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Anthropometric Dimensions and Preferred Working Surface Heights for the Electronic Operators Workbench

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ABSTRAK

Industri elektronik adalah penyumbang utama ekonomi Malaysia dan sumbangannya akan meningkat lagi di masa hadapan. Buat masa ini, lebih dari 168,000 pekerja terlibat dalam industri elektronik dan lebih banyak peluang pekerjaan akan dibuka. Kajian ergonomik menunjukkan rekabentuk tempat kerja mempengaruhi perlaksanaan kerja. Oleh kerana bangku kerja diguna secara meluas dalam industri elektronik, satu rekabentuk bangku kerja yang mempunyai ketinggian permukaan kerja pemasangan optimal perlu dipertimbangkan untuk pekerja. Satu kajian telah dijalankan untuk dijadikan sebagai asas merekabentuk bangku kerja dengan ketinggian permukaan kerja pemasangan optimal yang sesuai digunakan oleh pekerja wanita dalam industri elektronik di Malaysia. Kertas kerja ini membincangkan hasil dari kajian tersebut. Ukuran antropometrik yang sesuai dan pemilihan ketinggian permukaan kerja untuk 52 pelajar wanita di Fakulti Kejuruteraan Universiti Pertanian Malaysia, Serdang telah direkodkan. Hubungan antara pemilihan ketinggian permukaan kerja dan ketinggian siku dianalisis.

ABSTRACT

The electronics industry in Malaysia is a leading contributor to the economy, and its contribution will undoubtedly rise in future. Currently it employs more than 168,000 workers and is expected to introduce more new jobs. Ergonomics studies have shown that workplace design greatly influences the performance of workers. Since workbenches are widely used in the electronics industry, design of workbenches with optimal assembly working surface heights for the workers must be considered. A study was conducted to gather data for recommendations for an optimal working surface height for female electronics operators in Malaysia. This paper presents the findings of the above study. Relevant anthropometric dimensions and work surface height preferences for 52 female adults in the Faculty of Engineering, Universiti Pertanian Malaysia, Serdang were recorded. The relationship between preferred work surface height and elbow height was analysed.

Keywords: electronics, workbench, ergonomics, anthropometric, optimal working surface heights

INTRODUCTION

The development of Free Trade Zones in the 1970s saw rapid growth in the electronics industry in Malaysia. Currently it employs more than 168,000 workers, mostly women (Government of Malaysia 1991/92).

Due to the work conditions, the working hours, the fast pace of work and the pressure from management in electronics industries, constant complaints of stress and fatigue have been reported (Grossman 1978; Lim 1978; Paglaban 1978; Woon 1982). Back strain, leg pains and excessive fatigue are common to the type of job performed in the electronics industry, and these problems can be attributed to poor workplace design (Rosenthal 1973).

Workplace design which conforms to ergonomic requirements can help in elevating the physiological, and to a certain extent the psychological, problems of the workers. Proper workplace design also increases workers' efficiency. The employment of workers with the required skills, abilities and attitudes, together with an efficient workplace design can enhance performance, thus increasing productivity.

In order to design an optimal work surface height for the electronics workers in Malaysia, relevant anthropometric dimensions are required. Ward and Kirk (1970), in their study on British women performing selected activities in the kitchen, found that there were significant correlations between elbow height and preferred work surface heights, both standing and seated.

An initial study adapted from Ward and Kirk (1970) was conducted at the Faculty of Engineering, Universiti Pertanian Malaysia to gather data on which to base recommendations for an optimal workplace design for female electronics workers in Malaysia. In this study 52 female students were asked to perform tasks similar to the workers in the electronics industry workers on an adjustable worktop.

The objective of the study was to establish preferred work surface heights for some tasks in two positions, standing and seated. It is hoped that the results can be used as a guideline in designing an optimal work surface height for the electronics operators. An ergonomically designed workplace can reduce fatigue and stress, enabling the workers to work for longer hours with fewer rest periods, thus increasing the productive time.

METHOD AND TASKS

Fifty-two female students, ranging from 18 to 26 years of age, from the Electronics Engineering Department were selected. The respondents were selected because they were familiar with the tasks to be performed and representative of the age group of the electronics workers.

The 52 subjects were required to perform the following tasks:

A: Working above the work surface (cutting wires, wire stripping and spraying cleaner on printed circuit boards (PCB)).

B: Working on the work surface (removing, installing and testing PCB components)
C: Exerting pressure on the work surface (soldering, screw-tightening and drilling PCB).

Tasks A, B and C were performed while standing and seated.

Before taking any reading, the subjects were asked to repeat the tasks until they were comfortable with the height of the worktop. Further details of this work can be found in Kandan (1992).

ANTHROPOMETRIC MEASUREMENTS

As shown in *Fig. 1*, the following anthropometric measurements were recorded:

Stature (1)
Floor to elbow (standing) (2)
Floor to elbow (seated) (6)
Seat to elbow (seated) (7)

The preferred working surface heights were those at which these activities were performed.

A, A_s - height of tasks A (standing), A_s (seated)
B, B_s - height of tasks B (standing), B_s (seated)
C, C_s - height of tasks C (standing), C_s (seated)

RESULTS AND ANALYSIS

Anthropometric Dimensions

The mean and the standard deviation for each of the four anthropometric dimensions were calculated.

Dimensions	Mean	Std. dev.
Stature (1)	158.98	7.17
Floor to elbow (standing) (2)	98.85	5.31
Floor to elbow (seated) (6)	70.99	3.79
Seat to elbow (seated) (7)	20.02	4.31

The mean height for the 52 females is lower than the mean height of the British women given in Ward and Kirk (1970). Thus, it is expected that all other anthropometric dimensions of the Malaysian female population are lower than those of the British women.

Preferred Working Heights

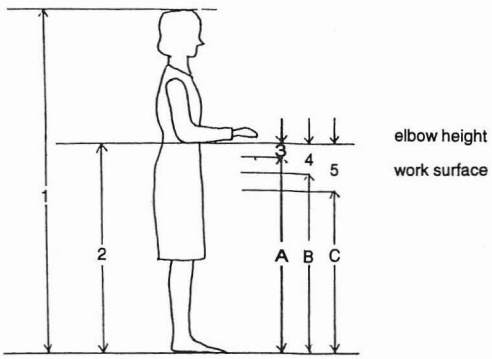
The mean and the standard deviation were calculated for each preferred standing working height and for seated working height. Results are given in Table 1.

TABLE 1a
Mean and standard deviation of preferred working surface height (cm)

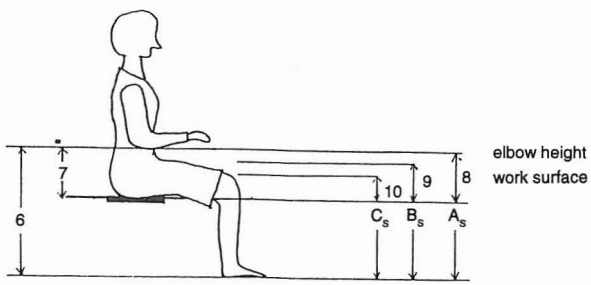
Activity	Mean	Std. dev.
A	88.32	2.37
B	88.57	3.78
C	89.09	3.83

TABLE 1b
Mean and standard deviation of preferred seated working surface height (cm)

Activity	Mean	Std. dev.
A_s	76.70	3.84
B_s	76.09	4.54
C_s	77.09	4.80



a) Anthropometric dimensions (standing)



b) Anthropometric dimensions (seated)

Fig. 1: Relevant anthropometric dimensions, (a) standing, (b) seated

The relationship between the vertical distance of the elbow to the work surface for each activity A, B and C, denoted by 3, 4 and 5 (*Fig. 1*) respectively, and the height from the floor to the elbow were calculated. The results of regression analysis are given in Table 2.

TABLE 2
Results of regression analysis between the standing elbow height and the elbow to the work surface for each activity

Regression output	between standing elbow height (2) and elbow to work surface (3)	between standing elbow height (2) and elbow to work surface (4)	between standing elbow height (2) and elbow to work surface (5)
Constant	87.38846	91.29878	90.7911
Std. Err. of Y Est.	2.388342	3.565171	3.82755
R Squared	0.805752	0.565171	0.5008
No. of Observations	52	52	52
X Coefficient	1.088351	0.734446	0.826O91
Std. Err. of Coefficient	0.075572	0.090736	0.116634
Correlation, r	0.8976	0.7531	0.70769
Significance	$p < 0.01$	$p < 0.01$	$p < 0.01$

The relationship between seat to elbow (seated) height and between seat to preferred seated working height for each activity A_s, B_s and C_s, denoted by 8, 9 and 10 (*Fig. 1*) respectively, was also calculated. The results of regression analysis are given in Table 3.

TABLE 3
Results of regression analysis between seat to elbow height (seated) and seat to preferred work surface height for each activity

Regression output	between seat to elbow (7) and seat to work surface (8)	between seat to elbow (7) and seat to work surface (9)	between seat to elbow (7) and seat to work surface (10)
Constant	1.686953	3.264964	4.87585
Std. Err. of Y Est.	2.426846	2.395698	2.617277
R Squared	0.695623	0.703386	0.64598
No. of Observations	52	52	52
X Coefficient	0.712483	0.667007	0.579807
Std. Err. of Coefficient	0.066651	0.061255	0.060702
Correlation, r	0.8340	0.8387	0.8037
Significance	$p < 0.01$	$p < 0.01$	$p < 0.01$

DISCUSSION

To determine whether the sample measurement is characteristic of the electronics operators, the heights of 104 female operators from two electronic companies were taken from their medical records. Since the heights were found to have a mean of 159.09 cm, the anthropometric data collected from the Faculty of Engineering students is considered within the range, and represents the height of electronics operators in Malaysia.

Standing Position

The mean work surface heights preferred by the 52 females were 88.32cm for activity A, 88.57 cm for activity B and 89.09 cm for activity C. As indicated in Table 1, the standard deviations about the mean values for preferred work surface height are quite considerable. This implies that to suit the majority of workers, adjustment of the work height may be between 80.83 cm and 96.75 cm (i.e. 2 sd's above and below the highest and lowest preferred mean heights). This range of heights takes into account the various activities carried out.

Seated Position

The mean seated work surface heights were 76.70 cm, 76.09 cm and 77.09 cm for activities A_s, B_s and C_s, respectively. Again, the standard deviations about the mean indicate a range of between 67.01 cm and 86.69 cm to satisfy the requirements of the majority of users (i.e. 95%).

Relationship Between Standing Elbow Height and Preferred Work Surface Height

Comparison of the means for standing elbow height and the three work surface heights shows that on average all the subjects prefer to have their elbows higher than the work surface. The regression analysis results indicate that there is a positive relationship between elbow height and preferred work surface height. There is also evidence that the greater the elbow height is above the floor, the greater is the difference between the elbow and the preferred work surface height.

Relationship Between Seated Elbow Height and Preferred Seated Work Surface Height

Comparison of the means of seated elbow height (70.99 cm) and the height of the three work surfaces (76.70 cm, 76.09 cm, 77.09 cm) indicates that subjects prefer the work surface to be higher than their elbows. Examination of the figures indicate that a majority of the females prefer work surfaces for all activities to be higher than their elbows. Only two females prefer work surface height to be level with their elbows for activity A. For activity B, one female prefers the work surface to be level with her elbows and two prefer their elbows to be higher than the work surface height. For activity C, two females prefer the work surface height to be slightly lower, almost level with their elbows.

From the regression analysis results it is evident that there is a positive relationship between seated elbow height and seated preferred work surface height; this result is the same as that found in the standing position.

CONCLUSION

The study indicated that the majority of subjects prefer their elbows to be lower than the work surface height for all activities, both standing and sitting. The results obtained were similar to those of Ward and Kirk (1970). When designing work surfaces, this factor must be taken into account to provide comfort and ease, as well as to reduce fatigue and stress to the muscles, enabling the workers to work for longer hours. Besides increasing the efficiency of the workers, it is hoped that the longer hours spent on work will increase the productivity of the workers.

The results also indicate that there was significant correlation between elbow heights and preferred work surface heights, both standing and seated (see Tables 2 and 3). The preference for work surface heights differed not only between subjects of different stature but also for the different activities performed.

To suit the majority of workers, adjustable worktops or adjustable chairs are strongly recommended.

It is also hoped that the anthropometric data collected from this study will form the basis for establishing an anthropometric database for the Malaysian population. This database will provide useful and appropriate information in the design of the workplace, tools and equipment to be used by the Malaysian population.

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