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ERGONOMIC WORKPLACE EVALUATION OF AN ASIAN GARMENT-FACTORY

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A large number of establishments in the garment industries of the world are situated in the southeastern part of Asia where labor is plentiful and cheap. Recent reports and observational studies suggest that employees in this industry often work under difficult conditions that are unacceptable in industrialized countries. This paper reports the results of an ergonomic study in an export garment manufacturing plant in South East Asia to evaluate the working conditions of the plant from an ergonomics/human factors perspective and to suggest possible solutions to management for implementation. The investigation was done by a questionnaire survey and by observations and measurements in the workplace. The results indicated that the plant conditions were stressful, involving long work hours with poor safety and labor relations, and that work equipment and the physical workplace design were acceptable ergonomic practices. A low-cost solution, presented to management by the investigators, was implemented and, over a period of six months, seemed to be the dominant reason for significant improvements in throughput (14.6%), reduction in absenteeism (65 %), job satisfaction (40 %), decrease in employee turnover (75 %), and reduction in health complaints (50 %).

Key words: garment manufacturing; ergonomics; work design; cumulative trauma disorders

INTRODUCTION

Workers in the garment industry work in clothes designing, sewing or cutting services, and clothes wholesaling (Chan et al., 2002). Due to the nature of these jobs, the prevalence of work-related musculoskeletal disorders has been high. The nature and severity of the disorders have been considered to be the results of the job characteristics -- constrained and sustained work postures, highly repetitive actions, and strong visual demands. The consequences are obvious from the ergonomics points of view – physical and emotional suffering of the workers, high worker compensation costs, decreased productivity and overall inefficiency.

Research on working conditions and associated problems in the garment industry have been conducted by a number of investigators (Keyserling et al., 1982; Punnett, et al., 1985; Blader, et al., 1991; Nag et al., 1992; Anderson et al., 1993; Serratos-Perez and Mendiola-Anda, 1993; and Chan et al., 2002), and their findings have supported the outcomes expected from work environments with poor ergonomic features, including constrained postures, repetitive motions and strong visual demands. Keyserling, et al. (1982) and Serratos-Perez and Mendiola-Anda (1993), for example, found cumulative trauma disorder prevalence rates among sewing machine operators to be 25 % and 47.5 %, respectively. High prevalence rates of problems in the upper body (the neck, shoulders,

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arms, hands, and back) have also been observed by others (Balder et al., 1991; Punnett et al., 1985; Nag et al, 1985; Anderson and Gaardboe, 1993; and Chan et al., 2002)

It is suggested that one of the worst aspects of sewing machine operations in the garment manufacturing industry is the body posture operators are forced to assume throughout the workday. Operators typically sit with a sharp forward flexed torso (Halpern and Dawson, 1996) which places them at risk to musculo-skeletal disorders (Vihma et al., 1982). Such a posture has been found to be mainly the result of the geometry of the workstation, and suggested and tested solutions have included work surface modification (Haslegrave and Corlett, 1993), the adoption of adjustable chairs (Keyserling and Chaffin, 1988; Yu et al., 1988) and various low cost workplace modifications (Chan et al., 2002). Li et al. (1995), in a review of the literature, noted that sewing machine operators' posture improved from changes in machine and work surface inclination, and Yu et al. (1988) also observed significant posture improvements from improved seat design (Yu et al., 1988).

Up to the mid-nineties there was little data and information available in the literature that suggested that these improvements, involving ergonomics principles, have been implemented in the South East Asian garment manufacturing industries (Ahsan, et al., 2000), even though these methods were well documented (Zohir et al., 1996a). To date, anecdotal evidence indicates that this situation has not improved. While the political and economic conditions of the countries concerned may be major factors in this lack of improvement, the awareness of the importance of ergonomic interventions can transcend some of these obstacles.

In addition to the poor physical workplace and equipment design, administrative problems, such as inadequate breaks and lack of job control by workers, as observed by Ahasan and Rabiul (2002), have most likely contributed to the physical ailments mentioned above. In the Asian garment industry, the laxity of labor law enforcement seems to have produced a lack of taking responsibility by management and owners toward working conditions. Studies have shown that most of the garment factories have not followed the country's labor laws and the International Labor Organization's conventions (Bongers, et al., 2002). Management and owners seldom take responsibility for any workplace injuries or accidents, and evade responsibilities, even for accidental deaths (Khan, 1997). In Dhaka, Bangladesh, for example, there is little enforcement of a national minimum wage and, while that wage is expected to be revised every three years, its implementation is lacking especially in the garment manufacturing industry. Violation of working hours is no less severe. According to the labor laws in Dhaka, the maximum number of working hours per day should be 10, including 2 overtime hours but, in most cases, workers are forced to work longer extending to 12 to 16 hours per day. Inadequate or absence of transportation, housing, insurance, social security or children day care facilities exacerbates already difficult working conditions. Anecdotal evidence points to congestion in people and equipment, excessive heat and humidity, poor furniture and physical workstation design. Prolonged sitting, in unnatural postures is not uncommon and is often accompanied with seats that have no backrests. There are also cases of inadequate rest break periods.

The present study is an assessment of the work conditions in a garment manufacturing plant in the export-oriented apparel manufacturing industry in Dhaka, Bangladesh. This particular plant was selected among a few that were visited mainly because of the cooperation and interest shown by its management in conducting the study. The plant is typical of those involved in the export-oriented garment industry in Bangladesh.

The objectives of the study were to enlarge the database of the working conditions in the garment manufacturing industry in South East Asia through an ergonomic evaluation of the working conditions of the workers and to suggest possible solutions to deal with observed problems.

METHODS

Workers' perceptions of their physical work conditions were solicited via a questionnaire, prepared by the study investigators and management of the plant. The questionnaire was administered in

the plant to a total of 460 subjects (419 females and 41 males). The subjects were volunteers and were not promised or given any rewards for their efforts. They were engaged in work activities such as drawing, cutting, operating machines, sewing, and ironing. Questionnaire information was gathered on personal characteristics, subjective opinions about work conditions, and cumulative trauma problems associated with work in the plant. The personal and job related characteristics of the subjects (age, years at work, gender, education level and work experience) are summarized in Table 1. The investigation lasted for six months and involved management participation at all stages. However, the acquiescence of management to perform a follow-up study could not be guaranteed and was not done. Also, a control group of subjects in the investigation was not practical because of high turnover. Quantitative data were analyzed with the SPSS statistical analysis system.

Table 1. Personal and job-related characteristics of the workers who participated in the questionnaire survey.

Variables	Mean	SD
Age (years)	27	4.1
Years at work	4.3	3.2
Working hours per week	52.5	5.6
	N	%
Education		
Primary	210	45.7
Secondary	188	40.9
Higher secondary	55	11.2
College	7	2.2
Marital Status		
Married	173	37.6
Not married	287	62.4

First a seminar lasting over an hour was conducted for the subjects to help them understand work related health problems and symptom recognition so that responses to the questionnaire would be as accurate as possible (Sarder and Ali, 1996). They were made aware of the distinction between injuries and pains caused by work activities and those caused by non-work activities. While this was always difficult to do, the aim was to make the workers aware that aches and pains felt at work might not necessarily have been caused by work activities. Workers were instructed that they should be totally honest and were advised that their individual responses would remain anonymous, protected by the study investigators who were university professors, and unavailable to company management. After the seminar, a walk-through investigation was conducted by the investigators and two of the industrial engineers from the plant, who were knowledgeable in the area of human factors/ergonomics, to gather information on work characteristics, work and workstation design and workplace environmental conditions. A checklist was used as an aid.

A small sample of 10 workers (3 males and 7 females), in excellent health, were also tested for their heart rate during the work shift, while working, using a portable telemetric device (Polar Electro, made in Finland). They were a mixture of older and younger workers. They wore the device by using an adjustable band, containing the electrodes and a transmitter, around the chest area. It is assumed that this intervention caused no significant interference to the workers' work activities. The heart rate results were taken as indicative of the physiological strain of the workers. The workplace environmental variables measured were relative humidity and ambient air temperature, by means of standard instruments.

RESULTS AND DISCUSSION

The subjects were relatively young, with the mean age of 27.1 years (n = 460). About two thirds of them were below 30 years of age, with about 15 % below 20. They were relatively inexperienced, with an average duration of 4.3 years on the job. These data, which suggest rapid turnover of the workforce, are typical of most of the South East Asian apparel manufacturing industries (Zohir and Majumder, 1996b) and imply that a severe human cost was embedded in the work. In addition, working hours in this plant were lengthy by the standards of the industrialized countries. Figure 1 is a photograph depicting a typical crowded work environment in the plant that was investigated in the present study. As Figure 2 indicates, approximately 70 % of the sample worked 50-60 hours per week and 65% of the sample were under 30 years of age.

Figure 1. Working environment inside a garment factory.

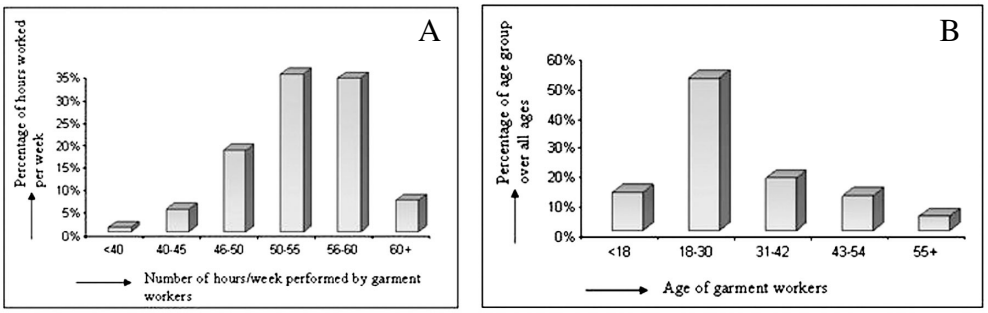

Fig. 2. Frequency distribution of hours worked per week (A) and frequency distribution of age (B) for 460 workers studied.

The walk-through investigation yielded the following observations:

i. Jobs were varied with respect to products, processes, and operations, and were performed both individually and in groups.

ii. Jobs were neither well structured nor routinely organized.

iii. Tasks were generally repetitive and burdensome to workers.

iv. Workspace was congested and sitting postures were typically constrained and uncomfortable. Sitting cross-legged crouched or leaning forward was common.

v. Gripping and pinching with considerable forces and for extended durations was common.

vi. Time schedules were tight and often required hurrying in performing tasks.

vii. Rest pauses were few and short when taken.

viii. Seats were devoid of a backrest (Figure 1), which would have allowed intermittent micro

breaks for resting the upper body after stressful sessions of bending the trunk and neck.

ix. Many seats were hard and wooden, without a cushion to prevent tissue compression at the area of the ischial tuberosities.

x. Sharp bending of the neck was common, combined with sharp bending of the trunk among taller workers, or moderate bending, among shorter workers.

xi. Workspace and equipment design features that would have allowed workers to assume a more upright posture with less trunk or neck flexion, as recommended or tested by Keyserling at al.(1982), Huoviala (1984), and Wick and Drury (1985) were absent. For example, the sewing table surface was neither adjustable in height nor tiltable. Drury (1985) found that an 11° tilt of the sewing table resulted in a reduction of trunk flexion from 17° to 1° and head/neck flexion from 46° to 37°.

xii. Equipment, including sewing machines, was generally old and inappropriately designed.

xiii. There was a general lack of control over work.

xiv. There was a general fear of being dismissed for reporting stressful or unsafe working conditions.

The occurrence of the various work-related disorders, reported on the questionnaire, are summarized in Table 2. As can be seen from the table, most of the reported incidences in the back, neck and shoulders are relatively high and are most likely the result of working with constrained postures, poorly designed workstations and non-ergonomic tools. The high incidence of wrist pains (26 % of the subject sample and 7.9 % of reported cases of pain or discomfort) is an indication of excessive hand work involving gripping and pinching with the arm in constrained postures, and the high incidence of ischial tuberosity pain (29 % of the subject sample and 8.8 % of the total reported cases of pain or discomfort) is the consequence of prolonged sitting on relatively hard surfaces. Moreover, it was observed that there were poor welfare services and a lack of health, hygiene and ergonomic measures taken by the factory owners for workers' legal protection. It is important to note that some of these reported incidences were lower than those reported by Chan et al. (2002) in California and Herbert et al. (2001) in New York (Table 3) but may not necessarily have been due to better work conditions. The results may have been due to (i) a greater degree of tolerance and acceptance of pain and suffering at work in the Bangladesh workplace compared to the American workplace and (ii) differences in reporting by subjects.

Heart rate was found to be significantly higher for older workers (above 40 years of age) than for those below 30 years of age. In general, heart rate increased from an average of 73 beats per minute at the start of a shift up to 84.5 beats per minute, declined during the mid-shift break to 75.5 beats per minute, then increased again after the break to 85 beats per minute (Sarder and Ali, 1996). Ambient plant temperatures ranged from 34-38 °C, which was about 3 to 4 °C higher than the outside temperature, due to the lack of air conditioning in the plant (Sarder and Ali, 1996). The relative humidity was between 50-70% (Sarder and Ali, 1996). This combination of environmental variables

Table 2. Occurrence of work-related disorders.

Reported work-related problems	Number of subjects	Percentage of subjects	Percentage of total reports of disorders
Back pain	285	62	18.7%
Neck pain	156	34	10.2%
Shoulder pain	160	35	10.5%
Wrist pains	120	26	7.9%
Ischial tuberosity pain	134	29	8.8%
Other pains in the upper body	86	19	5.6%
Visual discomforts	53	12	3.5%
Dehydration	47	10	3.1%
Other discomforts	168	37	11.0%

Table 3. Occurrence of work-related disorders compared with other studies.

	Present study (in Dhaka, Bangladesh)	Herbert et al. (2001, in New York)	Chan et al. (2002, in California)
Diagnosis	Number (%) reporting pain (n=460)	Number (%) reporting pain (n=36)	Number (%) reporting pain (n=99)
Back pain	285 (18.7%)	-	48 (26%)
Neck pain	156 (10.2%)	17 (47%)	33 (18%)
Right Shoulder pain	160 (10.5%)	23 (66%)	23 (13%)
Left Shoulder pain		13 (36%)	
Carpal tunnel syndrome symptoms	120 (7.9%)	16 (46%)	7 (4%)
Other discomforts	168 (11.0%)	-	8 (4%)

indicated a physiologically stressful work environment (Ahasan, 2002), which certainly affected the daily productivity and the long-term health of workers.

A comprehensive solution to deal with the ergonomics problems found in this study was proposed to the Factory Owners and Employers Association but was deemed to be too costly (approximately US $26,000.00). It was based on both engineering and administrative methods and also involved personal protective devices. Therefore another, less costly, alternative (US $3,300.00) consisting of basic low technology interventions was proposed. These solutions included mainly using chairs with backrests, floor mats for standing tasks (e.g. cutting), tilting the worktables by using wooden wedges under the legs, implementing training programs with work safety awareness, and playing background music. A balance line was implemented prior to ergonomic evaluation but the productivity improvement was not as much it was thought by the management. These low technology ergonomic solutions were implemented to boost the productivity in the manufacturing process, since management was interested not merely in line balancing but with other aspects that could improve productivity. Overall the plant gained an hourly production of 6 pieces solely from the ergonomic intervention.

The results of the implementation of the solutions reported by management, was a recovery of the cost of the ergonomic improvements ($3,300) within 4.4 months, a 14.6% increase in production rate, a 65% reduction in absenteeism, a 40% increase in job satisfaction, a 75% reduction in employee turnover, and 50% reduction in the number of health related complaints.

CONCLUSION

This study examined the ergonomic work conditions in a garment manufacturing plant in Dhaka, Bangladesh. Questionnaire survey responses, observations of the physical workplace and empirical measurements pertaining to working conditions showed clear evidence of work practices, workplace conditions and equipment designs that were detrimental to productivity, health and safety. The deleterious effects included relatively high incidences of musculoskeletal problems, mainly in the upper body, poor morale and high worker turnover. The observed effects are, however, not unlike those found in other South East Asian garment manufacturing plants. It seems that the tradition of management and owners of not making changes they consider costly, initially, is still difficult to overcome, and ergonomic interventions, which do not typically yield quick results are not exceptions. It is, therefore, pragmatic, as done in this study, to suggest changes that are modest, for gaining acceptability to management. Recommendations made to management in this study that included furniture and other equipment improvements were combined with improved line balancing of the manufacturing process. The implementation of these recommendations yielded significant improve-

ments in productivity and the effects on the workers over a relatively short period of time.

The information gained on work conditions and the ergonomic analyses, with implemented solutions, add to the state of knowledge of these workplaces and focus our attention on where work condition improvements are needed. Unless the work culture changes drastically, it would always be difficult to implement changes that alleviate suffering and ill health among workers in societies where unemployed people wait in abundance for a chance to work, and where their introduction into the workplace is seen as an alternative to spending money and other resources to improve work conditions.

REFERENCES

Ahasan, MR, Partanen, T, and Lee, K (2000) Occupational health and safety in the third world–a simple case of neglect. In: Human Space Time–Environment, ed. By Sohn JY, Proc. of the 5th International Congress on Physiological Anthropology, Seoul: pp. 247-252.

Ahasan, MR (2002) Occupational health, safety and ergonomic issues in small and medium-sized enterprises in a developing country. Department of Process and Environmental Engineering; University of Oulu, Oulu.

Anderson, JH and Gaardboe, O (1993) Musculoskeletal disorders of the neck and upper limb among sewing machine operators: a clinical investigation. *Am. J. Ind. Med.*, **24**: 689-700.

Blåder, S, Barck-Holst, U, Danielsson, S, Ferhm, E, Kalpamaa, M, Leijon, M, Lindh, M, and Markhede, G (1991) Neck and shoulder complaints among sewing machine operators: a study concerning frequency, symptomatology, and dysfunction. *Appl. Ergon.*, **22**: 251-257.

Bongers, PM, Kremer, AM, and ter Laak, J (2002) Are psychosocial factors risk factors for symptoms and signs of the shoulder, elbow, or hand/wrist? A review of the epidemiological literature. *Am. J. Ind. Med.*, **41**: 315-342.

Chan, J, Janowitz, I, Lashuay, N, Stern, A, Fong, K, and Harrison, R (2002) Preventing musculoskeletal disorders in garment workers: Preliminary results regarding ergonomics risk factors and proposed interventions among sewing machine operators in the San Francisco bay area. *Appl. Occup. Environ. Hyg.*, **17**: 247-253.

Halpern, CA and Dawson, KD (1997) Design and implementation of a participatory ergonomics program for machine sewing tasks. *Int. J. Ind. Ergon.*, **20**: 429-440.

Haslegrave, CM and Gregg, H (1988) Improving the ergonomics of production sewing tasks. In: Advances in Manufacturing Technology III, ed. By Worthington B., Kogan Page Ltd., London: pp. 284-288.

Herberta, R, Dropkina, J, Warrenb, N, Sivinc, D, Doucettea, J, Kelloggd, L, Bardine, J, Kassf, D, and Zolothg, S (2001) Impact of a joint labor-management ergonomics program on upper extremity musculoskeletal symptoms among garment workers, *Appl. Ergon.*, **32**: 453-460.

Khan, Z (1997) Musculoskeletal problems of female garments worker in Bangladesh: some anthropometrics. Unpublished Masters Thesis, Department of Human Work Science, Luleå University of Technology, Luleå.

Li, G, Haselgrave CM, and Corlett EN (1995) Factors affecting posture for machine sewing tasks. *Appl. Ergon.*, **26**: 35-46.

Nag, A, Desai, H, and Nag, PK (1992) Work Stress of Women in Sewing Machine Operation, *J. Human Ergol.*, **21**: 47-55.

Punnett, L, Robins, JM, and Wegman, DH (1985) Soft Tissue Disorders in the Upper Limbs of Female Garment Workers. *Scand. J. Work Env. Hea.*, **11**: 417-425.

Sarder, MD and Ali, MY (1996) Design of a Production Line– It's Balancing and Layouting for a Garment Factory. B.Sc Engineering thesis, Department of Industrial and Production Engineering. Bangladesh University of Engineering & Technology, Dhaka.

Serratos-Perez, J and Mendiola-Anda, C (1993) Musculoskeletal disorders among male sewing machine operators in shoemaking. *Ergonomics*, **36**: 793-800.

Vihma, T (1981) Health hazards and stress factors in small industry-Prevalence study in the province of Uusimmaa with special reference to the type of industry and the occupational title as classifications for the description of occupational health problems. *Scand. J. Work Env. Hea.*, **7**: 149.

Yu, C, Keyserling, WM, and Chaffin, DB (1988) Development of a work seat for industrial sewing operations: results of a laboratory study. *Ergonomics*, **31**: 1765-1786.

Zohir, SC and Majumder, K (1996a) Occupational health of garments workers in Bangladesh. Unpublished Report, Bangladesh Institute of Development Studies, Dhaka.

Zohir, SC and Majumder, K (1996b) Garment workers in Bangladesh: Economic, social and health condition. Research Monograph No 18, Bangladesh Institute of Development Studies, Dhaka.