Physical and Psychological Responses in a Data Entry Task

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ABSTRACT

Computerized office work is of concern throughout the world in relation to incidence of WRULDs (Work Related Upper Limb Disorders). Both physical and psychosocial may have an influence, although the task does not involve high force exertion. Experimental study was carried out to look at possible interaction between physical and psychosocial risk factors. Statistical analysis showed that pace of work as psychosocial risk factor significantly affect stress scores, fatigue scores, pain and discomfort scores. It could therefore be concluded that this particular psychosocial risk factor had substantial effect on both subjective and objective initial body responses and could disturb the internal state of the body.

Key Words: **Office Work, Pace, Stress, Fatigue.**

1. INTRODUCTION

Applying new technology in manufacturing industry has imposed new conditions in the workplace with high potential of development musculoskeletal disorders; for example highly repetitive movements are required while working in some conditions such as feeding the material to the system, withdrawing products from an automated system and machine operating [1].

Most of the work requirements in the light assembly work, such as unsupported posture, sitting work, and precision work, prolonged and repetitive movements of hands, arms and fingers are almost the same as the work requirements during work with computer [2]. Use of computer has become widespread in both the office environment and industries around the world. Moreover, many studies have indicated high prevalence of discomfort and pain in the neck and upper limb of VDU operators [3]. There have been different reactions about complaints reported by VDU operators. Some believe that they exaggerated the adverse effects of VDU tasks, while others believe that complaints are symptoms of a health hazard [4]. This is an area that needs to be more cleared [5].

Keyboard operations are characterized as tasks with repetitive movements of the fingers, hands and wrists with static muscle contractions of arms, shoulders, neck and back. These conditions could contribute to the development of work related musculoskeletal disorders [6]. Galinsky, et. al., [7] conducted a field study to

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investigate the effects of supplementary rests breaks during the data entry tasks. The results of the study showed that neck, back and right shoulders were the body parts which received the highest levels of discomfort. The results were consistent with the majority of the previous research reported by other researchers.

Use of computer has expanded both the office environment and in industry. This technology has advantages and disadvantages depending on the way it is used. Although this machine has solved many problems of human kind, there have been complaints from computer operators about visual strain and physical discomfort in the fingers, hand, wrist, forearm, arm, shoulder, neck and back [8]. There are different reactions to these complaints. Some believe that complaints are not very important, while others consider that complaints are symptoms of health hazards. The health hazards of VDU work have been investigated from the early 1970s. The first concern was eye problems. When other problems, especially ULDs, were recognized in VDU operators, researchers focused their studies on the area of musculoskeletal load, work posture, stress and mental work load [9].

In addition, in recent years there has been an increased emphasis of automation of heavy assembly production lines. Two chief reasons for changes that can be taken into account are, firstly getting more productivity and, secondly, avoiding large compensation and rehabilitation cost resulting from low back injuries. However, unlike heavy manual on production lines, manual handling activities in light assembly and packing work remain at a high level in manufacturing industries [10]. High prevalence of WRULDs has been reported among various industrial workers, including electronics workers, sausage makers, assembly line packers, shoe assembly workers, meat cutters and scissors makers [7].

The purpose of this research is therefore, to investigate the immediate response (e.g. subjective reports of pain/ discomfort, postural behaviour and perceived fatigue) during both data entry and light assembly task.

2. METHODS

To attain the objectives of the research, experiment was designed and conducted. The general method and methodology were adopted from the methodology that McAttamney [11] used for experiments on data entry tasks so that to be able to compare the experimental results.

2.1 Experimental Design

For selected task (i.e. data entry and light assembly task) a related subject design experiment using a simulated task was developed to test the experimental variables. Three risk factors were included in the experiment. Each risk factor had two levels. Considering the feasibility of the experiment performances, the levels of risk factors were limited to only two levels. Otherwise findings of the subjects who could participate into the all experimental conditions for both data entry and light assembly task would be so difficult (This paper however, covers only data entry tasks and the combined results of both the tasks will be presented in next paper).

Independent Variables: Following are the variables chosen as independent variables.

Physical Variable: Key activation force demand in two levels. The force values were 0.5N key activation force as low force demand (using a normal keyboard) and 1.5N key activation force as high force demand (using modified keyboard type).

Psychosocial Variables: Pacing in two levels defined by time allowed for task cycles and mental effort in two levels. A five and three seconds time allowance were chosen as low and high pacing conditions for a task cycle (entering a 5-digit number) performance in a data entry task respectively. Memorizing the five digit random numbers was chosen as basis of low mental load conditions while distinguish between odd and even numbers, memorizing them and reorder

Dependant Variable: The dependant variables chosen to measure the immediate responses of the body were; Physical discomfort rating, stress and arousal, and fatigue score.

2.2 Simulation of Data Entry Task

A computer program generated 5 digit random numbers and displayed them into a box on the screen for 5 or 3 seconds (for the two levels of pacing). Operators entered the same or reversed numbers into the box on the screen simultaneously. Then a new number appeared after time allocated. This continued 31 minutes duration of the trial. The task was repeated in each of the eight different conditions according to the experimental design.

The general idea was to create the mental load in the data entry task by asking the subjects to think about the set of five digits numbers to find whether they were even or odd.

The data entry task requires repetitive movements of the fingers, hand and wrists, which are accomplished by static muscle contractions in arms, shoulders, neck and back and also prolonged viewing of the screen [12]. Keystroke forces vary with different keyboards and typewriters, for example 1.8N for mechanical typewriters and 0.5 N for a flat PC keyboard. The force levels between 0.25 and 1.5N were recommended as optimum key forces.

To simulate a data entry task, firstly a normal gateway keyboard with 0.5N key activation forces was selected to provide low force demand and another keyboard of identical type and characteristics was modified to increase key activation force to 1.5N levels. It was modified by adding a set of especial elastic parts to the existing rubber domes.

3. PROCEDURE

Each subject attended in the experiment over four consecutive weeks (one session per week) and in each session two trials were performed. Each session lasted three and half hour. Each subject used the same experimental instrument and standard workstation during the performance of the task, which was carried out at the normal room temperature. As both data entry and light assembly tasks are usually performed in sitting position and in this particular simulated assembly task use of computer was also necessary, the workstation was adjusted according to ergonomics criteria for both task as follows (following guidelines of [5]).

- Adjust seat height until their hand position was about 5cm below elbow height for assembly operators.
- Add footrest if they find that comfortable
- Adjust seat back angle at 110 degrees.
- Eye distance from screen70cm, shoulder relaxed, 90 degree knee angles, hips at 90-100 degrees and head flexion between 10-20 degrees.

After arrival subjects were asked to sit at the workstation and read the relevant task information sheet. The task was then introduced to them. They were asked to complete the set of checklist, consisting of stress and arousal [12], physical well being checklist, fatigue scale [13] before and after of 30 minutes task performance in each trial. Table 1 shows the eight conditions carried out by each subject.

4. RESULTS

4.1 Stress and Arousal

Table 2 and Fig. 1 show the summary of stress scores in the different task conditions. Raw scores and means of stress scores before and after each trial and also changes in them. As can be seen in Table 1 the mean stress score after the trial were greater than the mean stress score for all conditions. A 2x2x2 analysis of variance with repeated measure design was performed to find a significance due to effects of pacing levels was found to be significant (F=7.2, df=1,7, $p<0.05$).

TABLE1. EXPERIMENTAL CONDITIONS

No.	Task Conditions	
1.	Low force, Low pacing, Low memory	LF,LP,LM
2.	Low force, Low pacing, High memory	LF,LP,HM
3.	Low force, High pacing, Low memory	LF,HP,LM
4.	Low force, High pacing, High memory	LF,HP,HM
5.	High force, Low pacing, Low memory	HF,LP,LM
6.	High force, Low pacing, High memory	HF,LP,HM
7.	High force, High pacing, Low memory	HF,HP,LM
8.	High force, High pacing, High memory	HF,HP,HM

4.2 Arousal Scores

Table 3 and Fig. 2 show summary of the arousal scores in different task conditions. The mean of arousal after the trial were less than the mean of them before the trial of all conditions. A 2x2x2 analysis of variance with repeated measure design was performed and found no significant difference in the effects of any of three independent variables on the changes in arousal scores.

4.3 Fatigue Scores

Table 4 and Fig. 3 show the summary of the fatigue scores in different conditions. As can be seen from Table 3, the mean fatigue scores after the trial were greater than the mean fatigue scores before them for all conditions. A 2x2x2 repeated measure ANOVA showed a significant difference between mean of changes in fatigue scores due to the effects of pacing levels (F=9.09, df=1,7, $p<0.05$). There were no significant difference due to effects of force and mental load levels.

TABLE 2. MEAN STRESS SCORE

Pacing Level	Mean	Standard Error	95% Confidence Interval	
			Lower Band	Upper Band
Low	6.96	2.55	0.92	13.01
High	12.87	2.09	7.91	17.82

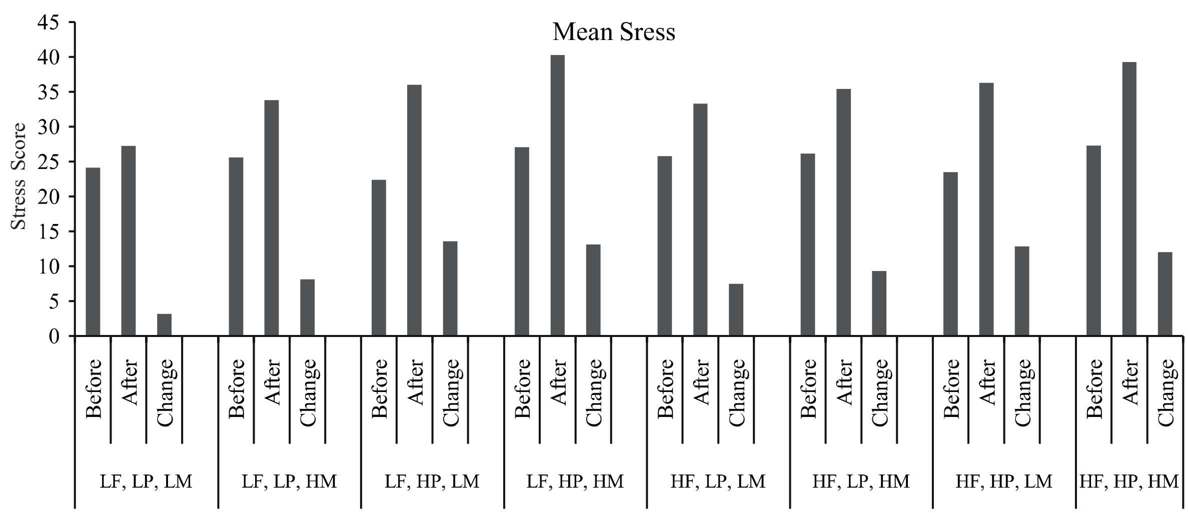

FIG. 1. MEAN STRESS SCORE IN DIFFERENT TASK CONDITIONS OF DATA ENTRY TASK

TABLE 3. MEAN AROUSAL SCORE

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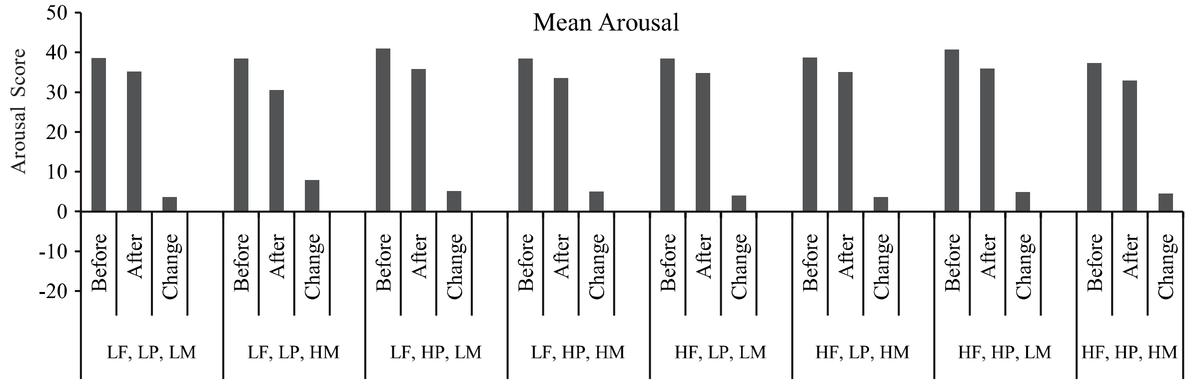

FIG. 2. MEAN AROUSAL SCORE IN DIFFERENT TASK CONDITIONS OF DATA ENTRY TASK

TABLE 4. MEAN FATIGUE SCORE

Pacing Level	Mean	Standard Error	95% Confidence Interval	
			Lower Band	Upper Band
Low	5.8	1.08	3.27	8.41
High	8.1	1.57	4.39	11.86

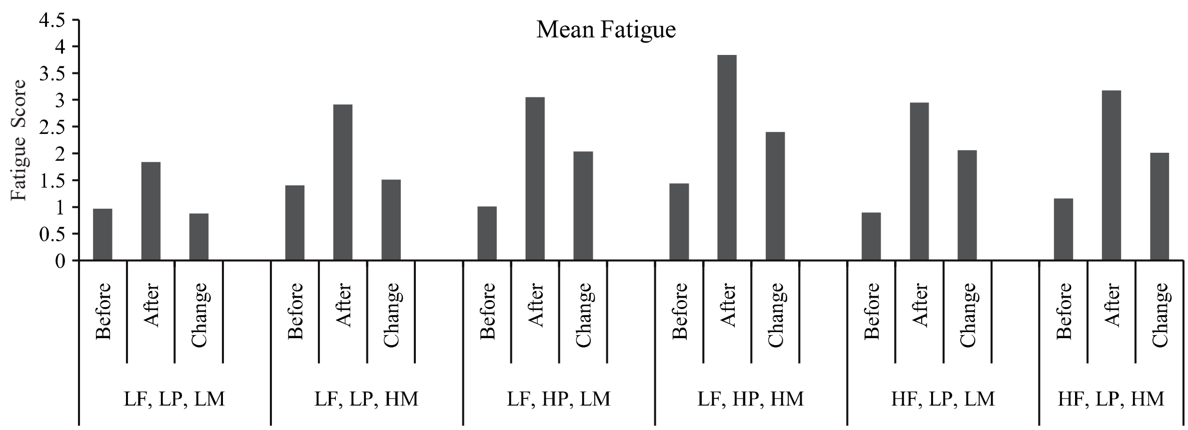

FIG. 3. MEAN FATIGUE SCORE IN DIFFERENT TASK CONDITIONS OF DATA ENTRY TASK

4.4 Physical Discomfort Scores

Physical discomfort score before and after each trial was measured on the body chart diagram and rating scale from 0 (no symptoms) to 10 (severe symptoms). Total physical discomfort score for each task condition was calculated by summing the discomfort rating of all body parts during that task conditions. The change of physical discomfort score was calculated by subtracting the before total score from the after total score as shown in Table 5.and Fig. 4.

4.5 Discussion

A summary of significant results of the experiment on data entry task is presented in Table 6. As can be seen in Table 6, pacing levels significantly affected on stress scores, perceived fatigue scores, pain and discomfort scores.

There are some similarities and differences between the results of present study and those reported by [7,13,14], who studied computer keyboard force and upper extremity symptoms to determine whether keyboard operators who reported more severe levels of upper extremity symptoms applied significantly higher keyboard operating forces than operators with less severe symptoms.

TABLE 6. SUMMARY RESULTS

	Pacing	Force	Mental load
Stress	x		
Arousal			
Perceived fatigue	x		
Discomfort	x		

TABLE 5. MEAN PHYSICAL DISCOMFORT SCORE

Pacing Level	Mean	Standard Error	95% Confidence Interval	
			Lower Band	Upper Band
Low	5.8	1.08	3.27	8.41
High	8.1	1.57	4.39	11.86

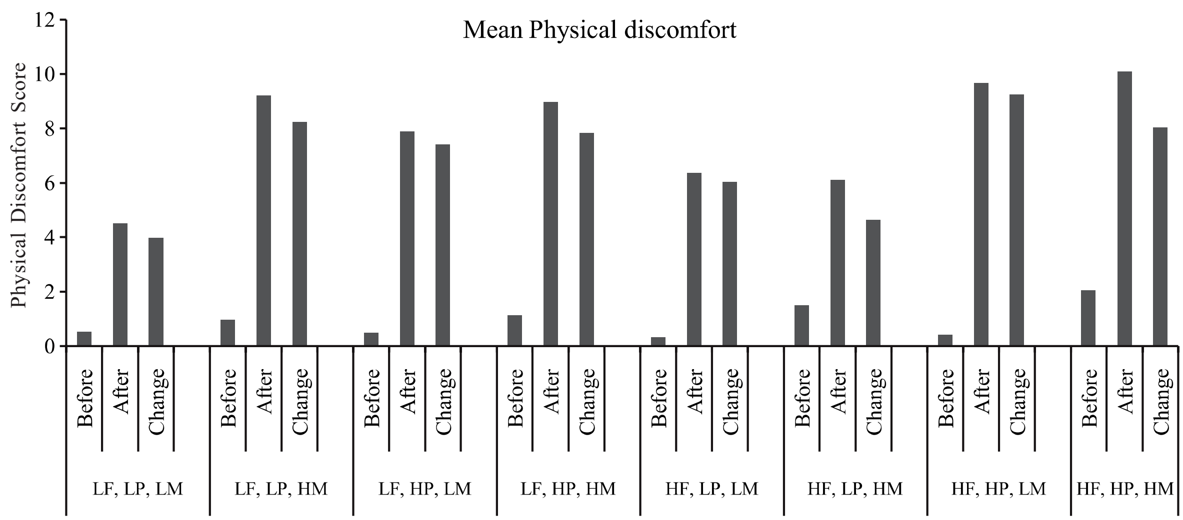

FIG. 4. MEAN PHYSICAL DISCOMFORT SCORE IN DIFFERENT TASK CONDITIONS OF DATA ENTRY TASK

The subjects were 48 office workers who were divided into case and control groups based on self report symptoms. The results showed that operators who reported higher severity of upper extremity symptoms applied significantly higher keyboard operating forces than operators with less severe upper extremity symptoms, although both groups generated forces 4-5 times more than the required key activation force.

The subjects in present study and the subjects (both case and controls) in the former study reported higher levels of discomfort, fatigue and pain after the task performance than before it. The relevant hypothesis regarding the physical discomfort states that different levels of each task pacing, force and mental load would cause a significant difference on physical discomfort levels. The information from all eight task conditions shows physical discomfort caused by general conditions related to the simulated data entry task. Based on this information right shoulder, neck, right hands and fingers, right wrists and eyes were the most frequently reported body parts in which pain and physical discomfort occurred in data entry. When the data related to the high force conditions were excluded and analysis was carried out on remaining on remaining data, a slight change was found in the reported body parts. Based on the later analysis right shoulder, neck, right hands, and fingers, left shoulders and eyes were the most frequently reported body parts.

In addition, duration of work may play an important role in causing discomfort and fatigue and it may differ from different risk factors. There was also a significant interaction between force and mental effort ($F=8.81$, $df=1,7$, $p<0.05$). The level of physical discomfort increased by increasing of the force levels in low mental conditions, by contrast the level of physical discomfort decreased by increasing of the force levels in high mental conditions.

The relevant hypotheses regarding the stress/arousal states that different levels of each of the task pacing, force and mental load would cause significant difference on stress/arousal levels. The results showed that mean stress scores after the trials were greater than the mean stress scores before them; accordingly, the mean stress scores was positive for all the conditions, which indicates level of stressful conditions during the task performance in data entry task. However, the repeated measure ANOVA showed that pace of work was the only factor that had significant effects ($F=7.02$, $df=,1,7$, $p<0.05$) on change of stress scores.

5. CONCLUSIONS

Statistical test showed that pace of work as a psychosocial risk factor does significantly affect stress scores, fatigue scores, pain and discomfort scores. It could therefore be concluded that this particular psychosocial risk factor had substantial effect on both subjective and objective initial body responses and could disturb the internal state of the body.

According to the conceptual model for the developments of WRULDs (Armstrong, et. al. 1993) human capacity might be decreased by such disturbances within periods of time. The findings clearly revealed significant effects of pace levels related to cause of physical discomfort.

There was an interaction between force and mental effort with respect to the physical discomfort. This could be evidence showing that physical (force) and psychosocial (mental load) risk factors could have interaction effects to cause physical discomfort in data entry operators. Another interesting point is that pace of work in data entry task has not only a direct effect to produce physical discomfort, but also indirect effect by increasing of wrist displacement either in flexion/ extension or in ulnar/ radial deviation.

Right shoulders, neck, right hands and fingers, right wrists, eyes were the most frequently reported body parts in which pain and physical discomfort occurred in data entry operators.

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