

National

Conference Proceedings

Feb 2013



ERGONOMICS

for Enhanced Productivity

Edited by

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Ergonomically Designed Checking Table and Stool for Garment Industry in Tirupur, India

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Abstract—Clothing is the basic necessity of any human being. The textile garment industry is the largest foreign exchange earner. It is also the second largest employment provider next to agriculture. The garment industry contributes 16.63% to the foreign earnings of India and it employs over 3.5 million workers. Garment production in Tirupur, also known as "T-Shirt City", located in Western Tamil Nadu, accounts for approximately 80 per cent of India's total production of knitwear for export. Tirupur contains a vast network of factories and subcontractors, with units ranging in size from 1000 workers to a handful of workers to individual home-based units. These workers are employed in various sections such as pattern making, cutting, stitching, checking, ironing and packing of garments. Garment production involves different postures to be adopted by the workers; as a result of which majority of them face hazards and risks. Among all the activities carried out by the workers, stitching and checking of garments were found to be most hazardous. This was proved by three assessment tools such as Rapid Upper Limb Assessment (RULA), Body Part Discomfort (BPD) and Hazard Identification and Risk Analysis [HIRA] respectively. The table and stool developed by earlier research were adopted for the study and modified based on the suggestions given by the workers. The modified ergonomically designed table and stool were given to ten workers to use for a period of two months. Evaluation of the improved furniture was carried out using the following headings namely RULA, BPD, Heart rate studies and worker productivity. Studies on the impact of the improved furniture on postural discomfort and productivity revealed that there were a reduction in the discomfort level and also improved the productivity.

Keywords: Garment Workers, RULA, BPD, HIRA, Heart Rate Studies, Worker Productivity

INTRODUCTION

Worker productivity improvement is a major concern in industries, especially with repetitive industrial tasks. These tasks are considered boring, monotonous, fatiguing and de-motivating. This in turn results in reduced worker productivity, poor work quality, and high absenteeism and causes detrimental effects on worker physical and mental well-being. Improving worker productivity in such tasks, therefore, is a challenge for the industrial managers.

Ergonomics is concerned with making the workplace as efficient, safe and comfortable as possible. Effective application of ergonomics in work system design can achieve a balance between worker characteristics and task demands. This can enhance worker productivity, provide worker safety, physical and mental well-being and job satisfaction. Many research studies have shown positive effects of applying ergonomic principles in workplace design, machine and tool design, environment and facilities design (Das *et al.*, 2007).

Clothing is the basic necessity of any human being. The textile garment industry is the largest foreign exchange earner. It is also the second largest employment provider next to agriculture (Vasugi, 2007). The garment industry contributes 16.63% to the foreign earnings of India and it employs over 3.5 million workers. There are five different garment production hubs such as Delhi, Mumbai, Tirupur, Bangalore and Chennai in India; all specialize in different types of garment production (Singh, 2009). Garment production in Tirupur, also known as 'T-Shirt City', accounts for approximately 80 per cent of India's total production of knitwear for export (Regional Report, 2010). Tirupur contains a vast network of factories and subcontractors, with units ranging in size from 1000 workers to a handful of workers to individual home-based units. These workers are employed in various sections such as pattern making, cutting,

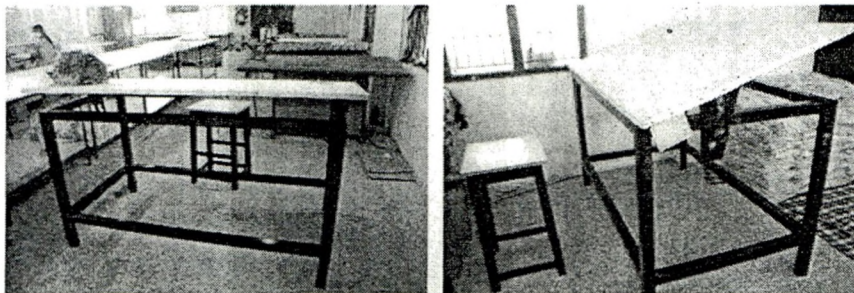
stitching, checking, ironing and packing of garments. Garment production involves different postures to be adopted by the workers; as a result of which majority of them face hazards and risks. Among all the activities carried out by the workers, stitching and checking of garments were found to be most hazardous. This was proved by three assessment tools such as Rapid Upper Limb Assessment (RULA), Body Part Discomfort (BPD) and Hazard Identification and Risk Analysis (HIRA) respectively. In the present study, redesigning of workstation was carried out only in checking section of garment industry.

OBJECTIVE

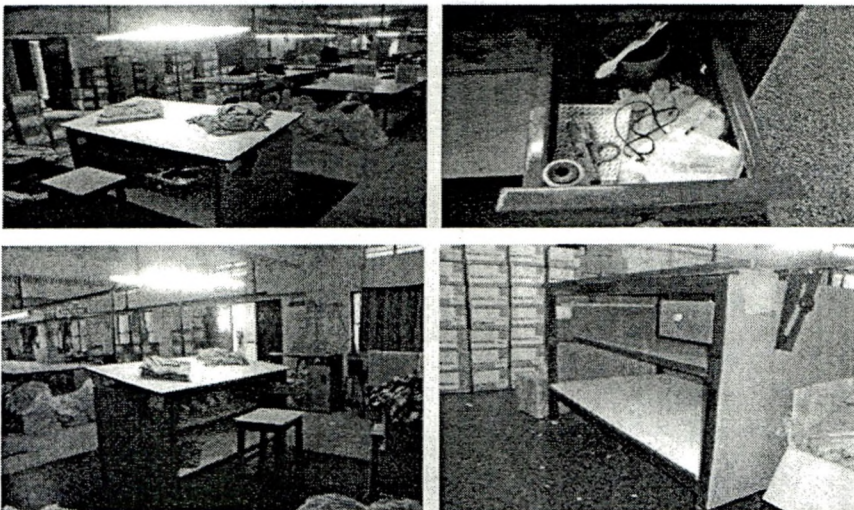
To know the effect of ergonomically designed checking table over conventional table.

METHODOLOGY

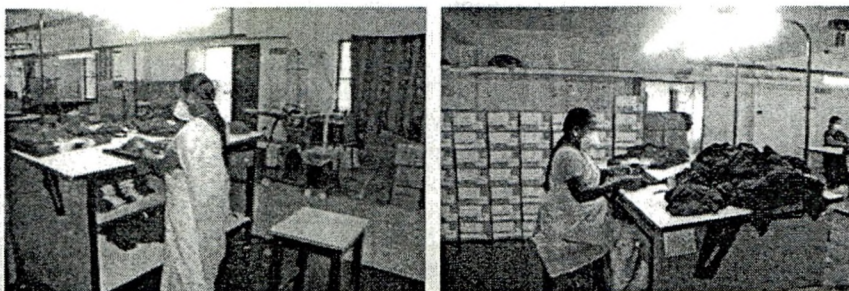
The study was taken up in Tirupur district situated in the Western Tamil Nadu. The table and stool for checking workers of garment industry developed by earlier research (Ganguli et.al. 2007) were adopted for the present study and modified based on the suggestions given by the workers. The modified ergonomically designed table and stool could be used as a sit-stand workstation. The major changes made in the original workstation were the following and it is illustrated in Figure 1.



(a) Ergonomically Designed Checking Table before Modification



(b) Attachment of Provisions to the New Workstation



(c) Modified Ergonomically Designed Checking Table in Use

Fig. 1: Details of New Workstation

- An ergonomic stool.
- An adjustable and adequate worktable.
- Two wooden racks underneath the tabletop were fixed where the centre rack is three-fourth of the bottommost rack in order to enable the worker to have sufficient thigh clearance while working on a seated position. The bottommost rack is used for storing the stitched garments to be checked while the centre rack for keeping the completed checked garments. The bottommost rack is sometimes used as footrest as well.
- Fixation of two white fluorescent tubelights for proper vision while at work. Eighteen volts tubelights were used to generate less heat.
- Closing the sides of the table with plywood so as to prevent accumulation of cotton dust.
- A wooden drawer for keeping a worker's work tools and personal protective equipments such as trimmer, cotton thread, sticker of arrow shape, plastic glass, toothbrush, cotton hand gloves, face masks, etc.

The modified ergonomically designed table and stool were given to ten workers to use for a period of two months. Evaluation of the improved furniture was carried out using the following headings namely RULA, BPD, Heart rate studies and worker productivity respectively.

RAPID UPPER LIMB ASSESSMENT

In order to assess physical exposure to work related musculoskeletal risks, Rapid Upper Limb Assessment (RULA) technique, which is known as a pen-paper observational method, was applied (McAtamney and Corlett, 1993). According to this method, a score is calculated for the posture of each body part. For operations with one hand, either right or left, only one assessment was taken, while separate assessments for the right hand and the left hand were taken in cases where both the hands were used for performing the operations. Score 1 indicates the most neutral posture and score 4 shows the worst position. The combined individual scores for shoulder, elbow and wrist give score A and those for neck, trunk and legs give score B. Muscle use and force exerted are attributed a score of 0 or 1. These scores are added to scores A and B to obtain scores C and D, respectively. Combination of scores C and D, called Grand Score (ranging from 1 to 7), shows the musculoskeletal loading associated with the worker's posture. Low Grand Scores (1 or 2) indicate acceptable working posture (action level 1). For Grand Scores of 3 or 4, further investigation is needed and changes may be required (action level 2). Prompt investigation and changes are required soon for scores of 5 or 6 (action level 3). Finally, immediate investigation and changes are required for Grand Score of 7 (action level 4).

To conduct the assessment by RULA system, the worker was videotaped during her routine job activities. After recording the video, it was cropped after every ten seconds to get snapshots for the analysis of posture of the worker. Hence snapshots of 10 workers working in checking section in the garment industry were obtained. The snapshots were analyzed to fill the scores in RULA scoresheets. The RULA Grand Score was then calculated for each case. Consequently, the level of interventional action required to reduce the risks of musculoskeletal injury due to physical loading on the worker was determined.

BODY PART DISCOMFORT

Postural discomfort was one of the crucial problems of the workers in the garment industries. This was assessed by using body mapping. This is one of the most common and widely accepted methods of obtaining information about body discomfort (Corlett and Bishop, 1976).

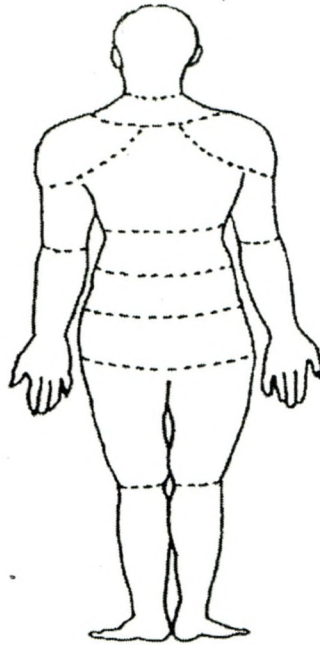


Fig. 2: Body Map

A body map (Figure 2) was used for the study. It was handed over to the ten selected workers employed in checking section with a five point scale, with the extremes anchored by the terms 'no discomfort' and 'extreme discomfort', to each of the workers asking her to judge the present level of overall discomfort. Following this, the worker was asked to indicate the part/parts of the body most uncomfortable and the next most uncomfortable part and so on until no more parts were reported. The procedure was carried out at regular intervals, namely, before the starting of work, before mid-morning tea, before lunch, before afternoon tea and before the end of work throughout the day to study the growth of discomfort as a result of the work. The mean weighted score was estimated for each part of the body experiencing pain and analyzed further to make a realistic appraisal of the body discomforts of the workers in the section.

HEART RATE OF WORKERS

Heart rate is one of the indices of assessing the physical fitness of an individual. The resting, working and recovery heart rate of ten selected workers employed in the checking section were recorded using S-410 Polar Heart Rate Monitor. The working heart rate was recorded for the complete work cycle or for a period of eight hours.

PRODUCTIVITY OF WORKERS

Productivity of ten selected workers employed in the checking section was recorded.

The data thus collected from the above assessment tools were analyzed using SPSS 16.0.

RESULTS AND DISCUSSION

The results of the posture analysis among workers employed in checking section using RULA are shown in Table 1.

Table 1: Overall Distribution of RULA Score

S. No.	Risk Level	Action Level	Ergonomic Intervention	Conventional Table		Ergonomically Designed Table	
				No. (10)	%	No. (10)	%
1	Negligible	1	Acceptable	-	-	-	-
2	Low	2	Investigate further	-	-	1	10.0
3	Medium	3	Investigate further and change soon	6	60.0	9	90.0
4	High	4	Investigate and change immediately	4	40.0	-	-

These results reveal that all categories of the risk levels exist in jobs postures. None of the worker is at negligible and low risk level among checking workers using conventional table. In 60 per cent of the workers studied, RULA Grand Score was between 5 and 6 indicating that the level of exposure to musculoskeletal risks was high and ergonomics intervention to decrease exposure level seemed essential (action level 3). In 40 per cent of the workers studied, RULA Grand Score was 7 indicating that the level of exposure to musculoskeletal risks was very high and immediate ergonomics intervention to decrease exposure level seemed essential (action level 4).

The findings of workers using ergonomically designed table show that none of the worker is at negligible and high risk level. In 10 per cent of the workers studied, RULA Grand Score was between 3 and 4 indicating that the level of exposure to musculoskeletal risks was high and ergonomics intervention to decrease exposure level is needed (action level 2). In 90 per cent of the workers studied, RULA Grand Score was between 5 and 6 indicating that the level of exposure to musculoskeletal risks was high and ergonomics intervention to decrease exposure level seemed essential (action level 3). The finding thus shows that there is risk level in low and medium because the new workstation has the provision of height adjustable table with tilting facility.

The workers' RULA score in detail is presented in Table 2.

Table 2: Process wise Distribution of RULA Score

Conventional Table			Ergonomically Designed Table		
No.(10)	Score	%	No. (10)	Score	%
-	4	-	1	4	10.0
2	5	20.0	6	5	60.0
4	6	40.0	3	6	30.0
4	7	40.0	-	7	-

A similar study (Singh, 2010) was conducted among 130 workers engaged in various process of small scale forging firms of northern India. Posture analysis tools RULA, REBA and OWAS were used. The results of RULA showed that about 30% of the workers were under high risk levels and required immediate change. About 33–38% of the workers were at lower risk levels and 32–33% of the workers were at medium risk levels. It was concluded that there is a lack of ergonomics planning and methods in small scale forging industry.

Another study (Mukhopadhyay and Srivastava, 2010) was investigated among three craft sectors in the Jaipur city of Rajasthan, India, namely stone painting, bangle manufacturing and clay sculpture. Posture analysis techniques REBA, RULA and OWAS indicated that the workers were subjected to vulnerable postures that exposed them to injury and work related musculoskeletal disorders.

Table 3: Comparison of Total RULA Scores of Checking Workers

Variables	Conventional Table	Ergonomically Designed Table	t-Value
Mean	6.2	5.2	6.71**
Standard Deviation	0.789	0.632	

* $p < 0.05$, ** $p < 0.01$, NS: Non-Significant

't' test was used to compare conventional table with ergonomically designed table in terms of RULA scores and it is presented in Table 3. A high significant difference at one per cent level was found between conventional table with ergonomically designed table.

Choobineh *et al.* (2007) states that RULA is used to find out the work related musculoskeletal disorders (WRMDs) and it is found that there is very high score of RULA (action level 3 and 4). RULA score can be reduced by designing ergonomic workstation and thereby reduce the WRMDs among the workers. RULA shows that the awkward working postures and static work are found to be the major risk factors that the workers encountered. Improper design and ill arrangement of workstation are the causes of postural problems and can be cured by redesigning workstations based on ergonomics principles and will reduce the RULA Grand Score.

Table 4 presents the mean scores of the body part discomfort of ten workers (by end of day's work) using conventional table and ergonomically designed table.

Table 4: Comparison of Mean Scores of the Body Part Discomfort of Workers using Conventional and Ergonomically Designed Table

S. No.	Body Parts	Mean Scores of Body Part Discomfort		t-Value
		Conventional Table	Ergonomically Designed Table	
1	Neck	3.40	2.30	6.13**
2	Left shoulder	3.60	2.50	6.13**
3	Right shoulder	3.60	2.50	6.13**
4	Left upper arm	3.10	2.20	3.86**
5	Right upper arm	3.40	2.50	5.01**
6	Left lower arm	3.50	2.70	6.0**
7	Right lower arm	3.60	3.10	2.24*
8	Left palm	3.50	3.40	NS
9	Right palm	3.60	3.50	NS
10	Left fingers	3.70	3.60	NS
11	Right fingers	3.70	3.60	NS
12	Upper back	2.90	2.70	NS
13	Mid back	2.70	2.50	NS
14	Lower back	2.40	2.20	NS
15	Buttocks	2.30	2.20	NS
16	Left thigh	4.10	3.00	6.13**
17	Right thigh	4.10	3.00	6.13**
18	Left leg	4.10	3.00	6.13**
19	Right leg	4.10	3.00	6.13**
20	Feet	4.10	3.00	6.13**

*p<0.05, **p<0.01, NS: Non-Significant

From the Table 4, it is evident that workers experienced extreme discomfort (mean score of 4.10) in the thighs, legs and feet while using conventional table. It may be due to prolonged standing posture mainly by female workers. They also reported severe discomfort in the neck region, shoulders, arms, palms and fingers.

While using ergonomically designed table, workers experienced moderate discomforts in the thighs, legs and feet followed by upper back, mid back, lower back, lower arm, upper arm, shoulders and neck except palms and fingers where they felt severe discomforts. When 't' test was computed between both the tables, a high significant difference at one per cent level were observed in the thighs, legs, feet, neck, shoulders and arms. There was no reduction of discomfort in the palms, fingers and back regions. Body part discomfort of workers is illustrated in Figure 3.

Ghosh *et al.*, (2010) discussed in their paper about MSDs which are reported in different occupations due to improper body posture and work load. Poor designs of workstation are causes of improper postures such as twisting, bending and over reaching. These postures increase the discomfort and pain at different parts of the body such as back, neck and shoulders. By providing proper work desk, the work condition can be improved.

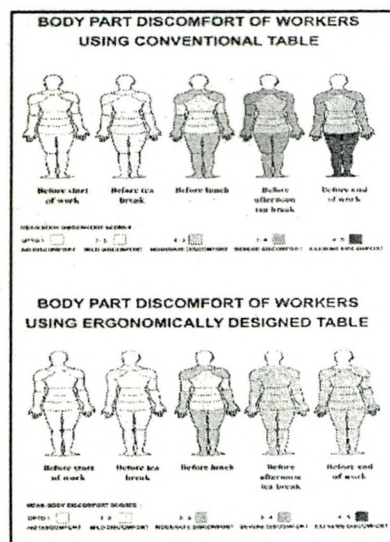


Fig. 3: Body Part Discomfort of Workers

Table 5: Comparison of Heart Rate Studies of Checking Workers using Conventional Table and Ergonomically Designed Table

S. No.	Age (yrs)	Work Experience	Conventional Table			Ergonomically Designed Table		
			Minimum (bpm)	Maximum (bpm)	Average (bpm)	Minimum (bpm)	Maximum (bpm)	Average (bpm)
1	34	10	89	110	100	77	105	92
2	38	20	91	114	102	86	109	97
3	30	5	80	112	95	75	110	92
4	33	9	85	115	99	79	105	91
5	36	22	89	116	102	83	106	95
6	37	20	90	119	104	85	114	100
7	23	6	84	111	96	78	108	92
8	31	11	88	110	99	79	102	90
9	22	4	83	115	98	73	105	87
10	17	1	80	111	95	71	99	85

Table 5 presents the details of heart rate of ten selected workers using conventional table and ergonomically designed table. The minimum heart rate of workers using conventional table ranged from 80 to 91 beats/ min and maximum heart rate from 110 to 119 beats/ min. There was a slight decrease in the heart rate of workers using ergonomically designed table. The minimum heart rate of workers using ergonomically designed table ranged from 71 to 86 beats/min and maximum heart rate from 99 to 114 beats/ min. The reduced heart rate observed in new workstation may be due to less mobility as racks are provided to store the garments for a limited time period.

Vuori (1998) found that the constant fluctuations in heart rates occur due to changes in breathing rate, blood pressure, hormones, various actions of the sympathetic and parasympathetic nervous systems and emotional states, as well as working postures, environmental influences and health status, complicating the analysis of heart rate responses due to specific activity alone. Kapitaniak (2001) explained that despite the great variations in heart rates due to intra-individual differences, the majority of people display average resting heart rates between 60 and 90 beats/ min.

Table 6: Comparison of Heart Rate of Checking Workers

Variables	Conventional Table	Ergonomically Designed Table	t-Value
Mean	99	92.1	7.89**
Standard Deviation	3.091206	4.433459	

* $p < 0.05$, ** $p < 0.01$, NS: Non-Significant

't' test was used to compare heart rate of checking workers using conventional table and ergonomically designed table. A high significant difference at one per cent level indicates clearly that the new workstation is user friendly and much better than the conventional workstation.

Table 7: Productivity of Workers

Worker	Number of Pieces Checked Per Day		Change in Productivity (%)
	Conventional Table	Ergonomically Designed Table	
1	901	982	8.9
2	919	957	4.1
3	812	907	11.7
4	847	923	8.9
5	912	945	3.6
6	923	1009	9.3
7	801	893	11.5
8	820	882	7.6
9	795	868	9.2
10	727	834	14.7

The productivity details of the ten selected workers using conventional table and ergonomically designed table is presented in Table 7. The percentage of increase in productivity ranged from 4 to 15. Their increase in the productivity pattern could be attributed to other factors such as nature of work, the physical fitness and the ability to adapt to the new tub. It could be confirmed that the productivity pattern could be improved by using the ergonomically designed table which has proved to have a reduction in their discomfort level and also the heart rate level.

Many studies showed that ergonomics and quality are closely related in the manufacturing context. In a study among apparel manufacturers in the US, the majority of participating companies reported that investing in ergonomics equipment (e.g. ergonomics chairs or tilted tables) resulted in less human errors and improved quality (Dillard and Schwager, 1997).

CONCLUSION

Any industry plays a significant role in building up of a country in terms of its share in employment, output production and wealth creation. For productivity improvement in manufacturing industries, efficiency of worker plays an important role. Productivity of worker greatly depends upon ergonomic design of workstation. Efficient ergonomics in workstation design shows better interaction between man-machine systems. In the present study, ergonomically designed checking table was adopted from an earlier research and implemented in one of the garment industry in Tirupur. The impact of the improved furniture on postural discomfort and productivity revealed that there were a reduction in the discomfort levels and also resulted in improved productivity. Hence ergonomically designed table and stool for checking section mainly comprised of female workers were found to be effective.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to all the workers and owner of garment industries who rendered immense co-operation during the completion of this study. The authors would also like to thank for adopting ergonomic checking table and stool fabricated and tested done by Dr.P. Parimalam, Professor and Head, Department of Family Resource Management, Home Science College and Research Institute, Tamil Nadu Agricultural University, Madurai and Dr.M.R. Premalatha, Professor and Head, Department of Food Science and Nutrition, Home Science College and Research Institute, Tamil Nadu Agricultural University, Madurai.

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