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Assessment of Work Related Musculoskeletal Disorders in Manufacturing Industry

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Abstract

Results of study show that experience workers having more reported pain in upper body parts due to poor work station design. This study is focused on measuring the Risks for WMSDs (Work related musculoskeletal disorders) among workers in a manufacturing company, by applying ergonomic tools like QEC (quick exposure checklist), RULA (rapid upper limb assessment) scores and Nordic questionnaire. A cross-sectional study was conducted among workers aged between 18 to 45 years with a total number of 48 workers selected through random sampling with in the duration of 12 weeks. Validated version of QEC, RULA score sheet and Nordic questionnaire was used to measure the risk level and number of reported pain in body parts among workers. The results showed that the mean score of QEC and RULA was 73.6 and 4.6 respectively. However, results showed that experienced workers reported more pain in different body parts, indicating more chances of WMSDs among them. 79% workers of total sample had reported pain in different parts of body according to Nordic questionnaire, out of which 86% workers had pain in upper part and 14% had pain in lower part of the body that was also verified from QEC and RULA score sheet.

Keywords: RULA and QEC comparison; Nordic questionnaire comparison with QEC; Work Related Musculoskeletal Disorders (WMSDs) risk

Abbreviations: WMSD's: Work Related Musculoskeletal Disorders; MSD: Musculoskeletal Disorders; RULA: Rapid Upper Limb Assessment; QEC: Quick Exposure Checklist; NMQ: Nordic Musculoskeletal Disorders

Introduction

Generally in developing countries, small scale industries employ high percentage of workers as a substitute of automation. Such industries contribute to major economic growth to these countries. Usually, health and safety initiatives for workers are less considerate in such industries [1]. The understanding and control measures regarding occupational hazards in developing countries is underprivileged [2]. Moreover, uneducated labour in these countries discourages to adapt new technologies. And also local manufacturing industry's workstation are poorly designed. Most of the time workstations are not designed according to the principles of ergonomics, as a result number of Work Related Musculoskeletal Disorders (WMSDs) are generated among workers. WMSD's have a significant influence on both labour and industries all over the world [3]. WMSD's have been recognised a most important problem in European Union in terms health, capital and productivity [4].

Manufacturing industry under study is highly labour intensive. Most of the tasks are being performed manually by the workers. Fitting, folding, pasting, stitching, trimming and cleaning tasks were studied. A typical manufacturing process have highly repetitive tasks, which is performed in sedentary position. Current working conditions in each task results in poor trunk and upper extremities postures. Traditional tools and poor work layout are also contributing to number of WMSD's among workers in these industries [5]. The term musculoskeletal disorders (MSDs) is used to refer to injuries and illness of different body parts involved in working. Symptoms of WMSDs in manual handling, prolonged standing and working in awkward posture are very high irrespective of tasks [6].

In manual tasks like pasting, fitting/folding, cleaning, tools and equipment such as hammers and scissors are extensively being used in fashion design industry. These tools considered to have poor ergonomic design. This study mainly focus manufacturing industry where cutting, pasting, stitching, trimming etc. activities are performed. As shown fitting and folding (Figure 1), pasting (Figure 2), stitching (Figure 3), trimming (Figure 4) and cleaning (Figure 5) shown below. And most of operations are done manually due to which this department is highly labour intensive. For this study, we selected these departments, as we observed more risk factor of WMSDs because majority of the tasks are being performed using traditional hand tools (hammers, scissors etc.) in sedentary posture. Hand tools being used are resulting in cumulative trauma disorders among workers [7].

The risk of WMSDs among workers with acceptable working posture and enhanced productivity with the usage of minimum resources. Current study is applicable on every industry where manual operations are performed irrespective of its size and nature of job.

This study was steered to determine the prevalence of WMSD's and to suggest possible solution for risk reduction among fashion designing industry. It is assumed that the result of this study could be suitable for planning, designing and implementation of ergonomics principles at fashion industry workplace to reduce WMSDs risks.

Methodology

Participants

Study population consisted of shoe and garment manufacturing workers, from leading industries, of Pakistan. There were different manufacturing lines with 5 different types of manual operations

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Figure 1: Fitting/Folding task.

Figure 2: Pasting task.

Figure 3: Stitching task.

including stitching, pasting, trimming, fitting and cleaning selected. A random sample of 48 workers were taken for study over 12 weeks. Study population was 18 to 45 years old with average working experience was between 1-5 years. All the selected workers for study were free from any disease.

Figure 4: Trimming task.

Figure 5: Cleaning task.

Figure 6: Tendonitis case reported.

Data gathering

Data were collected from October to December of 2015. Appointments were made twice a week and then investigators visited each workstation for data collection. Demographic details of the participant's age, height, weight and job experience were also collected.

Sampling data were collected in three phases. In phase I, QEC tool was applied randomly at 6 workstations having 5 operations in it. The purpose of applying this tool is to analyse the physical and psychological behaviour of workers. Sensitivity levels of QEC are high (the ability to detect a variation in exposure before and after an ergonomic intercession). QEC has two parts, first part is relevant to observer's assessment regarding wrist/hand, shoulder/arm, Neck and back assessment and second part is relevant to task duration, vibration and psychological assessment.

In phase II, RULA was applied with similar strategy as QEC was applied in phase I. RULA was used to evaluate working posture through direct observation [8]. RULA scores were calculated by using "ErgoFellow 2.0 by FBF SISTEMAS" software and identified angles of different body parts as shown (Figures 1-6). This is a validated tool for evaluating bio-mechanical and postural loading on the musculoskeletal arrangements of operators which are known to contribute to MSDs, and it is primarily applicable to sedentary jobs [9] similar to current tasks in this study.

In phase III, data of MSD symptoms in different body sections were noted, on the basis of validated and reliable Nordic musculoskeletal questionnaire. Nordic questionnaire comprises a body map with nine clearly known body regions comprising neck, shoulders, elbows, upper back, lower back, wrists/hands, hips/thighs/buttocks, knees, ankles or feet's. These questionnaires were self-administered [10]. Nordic questionnaire contains organized, required, binary or multiple choice options. The standardized questionnaire was designed to answer the question:

"Do musculoskeletal troubles occur in a given population, and if so, in what parts of the body are they localized?" Demographic details of workers were also mentioned in Nordic questionnaire. All of these techniques were applied on same sample.

Data scrutiny

Statistical scrutiny was steered using Minitab v.17. Descriptive analysis was presented in the form of percentage, mean and standard deviation. For variable inferential analysis, One-way ANOVA and independent T-test was used to obtain significant mean differences of QEC and RULA scores with respect to different tasks. ANOVA was individually applied over QEC and RULA score with respect to each task. One sample t-test was used to find significant variable difference with QEC and RULA score individually. WMSD's analysis was done using Nordic Questionnaire's result to find relation with job experience with the help of 2-sample t-test. The level of significance was set at 5%. For statistical tests, p-values=<0.05 were considered statically significant. Data normality tests were also performed.

Results

Descriptive analysis

Demographic details of the workers are presented in Table 1. Average job experience of worker is 3.52 years with standard deviation of 3.83 years.

Table 2 shows the mean and standard deviation of RULA (pasting, trimming, stitching, fitting and cleaning tasks). RULA score ranges from 1 to 7. Grand mean of all tasks that study are 4.2 according to RULA assessment.

From Table 3, that is the action table for RULA result, we relate our actual result of Table 2 with it. Our finding suggest that mean values of stitching and cleaning tasks are 3.5 and 3.8 that is the level 2, indicating further investigation is required for stitching and cleaning tasks. On the other hand pasting, trimming and fitting tasks RULA score are 4.9, 4.3 and 4.6 that is the level 3 indicating that 'investigation and changes required soon' for these tasks.

Mean and standard deviation of QEC questionnaire, operation wise are shown in Table 4. Maximum score of QEC is 100 out of which pasting and cleaning operations score is 69 and 68 respectively. Trimming, stitching and fitting task scores are 71, 73 and 74 and these all scores are greater than 70. Grand mean score of all tasks are 71 calculated with the help of QEC questionnaire then analyse with the help of ErgoFellow 2.0 software.

In Table 5, QEC responses relevant to tasks and its equivalent RULA score are shown. For comparison of Table 4 with 5, only pasting and cleaning tasks are in between 51%-70% its mean that we should investigated further and changed soon the cleaning and pasting tasks. In trimming, stitching and fitting tasks scores are greater than 70% so we should investigated further and immediately change these tasks.

Study variables	Mean	SD
Age (years)	25.52	2.68
Weight (kg)	69.52	0.08
Height (ft.)	5.39	2.77

Table 1: Demographic details of study population (n=48).

Task types	Mean	SD
Pasting	4.9	0.69
Trimming	4.3	0.79
Stitching	3.5	0.82
Fitting	4.6	1.21
Cleaning	3.8	0.71

Table 2: RULA grand score of workers for individual task (n=48).

Action level	Recommendation
Level 1	Score of 1 or 2 indicate posture is acceptable if not for long period
Level 2	Score of 3 or 4 indicates that further investigation is needed and changes may be required
Level 3	Score of 5 or 6 indicates that investigation and changes required soon
Level 4	Score of 7 indicate that investigation and changes are required immediately

Table 3: Action according to RULA score (Sara Dockrell, 2012).

Task types	Mean	SD
Pasting	69	6
Trimming	71	6
Stitching	73	4
Fitting	74	8
Cleaning	68	12

Table 4: QEC grand score of workers in percentage form for individual task (n=48).

QEC score (% total)	Action	Equivalent RULA score
≤ 40	Acceptable	1-2
41-50%	Investigate further	3-4
51-70%	Investigate further and change soon	5-6
≥ 70	Investigate further and change immediately	7+

Table 5: Action level of QEC (Geoffrey David, 2008).

RULA score grand average is 4.2 according to Table 4 and QEC grand score is ≥70, according to Table 5 [11]. Both these questionnaires RULA and QEC were applied on same workers and tasks, having same workstation position. On comparison of RULA grand score 4.2, QEC score should be within range of 41-70 on the basis of Table 5 but it is ≥70. QEC mean score is high as compare to RULA mean score the possible reason behind it the psychological factors that is included in QEC. In 2nd part of QEC 'worker assessment' section psychological questions are present like "difficulty keeping up with work", "Visual demand", "Stressfulness of work" and "Time spend per day doing task" these are manipulate by interviewing the participants while in RULA no such type of activities are done and these questions are absent in it. So that's the reason RULA and QEC mean scores are not coinciding with each other [12]. The high mean result of QEC also shows that participants are not satisfied psychologically. In operation wise comparison the fitting and stitching operations are more psychologically affected because mean RULA score in fitting is almost 4 but by QEC analysis it is 74 that is equivalent to 6 at RULA scale, similar scenario is with stitching task where RULA actual score is 3.5 but by QEC analysis it is 73, that is equivalent to 7 at RULA scale similar scenario with pasting, trimming and cleaning task. Its means that a psychological factor are contributing in these tasks.

Discomfort and pain reported of workers were measured by Nordic Musculoskeletal Questionnaire (NMQ) [13]. Percentage reported pain result of participants are shown in Table 6.

Table 6 shows percentage pain reported by workers in different body parts. This result shows that high pain in neck, shoulder and lower back 34%, 33% and 30% respectively reported by workers.

The results of NMQ elaborate that upper parts of body like neck, shoulders, upper back and elbow have more pain reported as compared to lower body parts like wrist, hips, knees and feet.

Inferential analysis

Inferential analysis of data is done by using Minitab v.17. ANOVA and t-tests are used for analysing result. ANOVA is used to compare any mean difference in task relevant to QEC and RULA result. 1 sample t-test is used to analyse the hypothesis of QEC score ≤ 40 and RULA score ≤ 2. 2 sample t-test is used to find relation whether working experience of workers have any effect on pain reported. In all inferential analyses confidence level is 95%.

These are three hypothesis, test by using ANOVA and T-tests:

H_0=All tasks exposure level is same (QEC)

H_0=All tasks risk level is same (RULA)

Body parts	MEAN % reported	SD
Head	0	0.00
Neck	34	2.88
Shoulder	33	3.21
Upper back	29	2.35
Elbow	17	1.52
Lower back	30	2.07
Wrist/Hand	25	2.07
Hips/Thighs	18	1.48
Knees	5	0.55
Ankles/Feet	4	0.55

Table 6: Summary of pain reported in different body parts on the basis of Nordic questionnaire.

H_0=Experience has no relation with No. of reported pain

Table 7 shows the ANOVA result of QEC that is our 1st hypothesis test. P value is ≥ 0.05 so the result is not significant, its means that exposure level of all 5 tasks is same on the basis of QEC scores.

Table 8 shows the ANOVA result of RULA. P value is not ≥ 0.05 so the result is significant all tasks risk level is not same based on RULA scores. Risk level of under consideration tasks are different.

Sample T-test: H_0=Experience has no relation with reported symptoms (Nordic questionnaire base). Table 9 shows significant results of experience with reported symptoms. This result shows that worker having working experience less than 3.5 years reported pain almost 2 body parts and worker experience more than 3.5 years reported pain in his 3 body parts as shown in Figure 7. These results strengthen alternate hypothesis that is, as job experience increase pain reported (Nordic questionnaire) also increased.

Discussion

This study is an attempt to evaluate the WMSDs risks in manufacturing area. Fashion Industry is highly labour intensive and most of the tasks were performed manually with hand tools. Due to hand tool usage, high risks of WMSDs. The present study observed a high RULA score that is 4.2, so investigation and changes required soon. The score is high because rapid movement of arm in pasting, cutting, folding and stitching are required for making upper part joining, as a result chances of musculoskeletal disorders were observed.

Similar with RULA score (Table 2) as well as with QEC score (Table 4), risk exposure in all task was very high and immediate changes were required. Possible reasons for high scores were poor working postures and strict attitude of the supervisors and management contributed psychologically in high risk exposure level.

Prevalence of MSD symptoms and their risk factor is very high among study population. Most common symptom body regions are neck, shoulders, upper back, lower back, wrist/hand and hips/thigh. Mostly these are the upper parts of body except hips/thigh as shown in Figure 8. Risk factors was high in these areas, due to number of reasons like, improper sitting benches having non-ergonomic design

Source	DF	Adj SS	Adj MS	F	P
Factor	4	398.6	99.66	0.79	0.538
Error	43	5417.9	126.00		
Total	47	5816.5			

Table 7: QEC result of ANOVA for exposure level in different tasks.

Source	DF	Adj SS	Adj MS	F	P
Factor	4	12.85	3.2137	4.09	0.007
Error	43	33.81	0.7863		
Total	47	46.67			

Table 8: RULA result of ANOVA for exposure level in different tasks.

Experience<3.5 yr. vs. Experience ≥ 3.5 yr.				
Variable	**N**	**Mean**	**SD**	**SE Mean**
Score	24	1.63	1.88	0.38
	24	2.79	2.06	0.42
95% CI for difference			(-2.315, -0.018)	
T-Test of difference			**T-value=-2.05**	
			P-value=0.047	

Table 9: T-test result of experience and reported symptoms.

with sharp corners and no proper footrest. These factors increase the risk of vertebrae disorders and contributes in more back and hips/thigh pain. Non-ergonomic tools were being used for cutting and pasting, also increasing risk of carpal tunnel syndrome, tendonitis (Figure 6) and tenosynovitis [14]. Similarly, a hectic 9 hours working shift with 1 hour break causes lot of fatigue among workers.

These findings support that MSDs (musculoskeletal disorders) are a significant problem in hand-sewn fashion industry. Findings are consistent with musculoskeletal pain among similar relative occupation study [15]. The workers in this study had frequently worked for long duration without breaks. These findings predict more pain in upper back due to abnormal ergonomic condition like long working hours with no short breaks, making these task worst for working [16-18].

According to result of T-test, working posture are contributing more in musculoskeletal disorders and as working experience increases, the MSD rate also increases as shown in Figure 8.

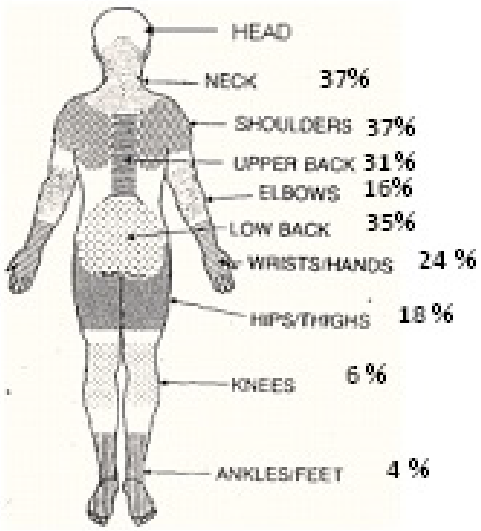

Figure 7: Pain reported in body regions.

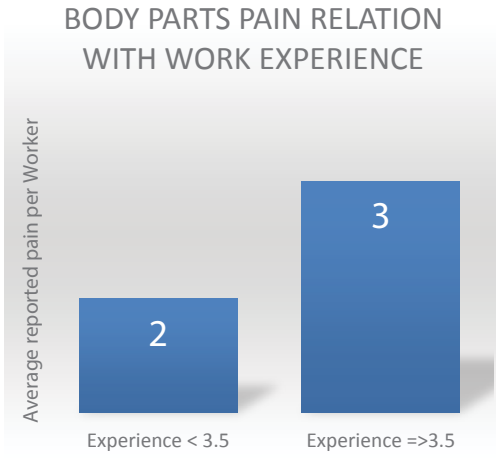

Figure 8: Body parts pain relation with work experience.

Figure 8 shows the relation of pain reported with working experience is shown. These bar graph show workers experience more than 3.5 years reported pain in 3 body parts on average and worker less than 3.5 years' experience reported pain in 3 body parts as per Nordic questionnaire. So we can conclude, as working experience increases chances for the WMSD's risks also increases.

Conclusion

The study shows that prevalence and severity of musculoskeletal disorders, especially in upper body parts neck, shoulder, upper back, elbow, lower back, wrist/hand and hips/thigh is high. RULA and Nordic questionnaire support and verify the results that poor working posture, long working duration, and use of traditional hand tools contributes in risk severity. While QEC also support that psychological factors and work environment contribute in high rating. Result shows that traditional way of working in manufacturing industry has become obsolete so ergonomic design of hand tools and proper workstation layout should be introduced. These ergonomic measures not only contribute in reduction of WMSDs risks but also enhances the chances for improving industry productivity.

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