

## Motor unit firing pattern in the trapezius muscle during long-term computer work

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### INTRODUCTION

Muscle pain in the shoulder/neck area and the upper extremities is a common and increasing problem among computer workers (Öberg and Åström, 2000). Hägg (1991) formulated the “Cinderella” hypothesis, proposing that the pain is caused by an overuse of low-threshold motor units (MUs). While this hypothesis is supported by laboratory studies that showed continuous activity of single MUs during e.g. long-term (60-minute) static contractions (Thorn et al., 2002), MU substitution (a shift from previously active MUs to newly recruited ones) has also been observed. It is unknown if the MU behaviour in an experiment more similar to long-term computer work may differ from that during a solely static muscle contraction. The purpose of this study was to investigate MU firing patterns in the trapezius muscle during a long-term computer work task. Specifically, are MUs continuously active during such work?

### METHODS

Four subjects participated in the study. Surface and 3-channel intra-muscular fine-wire EMG (IEMG) was recorded from the right trapezius muscle during a 60-minute combined mouse- and keyboard work task, which consisted of editing a text where every 20<sup>th</sup> word was in boldface. The subject was asked to double click on each boldfaced word, un-bold and retype it. A semi-automatic classification program, EMGLODEC, (Zennaro et al., 2001), was used to decompose the signal into motor unit action potential (MUAP) trains. A MU was defined as active when its low-pass filtered (0.5 Hz) pulse train (of identified firings) was above zero.

### RESULTS

Subject 4 was excluded from the study due to poor quality of the IEMG signals. Median surface EMG (SEMG) levels for Subjects 1-3 were 7.1, 14.1 and 3.3% of maximal voluntary electrical (MVE) activity, respectively. The average gap frequencies (SEMG <1% MVE, during  $\geq 1/8$  s) and the relative time with SEMG <1% MVE were less than 1 min<sup>-1</sup> and 1%, respectively, for Subjects 1 and 2, and 13 min<sup>-1</sup> and 13.4%, respectively, for Subject 3. It was observed from video recordings that Subjects 1 and 2 lifted their shoulders during the keyboard input task, which induced periodical SEMG increases and less gaps and muscle rest.

The average classification rate of decomposed IEMG segments into one or several MUAPs was 87% for Subject 2. For Subjects 1 and 3, there were decomposition problems due to external signal disturbances and too large pick-up volumes of the electrodes. Therefore, the classification rate for Subjects 1 and 3 was only 59 and 42%, respectively. Classification results from Subject 2 showed 10 out of 15 identified MUs to be firing during >90% of the working time while only 1 was active during <70% of the working time (Figure 1). Subject 1 showed a somewhat lower degree of long-term MU activity; among the 15 identified MUs, the activity percentage was >90% for 5 MUs and <70% for 4 MUs. For Subject 3, none of the 12 identified MUs showed an activity percentage >90% while 6 were active <70% of the working time. A low classification rate, as for Subjects 1 and 3, induces a negative bias in the estimated firing rate, which should be considered when interpreting the result.

## DISCUSSION AND CONCLUSIONS

The existence of long-duration active MUs, in at least one of the studied subjects, supports the Cinderella hypothesis in the context of computer work. Inter-individual differences in MU activity behaviour have previously been reported from more standardised tasks (e.g. Thorn et al., 2002). However, as a caveat, the present study contains results from only 3 test subjects, where 2 subjects showed a low rate of segment classification. Under these circumstances it is not possible to make any population-level conclusions about the MU activity behaviour among healthy computer users.

Changes in MU activities that could possibly be MU substitutions were found in all studied subjects, which may mean that only some of the registered low-threshold motor units follow the concept of the Cinderella hypothesis. These substitutions may also be related to high overall MU activity.

In conclusion, the study showed an existence of long-term active MUs in a computer work task. This result supports the Cinderella hypothesis. Indications of substitution were also found. The determinants for the prevalence of substitution as well as inter-individual differences are still not completely understood. Therefore, the present study will be enlarged in the near future with more participating subjects.

## ACKNOWLEDGEMENT

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## REFERENCES

- 1) Hägg, G.M., 1991. Static work loads and occupational myalgia - a new explanation model. In: Electromyographical kinesiology, Elsevier Science, Amsterdam, pp. 141-143.
- 2) Thorn, S., Forsman, M., Zhang, Q., Taoda, K., 2002. Low-threshold motor unit activity during a one-hour static contraction in the trapezius muscle. *Int. J. Ind. Ergon.* Accepted.
- 3) Zennaro, D., Wellig, P., Moschytz, G. S., Läubli, T. and Krueger, H., 2001. A decomposition software package for the decomposition of long-term multi-channel electromyographic signals. In: Proceedings of the 23rd Annual IEEE Conference, Istanbul.
- 4) Öberg S. and Åström L., 2000. Working environment for employed persons, by gender and age, per cent. Statistical yearbook of Sweden 2001, Örebro, pp 241.

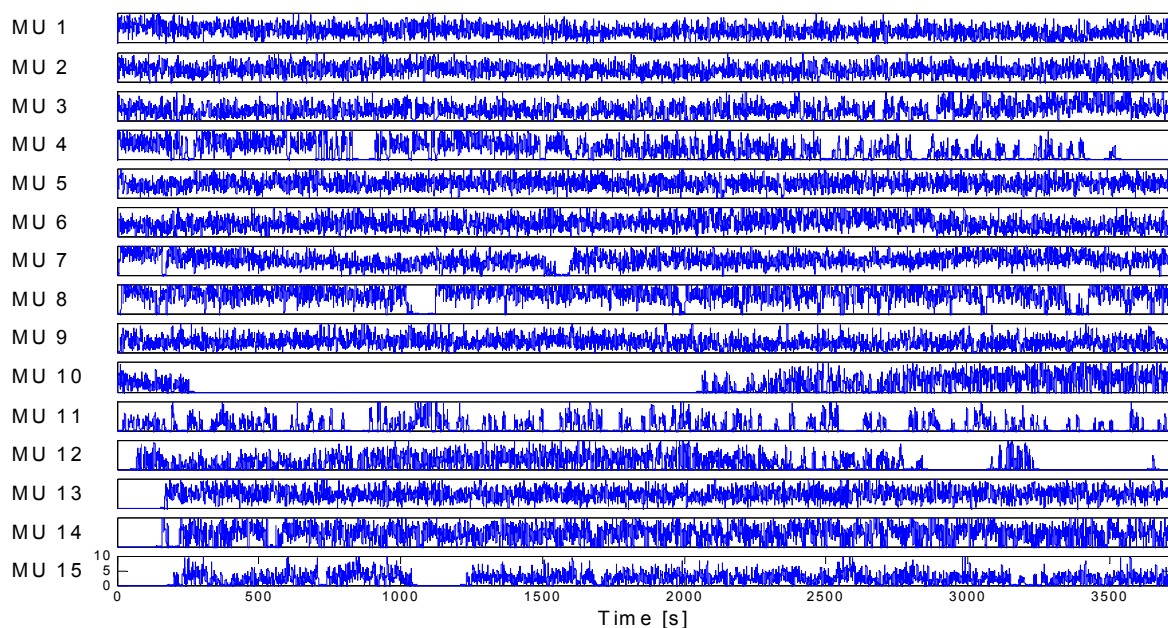


Figure 1: Firing frequencies (Hz) for identified MUs in Subject 2 during the 1-hour task.