MUSCLE LOAD AND DISCOMFORT IN COUNTER WORKSTATION USERS

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Abstract: This study reports the results of an investigation into muscle load and discomfort in counter workstation users. Two types of counter workstation— one fixed and one adjustable— were used in the study. Twelve male and female subjects participated in the study. Typical tasks performed by service counter workers at a customs check-in area were simulated. Work was carried out in the seated posture and was self-paced. Muscular activities of the bilateral upper trapezius, lower trapezius and anterior deltoid muscles were recorded through surface electromyography. Body discomfort ratings at the neck, shoulder and lower back areas were also recorded at the end of the task. The results of the study showed that there was approximately 25-34% decrease in muscular activity of both right and left upper trapezius, lower trapezius and anterior deltoid muscles as subjects moved to work from fixed counter workstation to adjustable workstation. Discomfort levels indicated by the subjects in the neck, shoulder and lower back areas were considerably higher in fixed counter workstation as compared to adjustable one. Statistical analysis of the muscle activities and discomfort ratings revealed significant differences between the two types of workstations. The paper presents suggestions for further work.

1. INTRODUCTION

Recent years have seen a dramatic rise in the cases of work related musculoskeletal disorders (MSD) worldwide. In Australia, according to available workers compensation statistics, about 24% of all injuries/disease cases are related to musculoskeletal disorders (ASCC2007). Nearly 31% of these cases are related to the upper limbs. It is estimated that musculoskeletal injuries/disorders cost nearly $20 billion dollars annually. In the US, the Occupational Health and Safety Administration (OSHA) have estimated that 50% of work related injuries are musculoskeletal type injuries. US Department of Labor reported that in 2005 about 30% of the injury and illness (including MSDs) cases resulted in days away from work (BLS, 2007). According to Health and Safety Executive (HSE) in the UK, MSD’s are the most common work related illness in affecting over 1.0 million workers a year (HSE, 2007). Approximately, 37% of MSDs mainly affect upper limbs or neck. Marcus et al. (2002) demonstrated, in a large scale epidemiological study of computer users, the existence of important relationships between certain static postural aspects of an individual sitting at his/her workstation and the development of MSDs. Counter workers such as bank tellers, supermarket checkout operators, airline ticket counter operators, etc make extensive use of computer workstations for their jobs and are forced to adopt static postures with frequent reaches. Most of them complain of neck and shoulder discomfort and/or pain.

Cranz (2000) has discussed computer workstations of the future and suggested that systematic investigations into working postures can have a significant effect on the reduction of MSDs. Vieira (2004) has pointed out the importance of working postures in relation to prevalence of MSD in workplaces and has argued that the research on working postures is inadequate. Allowing workers to change working postures during prolonged work can have significant beneficial effects on the productivity and health of the worker. Sengupta and Das (2000) have investigated sit/stand type of industrial workstations and have shown that there a significant functional performance difference between standing opposed to sitting at a workstation. Similarly, Hedge (2004) has shown that adjustable work surfaces have beneficial effects on musculoskeletal disorders. Roelofs et al. (2002) studied bank tellers’ workstations and have suggested that alternation between two postures (sitting and standing) allows for increased rest intervals of specific body parts, and reduced potential for the adverse impact of risk factors commonly associated with MSD development. There are physiological advantages in having the option of alternating between sitting and standing when confined to a counter workstation (Goel et al. 1999).
Whereas office-based computer workstations have been extensively studied and have specific design guidelines, the counter-type workstations have received inadequate attention. There are significant differences between the general office-based tasks and those performed at counter workstations. Custom and passport control employees, bank tellers, supermarket checkout operators, airline ticket counter operators, production line workers etc. are all constrained to the workstation and complete tasks that have high repetition with long duration. Recent studies (Fraser et al., 2004, Sengupta and Das, 2000) have pointed out to the need for adjustable counter workstations as opposed to currently prevalent fixed workstations to reduce musculoskeletal disorders.

The aim of the present study was to investigate the effect of the type of counter workstation on the muscular load and discomfort in the neck and shoulder regions in asymptomatic subjects. Two types of seated counter workstation were used in the study. One counter workstation was fixed and the other was adjustable to suit individual operator’s anthropometric characteristics. Muscular activities of the bilateral upper trapezius, lower trapezius and anterior deltoid muscles were recorded through surface electromyography (EMG). Body discomfort ratings at the neck, shoulder and lower back areas were also recorded at the end of the task.

2. METHODS

2.1 Workstation

A special purpose adjustable workstation was designed for the study. The workstation could work as a fixed or an adjustable counter workstation. For the fixed counter configuration, the table surface height was adjusted to 900mm from the floor. The table depth was 800mm with the reach position at 750mm. The workstation was equipped with an adequate foot rest. These counter measurements were set as per Australian Standard 3590.2 (1990). For the purpose of adjustable workstation the height and depth of the table surface were modified in accordance with individual subject’s height and comfortable reach envelope. Subjects were provided with an adjustable chair with lumbar support.

2.2 Subjects

Twelve subjects participated in the study. Subjects were randomly selected from the general population. Subjects were in the age group 18-60 years and had no previous history of neck/shoulder disorders. The study was approved by the University Ethics Committee. Before proceeding with the experiments, subjects were provided with a participation information sheet and requested to sign a consent form. Subjects were given the option of withdrawing from the study for any reason and at any time they wished.

2.3 The Task

For this study, typical tasks performed by a service counter worker at a customs check in area were simulated. Work consisted of frequent reaching of documents, entering document details in the computer, stamping and returning documents to the original point. Work was self-paced. Subjects made approximately 4-6 reaches per minute and stamped documents twice per minute. Work was performed in the seated posture for 30 minutes. Subjects were given at least 15 minutes of rest in between working on fixed and adjustable workstations.

2.4 Measurements

Muscular activity and body part discomfort ratings were measured. Surface EMG electrodes were attached to bilateral upper trapezius, bilateral lower trapezius and bilateral anterior deltoids following the guidelines published in the literature (Basmajian and De Luca, 1985, De Luca, 1997, Marras, 1990) to obtain excellent quality of signals. The EMG data was collated utilising the Biometrics DataLOG Type P3X8 and the data
was analysed utilising the Biometrics DataLOG software (Biometrics Ltd, Cwmfelinfach, Gwent, NP11 7HZ, UK). EMG signals are high pass filtered to remove DC offsets due to membrane potentials and to minimise low frequency (below 15Hz) interference caused by the movement of electrodes on the skin surface, and also low pass filtered to remove unwanted frequencies above 450 Hz. According to De Luca (1997), root mean squared (RMS) value of myoelectric signals is the most sensitive of all amplitude parameters and contains maximum information. Hence EMG signals from various muscles were processed to obtain mean root mean squared (RMS) values. At the end of the work on each type of counter workstation, subjects were asked to record body discomfort rating on the 10 point scale.

### 3. RESULTS

#### 3.1 Anthropometrics

A total of 12 male and female subjects participated in the study. Their mean age, weight and stature height were 4.4±9.7 years, 76.1±63 Kg and 171.8±7.9 cm respectively. Eleven participants were right handed and one was left hand. The subjects forward grip reach was 698±56.2 cm. The subject’s perceived comfortable reach ranged from 31.0 – 43.0 cm with a mean of 37.6±: 3.99 cm.

#### 3.2 Muscular activity

Figure 1 shows mean RMS values for the right and left upper trapezius for fixed and adjustable workstations. Muscle activity was measured in terms of mean EMG RMS values (De Luca, 1997). It is clear from the Figure 1 that adjustable workstations resulted in decreased muscle activity in upper trapezius by as much as 25% on the left side and 32.4% for the right side. The decrease was found to be statistically significant ($p<0.001$).

![Figure 1](image-url)  
Figure 1: Upper trapezius muscle activity (mean EMG RMS) in fixed and adjustable workstations.
Figure 2 represents muscle activity of the lower trapezius muscle for fixed and adjustable workstation. As before, adjustable workstation generated less mean EMG RMS values as compared to fixed workstation. The decrease in muscle activity was observed to be 33% for the left and 34.4% for the right side. Once again, the decrease in muscle activity was statistically significant ($p<0.001$).

![Figure 2: Muscle activity of lower trapezius (mean EMG RMS) in fixed and adjustable workstations.](image)

Figure 3 shows mean RMS values for the right and left anterior deltoid muscles for fixed and adjustable workstation. Results show 33% and 32% decrease respectively for the left and right anterior deltoid muscle when subject moves from fixed to adjustable workstations.

Figure 4 shows discomfort levels at the neck, shoulder, upper back and low back regions for the body for the fixed and adjustable workstations. It can be seen that Discomfort levels indicated by the subjects in the neck, shoulder and lower back areas were significantly higher in fixed compared to adjustable workstation.

4. DISCUSSION

The results of the study revealed that the adjustable workstation considerably decreased muscular activity in the neck and shoulder regions. The decrease in muscle activity was observed in all the muscles considered in the study. The reasons for the difference in muscle activity between fixed and adjustable workstations can be understood in terms of the involvement of the muscles in producing the necessary arm and shoulder movements.

For example, the primary function of the upper trapezius muscles is to elevate the scapula for facilitating a forward reach of the arm. In addition the upper trapezius muscle is also partially responsible for extension of the c-spine. To complete an extended forward reach with the right arm, the subject will
need to adopt a working posture with neck extension, thereby utilising the bilateral upper trapezius more in extended reach than in a functional reach. Hence the upper arm will generate larger muscle activity in fixed workstation which would require a subject to perform extended reach. Lower trapezius is involved in facilitating forward arm reach as well as assisting in pulling the arm back towards the body during the
retraction of the shoulder girdle. Hence more muscle activity is observed in fixed workstation as compared to adjustable workstation. The anterior deltoid’s main function is in flexion; it aids in bending the elbow and shoulder and subsequently moving the arm upwards in forward reach. In addition, the anterior deltoid has a major role in transverse flexion, abduction and internal rotation of the shoulder and arm. This is especially important in functional movements such as tasks involving reach outside of the midline or away from the body.

The data on body part discomfort ratings showed that the neck discomfort was the most frequent complaint followed by shoulders and wrists/fingers. The difference in the discomfort experienced by subjects between fixed and adjustable workstations was statistically significant. The results of the study are consistent with published data (Cranz, 2000, Farinal, 2002, Vasseljin, 1995) obtained from workers, such as VDU operators performing similar activities.

5. CONCLUSIONS

The aim of the study was to investigate the muscle activity in the neck and shoulder in subjects performing counter style tasks in seated posture. The results of the study suggest that an adjustable workstation is better than a fixed workstation both for muscle load and discomfort point of view. Further research is needed to consider standing and/or sit/stand type of counter workstations to determine if seated adjustable counter workstations are better than those that provide alternating working postures.

6. REFERENCES


