Perceived Discomfort and Electromyographic Activity of the Upper Trapezius While Working at a VDT Station

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Ten female participants performed work at a video display terminal (VDT) station over a whole working day. Subjective local muscular fatigue was evaluated by means of the Category Ratio 10 scale. Electromyographic activity of the upper right and left trapezius was measured. A comparison was made between 5 participants who had previous complaints and 5 participants who reported no musculoskeletal problems in the shoulder-neck region. The subjective scores for the shoulder differed significantly between the two groups, being higher for the group with complaints. Both groups showed a decrease in discomfort after the lunch break. The activity of the trapezius increased significantly for both groups, in a more pronounced way for the group with disorders. Although it is found in literature that VDT work is a task with very low static loads, it seems from this study that the EMG activity increase can be an indication of muscle fatigue: More effort was required to accomplish the same VDT task at the end of the day.

1. INTRODUCTION

During the past 20 years, industrial tasks with heavy loads imposed on the worker seem to have been increasingly replaced by automation. The introduction of modern technology results in specialized monotonous tasks that impose static or repetitive loads on the shoulder and neck muscles (Kamwendo, Linton, & Moritz, 1991). Although the loads are very low, several studies claim that muscle fatigue can occur and can even result in occupational health problems (Chaffin & Andersson, 1984).

Working at a video display terminal (VDT) involves sitting in the same position for a long period of time. Design recommendations and guidelines for a “correct” posture, based on anthropometric and biomechanic studies, have already been extensively reported. It seems from literature that the static load component in the trapezius is very low in VDT tasks, which can be explained by the many short pauses in the working pattern compared with higher and longer static loads in production tasks (Jensen, Nilsen, Hansen, & Westgaard, 1993). However, many VDT users still report a feeling of fatigue or stiffness in the shoulder-neck region when working for several hours at their computers (Hagberg & Sundelin, 1986; Hüttig, Läubli, & Grandjean, 1983). Besides, some studies show a relation between time spent on VDT work and the occurrence of musculoskeletal symptoms, of which tension neck syndrome seems to have
the highest rates of occurrence (Hagberg & Wegman, 1987; Knave, Wibon, Voss, Hedström, & Bergqvist, 1985). This syndrome is characterized by a constant feeling of fatigue and/or stiffness and tenderness, especially in the upper trapezius region.

It is therefore important to know how the sensation of fatigue or pain develops throughout the work day, which can be evaluated by subjective fatigue scores. In order to measure the local muscular fatigue more objectively, electromyographic (EMG) techniques are used to provide evaluation of muscle activity and fatigue (De Luca, 1984). Several laboratory studies have demonstrated that amplitude parameters of the signal increase and frequency parameters decrease after holding a static task for a long time. These parameters are considered to be indicators of muscular fatigue (Baidya & Stevenson, 1988; De Luca, 1984). There are however few studies that concentrate on changes in EMG during real working situations, and most of them deal with assembly work (e.g., Christensen, 1986; Jonsson & Hagberg, 1981; Nakata, Hagner, & Jonsson, 1992). The evaluation of local muscular activity during a real working task at a VDT station has not yet been established.

The purpose of this study was, first, to analyze objective and subjective indications of muscular fatigue while working at a VDT station, and second, to compare the results of workers with and without experience of shoulder-neck musculoskeletal problems.

2. METHODOLOGY

2.1 Subjects
Ten female participants volunteered to participate in this investigation. They were fully informed about the test procedures and all had experience in VDT work. Based on medical reports, on previous interviews with a medical doctor, and on a questionnaire in which they were asked about their type of work and their physical problems, 5 participants constituted the group already experiencing pain, fatigue, or stiffness in the shoulder-neck region (complaining group), and the remaining 5 who had no previous complaints constituted the healthy group. The mean and extreme values of age, height, weight, and years of experience with VDT work are presented in Table 1.

2.2. Work Task
The participants were asked to perform their normal VDT work over a whole working day (8 hr). The VDT work was defined as follows: typing text or numbers, reading from the computer screen, reading from the original documents with hands on the keyboard, and working with a computer mouse. The participants were allowed to take short, spontaneous breaks, without moving away from the workstation. They were also free to choose the working pace and to have short breaks with their colleagues. During the lunch break, they could move freely. Participants were studied for 3 hr in the morning, and 3 hr after the lunch break.

2.3. Evaluation of Subjective Feeling of Fatigue
In order to evaluate the subjective feeling of fatigue, Borg’s (1990) Category Ratio 10 (CR-10) scale was used. This psychophysical scale measures on a scale from 0 to 10 perceived exertion

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>Experience (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complaining</td>
<td>5</td>
<td>47.4 (36-59)</td>
<td>166.6 (161-173)</td>
<td>59.2 (53-63)</td>
<td>8.6 (3-17)</td>
</tr>
<tr>
<td>Healthy</td>
<td>5</td>
<td>40.6 (24-44)</td>
<td>163.0 (158-172)</td>
<td>57.4 (59-70)</td>
<td>2.5 (1-5)</td>
</tr>
</tbody>
</table>
when performing a task. By connecting verbal expressions, the participant can give a correct position on the scale (e.g., “weak” stands for a score of 2). Every 30 min the scale was presented to each participant to discover their sensations of discomfort, stiffness, pain, or local fatigue in the shoulder region.

2.4. Electromyography
After cleaning the skin with ether, bipolar surface electrodes (silver-silver-chloride) were placed along the right and left descending parts of the trapezius muscle, with an interelectrode distance of 2 cm. The EMG signals were measured with a sampling rate of 500 Hz (bandpass 2–250 Hz). After amplifying, the signals were transmitted to the computer for further calculations. The calculation of muscular activity, described by Spaepen, Baumann, and Maes (1987a), was used as an amplitude parameter. This calculation is based on a differentiation of the EMG signal, which proved to be more accurate than an integrated signal. Also, high linear correlations between isometric muscular force and muscular activity were found (Spaepen, Wouters, Sansen, & Steyaert, 1987b). The algorithm (for a sampling rate of 500 Hz) is as follows:

\[ A_i = A_{i-1} + 0.9875 \times \sqrt{|E_i - E_{i-1}|} \]

where

- \( A_i \): muscle activity at time \( i \);
- \( A_{i-1} \): muscle activity at time \( i - 1 \);
- \( E_i \): EMG signal at time \( i \);
- \( E_{i-1} \): EMG signal at time \( i - 1 \);
- 0.9875: constant value.

2.5. Statistics
Student t-tests were used to compare the CR-10 scores of the two groups and the EMG results at the beginning and at the end of the work task. Linear regression analysis was performed between the activity values of each participant and time.

3. RESULTS

3.1. Evaluation of Subjective Feeling of Fatigue
The mean CR-10 scores for each group over the whole work day are presented in Figure 1 with time intervals of 1 hr. Already after 1 hr of VDT work, the task seems to be heavier for the complaining group. The difference between groups increases with time and is significant \( (\alpha = 0.05) \) at interval 3, just before lunch. After the lunch break, both scores decrease and are not significantly different anymore. Afterwards the scores of the complaining group increase again, being significantly different at intervals 5 \( (\alpha = 0.05) \) and 6 \( (\alpha = 0.01) \). The healthy group had a score of 1 at the end (almost no discomfort), whereas the group with complaints gave an average score of 4 at the end, which stands for moderate to heavy discomfort.

3.2. Muscle Activity
In the analysis of the activity values, it seemed that the values for the right and left trapezius increase for all participants, although the increase was not significant for all of them. When comparing the activity values at the beginning of the work day with the values at the end of
Figure 1. Mean CR-10 scores for the complaining group and the healthy group over the whole day.

The VDT task, a significant increase ($\alpha = 0.05$) was found for the right and left muscles for both groups. The increase for the complaining group was higher, although not significantly. This is presented in Figure 2, where the proportional increase for the right and left trapezius of the two groups is given.

Figure 2. Percentage increase in activity over a whole working day for Trapezius right and left for the group with complaints (compl.) and without complaints (healthy).
4. DISCUSSION

4.1. Perceived Muscle Discomfort

Because the use of VDT terminals has increased during the last few decades, much effort has been made to design recommendations and guidelines for a correct sitting position. Although most of the values of this study correspond to these recommendations (presented in Hermans, Spaepen, & Snoeks, 1994), the results indicate that the participants were fatigued after a long period of time. The ratings on the Borg scale corresponded to those of the Sundelin & Hagberg (1989) study in which subjects performed word processing continuously for 5 hr.

The flexion torque in a position with no forward flexion in the shoulder joint and 90° in the elbow is, for a female of 60 kg and 170 cm, 1.2 Nm in the shoulder (Chaffin & Andersson, 1984), which corresponds to approximately 3% of the maximal torque. Because there is a very good correlation between the load in the glenohumeral torque and the load on the upper trapezius, this means that a position with the hand on the keyboard without arm support already gives a low muscular static load (Hagberg, 1981). Prolonged static muscle load may cause the reported musculoskeletal discomfort, even if the contraction levels of the task were low. It is also possible that during tasks of long duration, co-contraction occurs: In order to perform the task longer, more muscles than necessary are activated. It seems that the muscles from the shoulder and neck region may be particularly prone to co-contraction, because the muscles interact in order to perform their biomechanical function: maintenance of stability and torque generation to allow a large range of motion (Järvelin, Palmerud, Karlsson, Herberts, & Kadedors, 1991). In order to study if co-contraction occurs during VDT work, it is necessary to analyze more muscles of the shoulder and neck region.

4.2. Muscle Activity and Fatigue

It seems from the literature that the muscle load in a typing position is quite low (Hagberg & Sundelin, 1986; Jensen et al., 1993). A large variation in muscle activation patterns when performing stereotyped movement patterns may be the reason why there was no significant linear increase in the activity values of this study. However, comparing the results at the beginning of the VDT task with the results at the end of the day, an increase in EMG activity of the trapezius was found. This increase can be interpreted as either an increase in the contraction force, or as an indication of muscle fatigue. Because the work position was the same during the day and the same type of work was performed throughout the study, it may be concluded that the increase in activity results from muscle fatigue: The participant needs to exert more force to produce the same work.

4.3. Breaks in Continuous Activity

From the results of laboratory studies, it seems that intermittent tasks result in longer endurance times than continuous activity. Introducing active pauses during work tasks results in lower ratings of subjective fatigue (Kamwendo et al., 1991; Sundelin & Hagberg, 1989). From this study, it seems that the lunch break resulted in a lower perceived discomfort, but also in lower activity of the muscles afterwards. Those decreases however were not long-lasting, because the end values for perceived discomfort and activity of the EMG signals were the highest at the end of the day. The introduction of frequent, short pauses instead of one long break could therefore be considered.

4.4. Complaining Group Versus Healthy Group

The perceived discomfort in the shoulder was significantly higher for the MSD group. However, no significant differences in EMG values were found. Christensen (1986) analyzed the EMG signals of workers in assembly lines. She found higher relative amplitude values for
people who reported pain or fatigue compared with people who felt no discomfort. In this study, it seems that long-lasting VDT work also causes higher amplitude values in a healthy group of people. This type of work seems to cause higher activity for the muscles after a long time, independent of previous or recent problems.

The complaining group was on average 7 years older and had 6 years more experience than the healthy group. In the corpus of literature, there is no general agreement on the influence of age and experience on muscular fatigue (Takala, 1991). Christensen (1986) claims in her study that there is no influence of age. It was not possible to investigate this in our study due to the low number of participants. However, it is important to note that 2 healthy participants, aged 26 and 32, with 2.5 and 1 year of experience, respectively, also showed subjective and objective signs of local muscular fatigue. Our view is that a reduction in load intensity by introducing several short breaks in continuous activity may be beneficial for each individual and should therefore be considered also during "light" VDT work. Within the scope of this study, a training program is developed in which people learn to adapt their movement and posture patterns during work in order to avoid prolonged static load.

REFERENCES

