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Ergonomic Intervention in Pharmaceutical Distribution Work in India using the Principles of Anthropometry

Pallavi Murarka and Manjit Kaur Chauhan

Department of Resource Management SNDT Women's University, Juhu, Mumbai – 400049, Maharashtra, India

ABSTRACT

This intervention research was done in a pharmaceutical distribution enterprise to reduce the ergonomic risk factors related to sustained and repetitive body postures. The ergonomic intervention was done in three stages. Stage one: assessment of existing work patterns and workplace layout to identify the area of improvement. Stage two: development of a workstation to eliminate ergonomic risk factors using Anthropometry and Standing work guidelines. Stage three: introduction of the workstation to workers. Considering the components of the proposed workstation, relevant anthropometric variables in standing position: elbow height, eye height, and arm reach front and arm reach side length and height were used. 5^{th}, 95^{th}, or 50^{th} percentile body measurements of the Indian male population were utilized depending on the anthropometric requirements of reach and clearance. The new workstation consisted of primary components: an elevated worksurface and two side tables attached to it, and secondary components: footrests and storage space. Foldable side tables and removable overhead shelf provided flexibility in shifting and maintenance. Ergonomics and anthropometry assisted in designing a workstation suitable to the majority and reducing ergonomic risk.

Keywords: Anthropometry, Anthropometric principles, Ergonomic intervention, Ergonomic risk factors, Workplace ergonomics, Workstation design, Posture, Musculoskeletal disorders (MSD).

INTRODUCTION

Ergonomics focuses on the interaction between man-machine and the interface between the two (Bridger, 2018). Workplace ergonomics aims at designing the workplace, keeping the capabilities and limitations of the worker in mind as poor workplace design leads to fatigue and lower productivity due to the three main workplace ergonomic risk factors: repetitions, forceful exertions, and sustained awkward postures (ErgoPlus, n.d.).

Ergonomic interventions seek to reduce the ergonomic risk factors: physical strain on the musculoskeletal system by improving the equipment, layout, and work environment to suit users (Hoe et al., 2018; Mulimani et al., 2018). Murarka & Chauhan (2022) reported the prevalence of musculoskeletal disorders (MSD) among pharmaceutical distribution workers and found no significant association between pain and demographic factors. In 9 hospital laboratories, when the ergonomic risks were found to be associated with poor workstation design, Haile et al. (2012) stated that workstations should match human anthropometric measurements to minimize extreme postures, improve task efficiency, and provide a safe working environment. Anthropometry is a branch of ergonomics that deals with body measurements (Pheasant, 2006). It is the study of statistical variation of human body dimensions and its implications on design (Berlin & Adams, 2017). A study at the Cranfield Technology Institute highlighted the consequences of not considering human dimensions while designing a lathe (Singleton, 1964). Poor workstation designs were found hazardous for operators in assembly production lines, and the need for anthropometric workstations was identified (Realyvásquez-Vargas et al., 2020). A possibility of fatal human errors was attributed to the mismatch between the console specifications and the operator's body size (Lee et al., 2020).

The objectives of this study are to

1. Do a physical intervention: design a workstation that reduces the risk of musculoskeletal injury for pharmaceutical distribution workers.
2. Identify the relevant anthropometric variables corresponding to the workstation components.
3. Identify the percentile values of the anthropometric measurements for various workstation components to make the workstation comfortable for the majority.
4. Construct a workstation using measurements identified using principles of anthropometry.

REVIEW OF LITERATURE

Human beings vary in size; therefore, it is not practically possible to design a workplace that suits everyone. Anthropometric is considered while creating a workstation that fits the majority of workers. Designing for average excludes too many users, so a commonly accepted rule is to eliminate extreme sizes: Designing based on measurements from the 5^{th} to the 95^{th} percentile. However, choosing which percentile for which dimension depends on the specifics of each design case. A workplace should provide sufficient space to move around and work comfortably. Using the 95^{th} percentile of the relevant anthropometric variable allows the maximum number of people to move around. On the other hand, when it comes to reaching parts on the work surface and work surface heights, the 5^{th} percentile should be used (Pheasant, 2006; Berlin & Adams, 2017).

Steps for using anthropometry in workstation design (Lee et al., 2020; Openshaw & Taylor, 2006):

- Understand the work pattern of the target users.
- Anticipate possible actions: movements and postures adopted to do the work. Identify the critical user/ target population.
- Identify whether static and dynamic measurements need to be considered.

- Identify the necessary body dimensions corresponding to each element of the workstation design.
- Determine suitable percentile ranges for each measurement.
- Find a suitable anthropometric database with relevant measurements.
- Make a model of the proposed design based on the selected data.
- Evaluate whether one fixed design will be adequate, or if adjustable equipment needs to be added to accommodate the whole working population.

Common postures adopted in the workplace environment such as standing, sitting, reaching, and moving need to be considered when designing workplace products, space, and parts of the workstation such as overhead storage and pedestals. The workplace should allow maximum movement of the user's body joints within healthy and natural range of motion and reduce repetitive movements (Openshaw & Taylor, 2006; Chakrabarti, 1997). An ergonomically appropriate working environment designed keeping workers into account minimizes the user exertion (Kalınkara et al., 2011). Dimensions considered to design furniture for students in India were bench surface height, bench depth and width, backrest width and height, backrest angle, desk height, desk depth, width, and desk angle (Taifa & Desai, 2017). For heavy processes like ironing, the height of the working surface should be 200 mm lower than the elbow height. Worksurface for light work, such as assembly-line or mechanical jobs should be about 5-10 cm below elbow height (CCOSH). Working at a standing desk is a popular strategy to help reduce low back pain due to prolonged work (Cregg et al., 2020). However, insufficient foot clearance at a standing desk may cause the workers to stand farther away from the workspace and lean forward in an unhealthy, awkward posture; therefore, sufficient foot clearance is required while working in a standing position (Konz & Johnson, 2007). Provision of footrest: built-in or portable allows the worker to shift body weight from one leg to the other while working in a standing position.

METHODOLOGY

Ergonomic intervention was done in three stages.

Stage 1: Description of Work and Workstation

This stage consisted of obtaining information on the current status of the work pattern, workplace layout, job demands, and work hours as preliminary analysis. Distribution units are responsible for the storage, packing, and distribution of medicines. The job of packing workers or pickers typically includes: picking, checking, packing, and carrying. Pickers lay the goods in specified quantities on the floor and pack them. Packed boxes are moved to be dispatched (Murarka & Chauhan, 2021). Currently, the work is performed on the floor, which requires workers to bend and twist their back and legs several times. As shown in **Figure 1**, they sit on the floor in a squatting and kneeling position.

Stage 2: Designing of Workstation

A workstation was designed to reduce ergonomic risk factors considering:

Figure 1: Existing workstation.

- Work pattern/ job demands of the workers involved in pharmaceutical distribution
- Anthropometric principles and measurements of workers
- Guidelines for standing work

Components of New Workstation

The new workstation design consists of an elevated horizontal platform on which four people can work (**Figure 2**). The two main components of this workstation are one main table and two side tables. Other appendages in the workstation are four drawers, one overhead storage shelf, one storage cum footrest (footrest 1), and footrest 2.

Advantages of the new workplace over the existing one:

- Avoids squatting kneeling on the floor
- Avoids back bending and twisting of back and legs in standing or sitting position
- Avoids bending to lift the load once

Anthropometric Variables Considered for Designing New Workstation

5^{th}, 95^{th}, or 50^{th} percentile of the below given anthropometric measurements for male population are considered for designing workstation:

1. Eye height
2. Elbow height
3. Arm reach front

i. Lower position arm reach length
ii. Lower position arm reach height
iii. Upper position arm reach length
iv. Upper position arm reach height

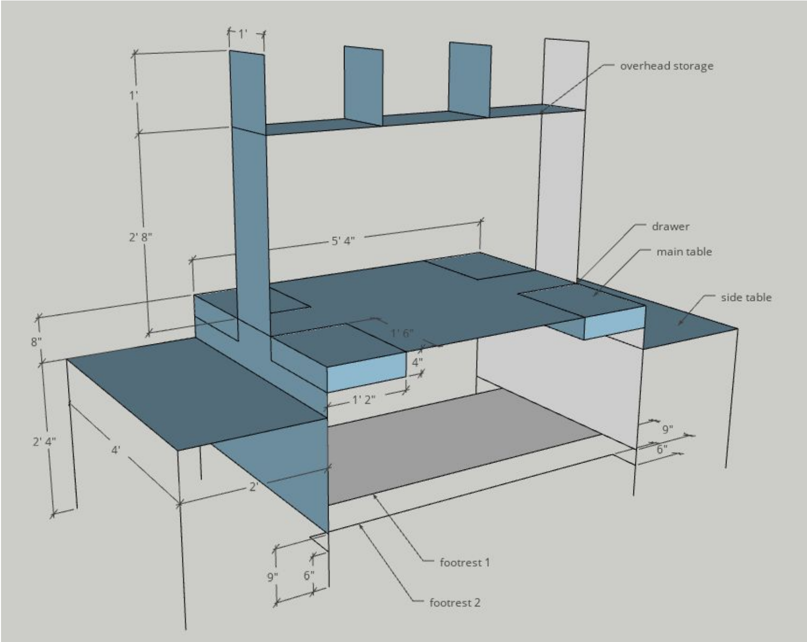

Figure 2: Workstation components and measurements.

Table 1. Reference table for anthropometric measurements. Source: Chakrabarti, 1997.

Anthropometric Variable	Minimum		5th percentile		95th percentile		Mean 50th percentile		Maximum	
	Inch	Feet	Inch	Feet	Inch	Feet	Inch	Feet	Inch	Feet
Eye height	50.91	4.24	55.87	4.65	64.76	5.39	60.19	5.01	71.96	5.99
Elbow height	31.14	2.59	37.20	3.10	44.21	3.68	40.87	3.40	55.31	4.61
Upper position length in front	15.35	1.28	18.46	1.54	31.46	2.62	24.88	2.07	37.01	3.08
Upper position height in front	62.01	5.16	65.31	5.44	81.26	6.77	73.78	6.14	87.40	7.28
Lower position length in front	13.39	1.11	16.50	1.37	30.28	2.52	23.50	1.96	40.55	3.38
Lower position height in front	20.08	1.67	25.94	2.16	36.97	3.08	31.02	2.58	43.31	3.61
Lower position length side	10.63	0.89	16.10	1.34	31.06	2.59	23.23	1.93	36.61	3.05
Lower position height side	17.32	1.44	23.58	1.96	37.76	3.14	30.43	2.53	45.08	3.75

4. Arm reach side

i. Lower position arm reach length
ii. Lower position arm reach height

Table 1 displays all the descriptive and percentile values of the relevant anthropometric dimensions that are considered while designing the workstation.

Figure 3: New workstation.

Stage 3: Implementation of Intervention

The new workstation was introduced to workers as shown in **Figure 3**.

RESULTS

Table 2 explains the components, measurement of each component, and the basis (guidelines) for selecting each measurement.

DISCUSSION

18 anthropometric measures, 9 sitting and 9 standing, were collected to design sitting and standing textile workstations (Kalınkara et al., 2011). Anthropometric measurements of workers were used to design work tables and chairs for manual packing to minimize work posture related risks (Rejeki et al., 2020). Work standardization and anthropometric workstation for the manual and mechanical box assembly operators decreased inefficient movements and body postures in operators from 230 to 78 (Realyvásquez-Vargas et al., 2020). The seat height, seat width, seat depth, upper edge of backrest, and worktable height were selected as the target design variables for deriving console specifications suitable for the body size of Korean users (Lee et al., 2020). Using a footrest in the height range of 10–30 cm during standing computer work was suggested to support better posture (Cregg et al., 2020). Recommended foot clearance space was found to be 150 mm deep, 150 mm high, and 500 mm wide (Konz & Johnson, 2007).

Table 2. Workstation components, measurements, and rationale for deciding size criteria.

Component	Measurements	Feet (Inch)	Criteria to decide size	Rationale
Main table	Length	5'4" (64")	95th percentile of lower side length*2 32" *2= 64" Anthropometric Criteria: Clearance	Gives clearance for work to two large size workers working next to each other.
	Width	4' (48")	5th percentile of lower front length *2 + clearance allowance 17" *2= 34" + 10"	Small size workers can reach without stretching their arms. Also, the allowance for space in the center is there.
	Height from the floor	3' (36")	95th percentile of elbow height – 20cm 44"- 20 cm = 36"	Tall workers can work comfortably. Short workers can use an elevated platform or stool to stand.
Side tables	Length	2'4" (28")	Size of the cardboard boxes used for packing + allowance 24" +4" = 28"	The average size of cardboard box is 24".
	Width	4' (48")	Same as above	Same as above
	Height from the floor	2'4" (28")	95th percentile of lower side height – 5 to 10 cm 36"- 8" = 28"	Avoids working above elbow level. (Chakrabarti, 1997)
Drawers with handle	Length	1'2" (14")	Approximate size	Clearance and easy to grab, push and pull
	Width	1'6" (18")	Approximate size	Clearance and easy to grab, push and pull
	Depth	4"	Approximate size	Clearance and easy to grab, push and pull
Overhead shelf	Length	5'4" (64")	Same as above	Same as above
	Width	1' (12")	Width of main table -5th percentile of upper front length *2 (from both front and back side) 48"-18" *2 = 12" Anthropometric Criteria: Reach	Small size workers can reach without stretching their arms.
	Height from the main work surface	2'8" (32")	5th percentile of upper front height and 95th percentile of eye height + 2" for clearance 5th percentile of upper front ht. = 2'6" 95th percentile of eye height = 2'6" 2'6" + 2" = 32" Anthropometric Criteria: Reach and Clearance	Short workers can reach without stretching their arms. Tall workers get visual clearance.

Table 2. Continued.

Component	Measurements	Feet (Inch)	Criteria to decide size	Rationale
	Height of the shelf	1' (12")	Approximate size of the folded cardboard boxes = 12"	Size of the folded cardboard boxes
Footrest cum storage shelf	Length	5'4" (64")	Same as above	Same as above
	Width	2'6" (30")	Width of the main table – 9" *2 (from both front and back side) 48"-9" *2 = 30"	9" foot clearance is given from both sides
	Height from the floor	9"	Foot clearance	9" foot clearance from the floor level
Additional footrest	Depth	6"	Foot clearance	6" foot clearance from both sides
	Height from the floor	6"	Foot clearance	6" foot clearance from the floor level

CONCLUSION

The ergonomically designed workstation considering anthropometric measures in this study is found to be useful for the pharmaceutical distribution workers by decreasing inefficient movements and awkward postures. The workstation dimensions considered 5th and 95th percentile of the user size, which excludes extreme 5% of the users on the both smaller and larger side. An adjustable workstation can be designed to accommodate the remaining population, but that would be costly. A cost effective and flexible way to cover the shorter users is to provide non-slippery platform to stand.

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