Ergonomic Workstation Design for Fish Smoking Workers in the Coastal Area of Surabaya

Dani Nasirul Haqi[1], Putri Ayuni Alayyannur[1]

[1]Professor, Department of Occupational Health and Safety, Public Health Faculty, Universitas Airlangga, 60115, Surabaya, East Java, Indonesia

Abstract

Introduction: Workstation design should be made adjusting the workers' anthropometry to not put additional burden on the worker's body. Fish smoking workers in the coastal area of Surabaya work sitting on a chair as high as their heels which cause them working with unnatural postures. This study aimed to determine ergonomic workstation design for fish smoking workers in the coastal area of Surabaya.

Methods: Respondents were the total population consisting of 12 male and 18 female workers. The worker's body was measured in a sitting position using a measuring tape. Dimensions measured included the reach of the thumb as measured from the back, elbow height when seated, calf height, hip width, buttock-popliteal length, and sitting height. Each dimension was calculated on the 5th and 95th percentiles to determine the size of the ergonomic workstation.

Result: Workstations were made with an adjustable concept. The size of the ergonomic workstation design for male workers includes table width 71.93-77.57 cm, table height 51.81-55.86 cm, chair height 28.64-32.03 cm, chair width 38.66-41.84 cm, chair length 43.24-50.10 cm, and chairback height 89.21-95.46 cm. In addition, for female workers, the size of the ergonomic workstation design includes table width 60.55-68.00 cm, table height 39.21-43.57 cm, chair height 23.64-27.47 cm, chair width 29.13-34.54 cm, chair length 35.80-39.87 cm, and chairback height 74.28-79.72 cm.

Conclusion: It is necessary to make improvements to workstation of fish smoking workers in the coastal area of Surabaya, as an attempt to make it ergonomic.

***Key words**: design, ergonomic workstation, fish smoking workers*

Introduction

Ergonomics has the main principle of "fit the job to the man". It is adjusting the work system for workers, so that they feel safe and comfortable during work. The workstation design should be made to adjust the human user (human centered design), considering the user's anthropometry to match the body dimensions. Workstation design that is incompatible with the workers' anthropometry can increase the load on the worker's body, which has an impact on the comfort and efficiency of workers in doing their work[1].

Fish smoking is a method of processing and preserving fish which is popular in Indonesia by absorbing various chemical compounds from wood smoke into the fish so that the fish has a distinctive color and smoky flavor[2]. Fish smoking can be easily found in coastal areas, one of which is coastal area of Surabaya. Fish smoking workers in the coastal area of Surabaya carry out the smoking process, which amounts to approximately 1.5 quintals, starting at 05.00 a.m. every day. Fish smoker used is conventional and made of traditional chimneys. In addition, the process of

Corresponding author:
Dani Nasirul Haqi,
Department of Occupational Health and Safety,
Public Health Faculty, Universitas Airlangga, 60115,
Surabaya, East Java, Indonesia;
E-mail: haqidani92@gmail.com; +62885730396977

smoking fish is still done at home.

Fish smoking workers in the coastal area of Surabaya sit on a small stool, called *dingklik,* while working. However, the stool is only as high as their heels and has no backrest or chairback, making it too short and less ergonomic. Moreover, all stools are the same size even though the anthropometry of fish smoking workers is different. Additionally, there is still no special table used for work. Therefore, it is important to make improvements to workstation of fish smoking workers in the coastal area of Surabaya.

This study aims to determine an ergonomic workstation design for fish smoking workers in the coastal area of Surabaya.

Materials and Methods

This research was conducted on fish smoking workers in the coastal area of Surabaya. The total population in this study was 30 people. Sampling was conducted using a total population sampling technique, so that all fish smoking workers were the respondents consisting of 12 male workers and 18 female workers. Data were collected in October 2020.

Anthropometric measurements of fish smoking workers were carried out when they were working in a sitting position using a measuring tape. Dimensions measured included: the reach of the thumb as measured from the back (A), elbow height when sitting (B), calf height (C), hip width (D), buttock-popliteal length (E), and sitting height (F).

Data were analyzed using descriptive statistics, covering the 5th (5%) and 95th (95%) percentiles of the data for each dimension for each gender. The calculation formula used is as follows.

$$5\ \% = \bar{x} - 1.645\ (\sigma) + \text{Allowance}$$

$$95\ \% = \bar{x} + 1.645\ (\sigma) + \text{A}$$

$$\text{Standard deviation } (\sigma) = \sqrt{\frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n-1}}$$

The allowance factor used was 0.5, while n was the total number of respondents, namely 12 for males and 18 for females. The 5th percentile was used as the lowest measure and the 95th percentile was used as the highest size in ergonomic workstation design since the workstation was made with an adjustable concept.

Dimension A was used as a measure of width, while dimension B was used as a measure of the height of an ergonomic work table design. Furthermore, dimension C was used as a measure of height; dimension D was used as a measure of width; and the dimension E was used as a measure of the length of the ergonomic work chair design. Finally, the dimension F was used as a measure of the back height of the ergonomic work chair design.

Result and Discussion

The results of anthropometric measurements of fish smoking workers in the Coastal Area of Surabaya are shown in Table 1.

Table 1. Anthropometric Measurements of Fish Smoking Workers in the Coastal Area of Surabaya

No.	Dimensions					
	A (cm)	B (cm)	C (cm)	D (cm)	E (cm)	F (cm)
Males						
1	75	53	30	39	45	93
2	73	54	29	40	47	94
3	74	52	30	39	48	94
4	75	51	30	38	43	92
5	76	55	29	41	42	91
6	77	55	29	40	49	91
7	72	54	29	40	48	91
8	76	54	31	40	47	93

Cont... **Table 1. Anthropometric Measurements of Fish Smoking Workers in the Coastal Area of Surabaya**

9	72	53	31	39	47	93
10	74	53	32	39	46	93
11	75	52	29	41	47	88
12	72	54	29	41	45	89
Total	891	640	358	477	554	1102
Average	74.25	53.33	29.83	39.75	46.17	91.83
Females						
1	64	41	25	33	37	77
2	65	42	24	31	37	78
3	61	39	24	31	38	77
4	64	42	24	30	38	77
5	65	42	25	30	35	77
6	61	39	27	30	35	79
7	61	39	26	30	38	78
8	67	42	26	33	37	78
9	63	41	26	34	39	74
10	61	41	23	30	38	75
11	64	42	25	30	37	73
12	65	39	24	30	40	74
13	61	39	24	34	37	75
14	68	42	26	32	38	77
15	62	41	26	32	38	78
16	67	41	27	34	36	76
17	64	41	25	31	37	77
18	65	43	24	29	37	77
Total	1148	736	451	564	672	1377
Average	63.78	40.89	25.06	31.33	37.33	76.50

Based on the anthropometric data in Table 1, the size of the ergonomic workstation design for fish smoking workers in the Coastal Area of Surabaya was calculated for each dimension using the 5^{th} and 95^{th} percentiles for each gender. The results of these calculations are shown in Table 2.

Table 2. Size of Ergonomic Workstation Design for Fish Smoking Workers in the Coastal Area of Surabaya

No.		Dimensions	Note	Lowest Size (cm)	Highest Size (cm)
Males					
1	Table Size	A	Table width	71.93	77.57
2		B	Table height	51.81	55.86
3	Chair Size	C	Chair height	28.64	32.03
4		D	Chair width	38.66	41.84
5		E	Chair length	43.24	50.10
6		F	Chairback height	89.21	95.46
Females					
7	Table Size	A	Table width	60.55	68.00
8		B	Table height	39.21	43.57
9	Chair Size	C	Chair height	23.64	27.47
10		D	Chair width	29.13	34.54
11		E	Chair length	35.80	39.87
12		F	Chairback height	74.28	79.72

Table 2 shows the lowest and highest sizes of each dimension in the ergonomic workstation design for fish smoking workers in the Surabaya Coastal Area. A workstation that is not ergonomic can have several impacts on workers, including an increase in workload, musculoskeletal complaints, fatigue, and decreased productivity[3,4]. More importantly, there will be a higher rate of pain and muscle spasms and a lower rate of productivity[5]. Based on a systematic review of 5 studies, it was found that there is a positive impact of improving chair design in reducing musculoskeletal symptoms[6]. Thus, it is substantial to make ergonomic workstation design.

Gender is one of the factors that influence anthropometry because there are statistically significant differences between male and female body dimensions; male body dimensions are greater than that of women[7]. Accordingly, ergonomic workstation designs between the genders are differentiated.

Table Width

The design size of the table width for fish smoking workers in the coastal area of Surabaya was determined based on the reach of the thumb which was measured from the worker's back, so that workers could easily reach the table without bending over. Other studies have also determined the table width using the length of the hand held in front of the user [8], but some are not caused by limited space but still consider ergonomic factors and flexibility to put work tools[9]. Another study used only the 95th percentile to determine the table width[10]. However, the table width for fish smoking workers in the coastal area of Surabaya used the 5th and 95th percentiles

so that workers with the smallest to the largest body anthropometry still matched the size of the ergonomic workstation design.

Table Height

The table height in the ergonomic workstation design for fish smoking workers in the coastal area of Surabaya used the height of the workers' elbows in their sitting position. Several other studies have also used elbow height in a sitting position to determine the table surface height[11,12]. A table that is too high can cause pain in the shoulders and neck, while a table that is too low causes the back to bend, causing tense back and shoulder muscles[11]. The table height in the ergonomic table design for fish smoking workers in the coastal area of Surabaya used the 5th to 95th percentiles from the workers' elbow height data. The table height in this range can accommodate anthropometry of workers with the smallest to largest body sizes.

Chair Height

Fish smoking workers in the coastal area of Surabaya sit on very low stool during work, so that they always kept their legs bent and their backs bent. This kind of work posture also have an impact on the muscles and skeleton since there is excessive stress on the tendons, ligaments and joints[13]. Ergonomic small chair height in each study was set according to the type of work. A study on batik crafters in Indonesia recommends small stool at the knees of workers[14,15]. However, work chairs for fish smoking workers in the coastal area of Surabaya could not be made as high as knee; the sitting position of the workers needed to adjust the height of the fish smoker. Thus, the chair height for fish smoking workers in the coastal area of Surabaya was made to be as high as the workers' calves.

Chair Width

The chair width in the ergonomic workstation design for fish smoking workers in the coastal area of Surabaya was determined based on the workers' hip width. Several other studies have also recommended chair width based on the user's hip width[8,15]. Chair that is too narrow cause workers to be unable to move freely while working[15]. A study determined the chair width with armrests on the chair based on the 95th percentile of the worker's hip width data, in order to tolerate workers with large hips. However, chairs without armrests were designed to the 5th percentile to tolerate workers with small hips[14]. The chair width for fish smoking workers in the coastal area of Surabaya was set using the 5th to 95th percentile, allowing it to accommodate all workers, whether they had large or small hips.

Chair Length

A study conducted in a company utilized the 5th percentile of the buttock-popliteal length data to determine chair length considering workers who had short buttocks-popliteal[16]. Another study conducted on tailors in a village used the 95th percentile of the buttock-popliteal length data to determine ergonomic chair length [4]. Chair that is too long make it difficult for users to reach the back of the chair, causing pain in the back and shoulders[17]. Accordingly, it is important to pay attention to the chair length so that it is not greater than the buttock-popliteal length of the user. The chair length in the workstation design for fish smoking workers in the coastal area of Surabaya used the 5th to 95th percentiles from the buttock-popliteal data of all workers, so that workers with long and short buttock-popliteal sizes could match the chair length.

Chairback Height

A study conducted on *songket* weavers in Indonesia has shown a decrease in the incidence of low back pain after the weavers were provided by chairback while working[18]. Thus, it is important to add chairback for fish smoking workers in the coastal area of Surabaya. A chairback that is too short can cause unnatural posture which can lead to back pain[19]. Besides, a study conducted in Bangladesh used back height to determine the chairback height[12]. Likewise, a study in Turkey recommends the chairback for the user[20]. The chairback height in the ergonomic workstation design for fish smoking workers in the coastal area of Surabaya was determined based on the workers' back height, so that it could accommodate the back height of all fish smoking workers in the coastal area of Surabaya.

Conclusion

Ergonomic workstation design for fish smoking workers in the coastal area of Surabaya are made by

adjusting the workers' anthropometry, using the 5th and 95th percentiles of the anthropometric data, so that the workstations are manageable. The size of the ergonomic workstation design for male workers includes table width 71.93-77.57 cm, table height 51.81-55.86 cm, chair height 28.64-32.03 cm, chair width 38.66-41.84 cm, chair length 43.24-50.10 cm, and chairback height 89.21-95.46 cm. In addition, for female workers, the size of the ergonomic workstation design includes table width 60.55-68.00 cm, table height 39.21-43.57 cm, chair height 23.64-27.47 cm, chair width 29.13-34.54 cm, chair length 35.80-39.87 cm, and chairback height 74.28-79.72 cm. Referring to the results of the study, it is important to make improvements to workstation of fish smoking workers in the coastal area of Surabaya, to make it ergonomic.

Acknowledgement: The researchers would like to extend their deepest appreciation to all parties involved in this research, especially Public Health Faculty, Universitas Airlangga and Kenjeran Public Health Center

Ethical Clearance: The study was approved by ethical clearance certificate Number 305/HRECC. FODM/VI/2020 from the institutional Health Research Ethical Clearance Commission, Universitas Airlangga

Source of Funding: Public Health Faculty, Universitas Airlangga

Conflict of Interest: Nil

References

1. Sugiono, Putro WW, Sari SIK. *Ergonomi Untuk Pemula: Prinsip Dasar & Aplikasinya*. Malang: UB Press; 2018.
2. S RSS, Djunaedi OS, Nurhajati J, Afrianto E, Udin Z. *Mekanisme Pengasapan Ikan*. Bandung: Unpad Press; 2011.
3. Adrianto B, Adiatmika I, Suardana I. Redesain Stasiun Kerja CV Massa Digital Printing Denpasar Meningkatkan Produktivitas dan Menurunkan Keluhan Muskuloskeletal Karyawan. *J Ergon Indones*. 2017.
4. Rosanti E, Wulandari D. Pengaruh Perbaikan Kursi Kerja terhadap Keluhan Muskuloskeletal pada Pekerjaan Menjahit di Desa X. *J Ind Hyg Occup Heal*. 2016.
5. Hoeben C, Louw Q. Ergonomic Chair Intervention: Effects on Chronic Upper Quadrant Dysfunction, Disability and Productivity in Female Computer Workers. *SA J Physiother*. 2014.
6. van Niekerk SM, Louw Q, Hillier S. The Effectiveness of A Chair Intervention in the Workplace to Reduce Musculoskeletal Symptomps. A Systematic Review. *BMC Musculoskelet Disord*. 2012.
7. Nurmianto E. *Ergonomi: Konsep Dasar Dan Aplikasinya*. 2nd ed. Surabaya: Guna Widya; 2004.
8. Hariandja J, Ishlah D. Rancangan Kursi dan Meja Laptop yang ergonomis di Universitas Katolik Parahyangan. *J Rekayasa Sist Ind*. 2013.
9. Suhartono, Mindhayani I. Intervensi Ergonomi pada Perancangan Meja Las untuk Sekolah Vokasi. *J Rekayasa Ind*. 2020.
10. Wilson I, Desai D. Anthropometric Measurement for Ergonomic Design of Student's Furniture in India. *Eng Sci Technol an Int J*. 2017.
11. Musa A, Ismaila S, Adejuyigbe S, Akinyemi O. Ergonomic Evaluation and Design of Tables and Chair for Use in Tertiary Institution in Nigeria. *Hum Factors Organ Des Manag*. 2010.
12. Kapuria T, Rahman M, Z. M, G. M. Ergonomic Design of Table and Chair based on QFD and Anthropometric Measurement and Improved Facility Layout. *Ergon Int J*. 2018.
13. Iridiastadi H, Yassierli. *Ergonomi Suatu Pengantar*. Bandung: PT Remaja Rosdakarya; 2014.
14. Sokhibi A, Sugiharto W. Perancangan Kursi Ergonomis untuk Mengurangi Keluhan Pembatik pada UKM Batik Alfa Shoofa Kudus. *Pros SENDI_U*. 2018.
15. Sumardiyono, Ada Y. Perbedaan Gangguan Muskuloskeletal Pembatik Wanita dengan Dingklik dan Kursi Kerja Ergonomis. *J Kesehat Masy*. 2014.
16. Amri F, Yusdinar. Perancangan Kursi yang Ergonomis sebagai Alat Bantu di Stasiun Kerja Produksi Air Galon (Studi Kasus PT Ima Montaz Sejahtera). *Malikussaleh Ind Eng J*. 2015.
17. Ansari S, Nikpay A, Varmazyar S. Design and Development of an Ergonomic Chair for Students in Educational Settings. *Heal Scope*. 2018.
18. Natosba J, Jaji. Pengaruh Posisi Ergonomis terhadap Kejadian Low Back Pain pada Penenun Songket di Kampung BNI 46. *J Keperawatan Sriwij*. 2016.

19. Castellucci H, Catal M. Evaluation of the Match between Anthropometric Measures and School Furniture Dimensions in Chile. *Work*. 2016.

20. Kurban H, Tankut A, Melemez K. Ergonomic and Structural Analysisi of Classroom Furniture: A Case Study for High School in Bartin, Turkey. *Proc 27th Int Conf Res Furnit Ind*. 2015.