and data on the level of complaints. The population in this study consisted of 36 sewing machine operators. In this study, all machine operators were used as samples from the entire population of sewing machine operators. These operators work with sewing machines in the sitting posture required for this research data.

Completing the NBM questionnaire by operators is based on interviews conducted with sewing machine operator workers. These data are the part of the body that feels pain and the level of complaint. Meanwhile, for the ART method, the data required is an assessment based on interviews and direct observation of workers, which includes frequency and repetition factors, hand strength factors, awkward posture factors and additional factors.

Data analysis and discussion is carried out to provide suggestions for improvements that can be made based on the results and classification of NBM and ART data that have been previously processed so that the proposed improvements can be in accordance with the results of the research data processing carried out. NBM questionnaire data obtained is carried out by calculating the total risk value of the NBM questionnaire and then classifying the results of adding up the total risk values with risk level classification. ART method data processing

was carried out after filling in the 12 criteria assessment sheet which had been carried out by interviewing and observing sewing machine operator workers by calculating the scores task score based on data obtained from the ART method assessment factors, namely factors arm movements, repetition, force, head/neck, back posture, arm posture, wrist posture, finger / hand grip, breaks, work pace, additional factors.

3 Results and Discussion

3.1 Nordic Body Map (NBM)

Nordic Body Map (NBM) is a questionnaire containing 27 types of bodily complaints felt by workers. NBM questionnaire has 4 levels of complaints, namely Not Painful (NP), Somewhat Painful (SP), Painful (P), Very Painful (VP). Each level of complaint has a rating scale are 1,2,3,4. As a result of filling out the NBM questionnaire which was carried out by direct interviews with 36 respondents. The characteristics of respondents as sewing machine operators are shown in Table 1. This study focuses on complaints about body parts at the level of pain (3) and very painful (4) requiring further analysis. NBM results showing these levels complaints can be seen in the table 1.

Table 1 shows the results of NBM's identification of operator complaints. There are 27 areas of the body identified. Operators are asked to fill out a questionnaire to assess their level of pain, from the lowest level of no pain to the highest level of very painful. The results showed that the back, waist, buttocks and calf of the right leg were identified as having the most pain compared to other parts of the body. This condition is related to the chair used being uncomfortable because it does not have a backrest [12]. This causes soreness in the back and waist. Sitting statically for a long time, especially without support, can cause acute pain. Unfortunately, this position is not suggested because it is dangerous and can lead to MSD if performed every day [13]. Sewing operators sit for 8 hours, and this causes pain in the back, waist and buttocks, as shown in the NBM results in table 1.

Table 1. Nordic Body Map assessment for sewing operators

Body part complaint	Level of Pain			
	Painless	Moderate	Pain	Very painful
Upper neck	21	11	4	-
Lower neck	12	15	9	-
Left shoulder	12	11	12	1
Right shoulder	10	13	12	1
Left upper arm	18	17	-	-
Back	7	11	12	6
Right upper arm	19	16	1	-
Waist	-	4	16	16
Buttocks	1	16	11	8
Bottom	1	18	10	7
Left elbow	35	1	-	-
Right elbow	34	2	-	-
Left forearm	34	2	-	-
Right forearm	33	3	-	-

Body part complaint	Level of Pain			
	Painless	Moderate	Pain	Very painful
Left wrist	27	8	1	-
Right wrist	33	10	2	-
Left hand	35	1	-	-
Right hand	34	1	1	-
Left thigh	32	4	-	-
Right thigh	23	11	2	-
Left knee	32	3	1	-
Right knee	19	6	9	2
Left calf	28	3	4	1
Right calf	5	9	16	6
Left ankle	33	1	2	-
Right ankle	8	14	9	5
Left leg	33	1	2	-
Right leg	20	7	8	1

Table 2. Percentage of complaint levels 3 and 4

Body part complaint	Pain – Very painful (operators)	Percentage
Waist	32	89%
Calf right	22	61%
Buttocks	19	53%
Back	18	50%

Table 2 describes number of operator complaints at the sick and very sick levels are waist, right calf, buttocks and back. This complaint occurred because the operator operated the sewing machine for a long time, sitting on a chair without a backrest. A general increase in subjective discomfort levels across the 2-hour work period, implying that prolonged sitting may cause increasing discomfort over time among healthy employees. High contact pressures in numerous body locations correlated with perceived discomfort [14]. Figure 1 shows the order of the parts of the body that feel pain from the highest. It can be seen that the pain in the waist is the highest.

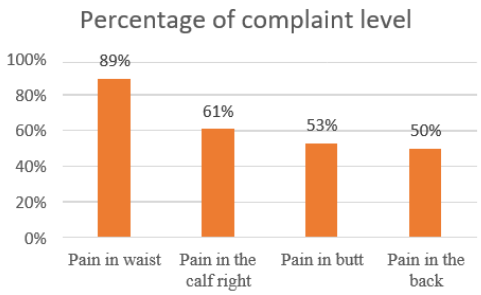

Fig. 1. Percentage of complaint level pain and very painful

Sewing operators reported complaints about the waist, calves, buttocks and back. The backless chair used by the operator caused these complaints. Operators become tired more quickly. The operator's back is not supported properly, causing fatigue to occur more quickly. A previous study recommended adding pillows for support to reduce the risk of MSDs [15].

Fig. 2. Sitting position sewing operators

Figure 2 displays a seated posture with a bending body posture when stitching. Based on random interviews with ten tailors at the White House in Ambon City, the sewing procedure, which is done in a sitting position with the back bent profoundly for a long time, leads in tailors frequently suffering many complaints [16]. Small industries do not pay attention to workers' comfort and health. The sewing operator's chair does not use a backrest, causing back complaints. Small industry workers are continuously at risk of injury since they operate in unconventional positions such as crouching, bending, tilting, and neck bending. As a result, workers complain of back, shoulder, neck, and wrist pain. This indicates that the action is dangerous and may result in musculoskeletal difficulties. MSDs [17].

3.2 Assessment of Repetitive Task (ART)

ART is a method used to assess risks in repetitive work. The assessment was carried out in four steps using the ART method, including (A) determining the amount of hand and arm movement, (B) determining the level of force exertion (i.e. low, medium, high, and very high force), (C) determining the subject's body posture when performing routine activities, and (D) determining other factors (namely rest time, work speed, activity duration, and psychosocial factors). Filling in the ART assessment sheet with direct observation and interviews with sewing operators. This method is intended to evaluate the risk of tasks requiring repetitive motions of the upper limbs, articularly the hands and arms [18].Interviews are needed to find out how much strength and speed they have when working. ART assessment result is shown ini Table 2. This table show about score of exposure, exposure categories and the number operator ini each score.

Table 3. ART analysis

Score of Exposure	Exposure Level	Number of operators
12	Moderate	6
12,8	Moderate	4
13,6	Moderate	7
14,4	Moderate	6
15,2	Moderate	2
16	Moderate	6
17,6	Moderate	5

ART analysis explain that all sewing operators are at a moderate exposure level, with scores ranging from 12-17.6. This condition still requires the company to carry out further reviews of the work station by improving the operator's workplace. The sewing operator's uncomfortable working posture, namely sitting in a chair without a backrest, causes complaints in several parts of the body. The sewing movement is a repetitive movement with high repetition. This type of work has the potential to cause Musculoskeletal Disorders (MSDs). The same result was also stated by [19], repetitive work, akward postures, and heavy handling, together with the related efforts, are major contributors to occupational disorders.

Fig. 3. Conditions of the sewing operator's work station

Further review of sewing workstations to reduce Musculoskeletal Disorders to fit appropriate work station standards for tailors. The review carried out a redesign of work tables and chairs to suit the anthropometry of sewing operators. It is necessary to organize the layout and distance at stations work on the main equipment and auxiliary equipment for the sewing workstation the tailor can reach out and do his job well and comfortable. It is necessary to regularly check the sewing machine so that each part is sewing machines can be used well and easily so that operators don't feel complaints of musculoskeletal disorder in the calf right foot because of the difficulty or hardness of stepping under the sewing machine to regulate the operation of the sewing machine while it is working. There is a need to change seats at the current work station with a chair that has a support for the back and can be adjusted to the height of the chair according to operator. Physical and ergonomic hazards were identified to be more associated with the sewing machine operators than any other hazard. Proper awareness and education should therefore be given to the textile sewing

machine operators on safe practices to minimize hazards and persistent pain associated with their routine operations that could lead to temporary or permanent health damages [20].

Sewing is the cause of complaints, because the work position and work station are not ergonomic. One study in the garment industry said that fore/aft sewing distance, sewing desk inclination, and sewing desk height all had an effect on trunk, neck, and arm posture. It was discovered that the main factor for sewing machine operators' impression of the trunk and neck was fore/aft sewing distance, sewing desk inclination. Recommended sizes for sewing workstations are sewing desk height has a considerable impact on arm posture. According to study [21]: (1) The front/back sewing distance must be adjusted to 140mm towards the sewing operator; and (2) A sewing table with a 10° slope to the sewing direction should be utilized in the sewing workspace. (3) The sewing table's height must be set between 762 mm and 787 mm from the ground level.

4 Conclusion

Analysis of 36 sewing operators showed that the most frequent complaints based on identification with NBM were waist, right calf, buttocks and back. The cause is that the operator sits on a chair without a backrest and the sewing machine cannot be used properly and comfort. Meanwhile, for the results of analysis with ART, it is known that the total score shows that all scores are in the moderate category. Employer must carry out further reviews regarding the condition sewing workstation. Recommendations for improvement is to use ergonomic chair for sewing operators, to reduce the risk of MSDs and fatigue.

References

[1] S. Das, M. Krishna Moorthy, and K. Shanmugaraja, "Analysis of Musculoskeletal Disorder Risk in Cotton Garment Industry Workers," *J. Nat. Fibers*, vol. 20, no. 1, 2023, https://doi.org/10.1080/15440478.2022.2162182

[2] T. Baskaran, K. Sankaranarayanasamy, and G. Kuruva, "Musculoskeletal disorder risk levels in mobile crane operators: An ergonomic assessment," in *Materials Today: Proceedings*, 2023, pp. 3089–3092, doi:https://doi.org/10.1016/j.matpr.2022.09.252

[3] N. Irawati, G. Yogisutanti, and N. Sitorus, "Relationship Between Nutritional Status, Years Of Service, And Work Attitudes With Musculoskeletal Disorders In Tailors At West Java" *JPH RECODE*, vol. 4, no. 1, pp. 52–60, 2020, [Online]. Available: https://doi.org/10.20473/jphrecode.v4i1.15637

[4] S. Shobur, M. Maksuk, and F. I. Sari, "Faktor Risiko Musculoskeletal Disorders (MSDs) pada Pekerja Tenun Ikat di Kelurahan Tuan Kentang Kota Palembang," *J. Med.*, vol. 6, no. 2, 2019, [Online]. Available: https://jurnal.poltekkesbanten.ac.id/Medikes/article/view/188

[5] E. Megawati, "Edukasi Pengurangan Resiko Terjadinya Musculoskeletal Disorders (MSDs) Dini, Pada Penjahit Keliling Di Ngaliyan Semarang," *Budimas*, vol. Vol 3, no. 2, 2021, doi: http://dx.doi.org/10.29040/budimas.v3i2.3478

[6] I. Pratiwi, M. Munfiah, R. Fitriadi, and M. F. Sufa, "Evaluation of Work Posture in Sohun Noodles Workers using OWAS and WERA Method," *Int. J. Innov. Technol. Explor. Eng.*, vol. 8, no. 11, pp. 1788–1795, 2019, https://www.ijitee.org/portfolio-item/K17670981119/

[7] D. P. Restuputri, R. U. Achmad, M. Lukman, and I. Masudin, "Analysis of Work Posture Using the Muscle Fatigue Assessment (MFA) and Novel Ergonomic Postural Assessment (NERPA)o Title," *J. Ilm. Tek. Ind.*, vol. 20, no. 1, pp. 9–20, 2021, https://doi.org/10.23917/jiti.v20i1.13222

[8] B. Andrian, A. Camelia, and H. . F. Faisya, "Analysis of Working Postures with Musculoskeletal Disorders (Msds) Complaint of Tailors in Ulak Kerbau Baru Village, Ogan Ilir," *J. Ilmu Kesehat. Masy.*, vol. 11, no. 1, 2020, doi:

https://doi.org/10.26553/jikm.2020.11.1.75-88
[9] V. Bhatia, J. S. Randhawa, A. Jain, and V. Grover, "Ergonomic Assessment of Indian Dentists Using theAssessment of Repetitive Tasks (Art) Technique," in *Proceedings of the 21st Congress of the International Ergonomics Association (IEA 2021*, 2021, pp. 688–696, doi: https://doi.org/10.1007/978-3-030-74611- 7_95
[10] A. S. R. Jafari, V. Feyzi, Z. Foroozanfar, and S. Rahimimoghadam, "The correlation between ART and OCRA methods used for posture assessment of repetitive tasks," *Med. Lav.*, vol. 112, no. 5, 2021 https://doi.org/10.23749%2Fmdl.v112i5.11117
[11] T. Sakthi Nagaraj, R. Jeyapaul, and K. Mathiyazhagan, "Evaluation of ergonomic working conditions among standing sewing machine operators in Sri Lanka," *Int. J. Ind. Ergon.*, vol. 70, pp. 70–83, 2019, doi:https://doi.org/10.1016/j.ergon.2019.01.006
[12] C. Bontrup *et al.*, "Low back pain and its relationship with sitting behaviour among sedentary office workers," *Appl. Ergon.*, vol. 81, p. 102894, 2019, doi: https://doi.org/10.1016/j.apergo.2019.102894
[13] O. Adiyanto, E. Mohamad, R. Jaafar, F. Ma'ruf, M. Faishal, and A. Anggraeni, "Application of Nordic Body Map and Rapid Upper Limb Assessment for Assessing Work-related Musculoskeletal Disorders: A case study in Small and Medium Enterprises," *Int. Journal of Integr. Eng.*, vol. 14, no. 4, pp. 10–19, 2022, [Online]. Available: https://penerbit.uthm.edu.my/ojs/index.php/ijie/article/view/5631/4898
[14] F. Arippa, A. Nguyen, M. Pau, and C. Harris-Adamson, "Postural strategies among office workers duringa prolonged sitting bout," *Appl. Ergon.*, vol. 102, p. 103723, 2022, doi: https://doi.org/10.1016/j.apergo.2022.103723
[15] K. G. Davis, S. E. Kotowski, D. Daniel, T. Gerding, J. Naylor, and M. Syck, "The home office: ergonomicLessons From the 'new normal,'" *Ergon. Des.*, vol. Volume 28, no. 4, 2020, doi: https://doi.org/10.1177/1064804620937907
[16] Z. Lating, M. Lihi, and A. R. Lapodi, "Hubungan antara Posisi dan Lama Duduk dengan Kejadian Low Back Pain (LBP) pada Penjahit di Kota Ambon," *Tunas-tunas Ris. Kesehat.*, vol. 12, no. 1, pp. 28–32, 2022, [Online]. Available: http://dx.doi.org/10.33846/2trik12106
[17] I. Pratiwi and T. Adhitama, "Ergonomic Risk Evaluation to Minimize Musculoskeletal Disorders in SMEs Leather Shoes at Indonesia," *J. Ilm. Tek. Ind.*, vol. 21, no. 2, pp. 203–212, 2022 https://doi.org/10.23917/jiti.v21i2.19502
[18] A. Hosseini, A. Choobineh, M. Razeghi, H. R. Pakshir, H. Ghaem, and M. Vojud, "Ergonomic Assessment of Exposure to Musculoskeletal Disorders Risk Factors among Dentists of Shiraz, Iran," *J. Dent.*, vol. 20, no. 1, pp. 53–60, 2019, doi: https://doi.org/10.30476%2FDENTJODS.2019.44564
[19] L.Saavedra-Robinson, "Ergonomic assessment of repetitive work time as a key parameter for job rotation schedules," *J. Hum. Factors Ergon.*, vol. 10, no. 1, pp. 1–14, 2023 https://dx.doi.org/10.1504/IJHFE.2023.128572
[20] O. T. Okareh, O. E. Solomon, and R. Olawoyin, "Prevalence of ergonomic hazards and persistent work- related musculoskeletal pain among textile sewing machine operators," *Saf. Sci.*, vol. 136, p. 105159, 2021, doi: https://doi.org/10.1016/j.ssci.2021.105159
[21] S. Tondre and T. Deshmukh, "Guidelines to sewing machine workstation design for improving working posture of sewing operator," *Int. J. Ind. Ergon.*, vol. 71, pp. 37–46, 2019, doi: https://doi.org/10.1016/j.ergon.2019.02.002