Fatigue effects on tracking performance

Maaike Huysmans\textsuperscript{a,d}, Marco Hoozemans\textsuperscript{a,d}, Allard van der Beek\textsuperscript{b,d}, Michiel de Looze\textsuperscript{c,d}, Jaap van Dieën\textsuperscript{a,d}

\textsuperscript{a} Institute for Fundamental and Clinical Human Movement Sciences, Faculty of Human Movement Sciences, Vrije Universiteit, Van der Boechorststraat 9, 1081 BT Amsterdam, The Netherlands
\textsuperscript{b} Department of Public and Occupational Health, Institute for Research in Extramural Medicine, VU University Medical Center, Amsterdam, The Netherlands
\textsuperscript{c} TNO Quality of Life, Hoofddorp, The Netherlands
\textsuperscript{d} Body@Work, Research Center Physical Activity, Work and Health, Amsterdam, The Netherlands

Abstract

The objective of the present study was to test the effect of fatigue on task performance in a tracking task performed with a computer mouse. Participants performed a two-minute tracking task twice before and once immediately after a fatiguing wrist extension protocol. Results indicate that the mean distance to the centre of the target and the standard error of the mean distance to the target were significantly larger after fatigue. The percentage of time on target was unchanged by fatigue. Subjects seemed to be able to meet the requirements of the task instruction despite fatigue, but it is likely that this was done at the expense of a higher muscular load.

Keywords: Upper extremity disorders, experimental, fatigue, computer use, performance

1. Introduction

Long duration of computer work, and especially mouse use, is an important risk factor for hand-arm symptoms [1,2]. Even though low forces are involved in computer work, hand-arm symptoms may be the result of fatigue building up through the working day [3,4]. Fatigue has been shown to diminish proprioceptive acuity [5,6]. With a reduced proprioceptive acuity it will be more difficult to work precisely, which may lead to either a decreased performance in precision tasks or a non-affected performance at the expense of an increased muscular effort. Therefore, the aim of this study was to investigate whether fatigue affects performance in a computer precision task.

2. Methods

2.1. Participants

Eleven healthy women, age 24.3 years (SD=2.7), body height 171.7 cm (SD=4.9), body mass 65.7 kg (SD=7.5), participated in the experiment. All participants gave informed consent prior to the experiments and reported no history of upper extremity symptoms.

2.2. Task and procedures

Participants performed a tracking task twice before a fatigue protocol and once immediately after a fatigue protocol.
In the two-minute tracking tasks, subjects had to keep the cursor positioned within a target dot (diameter 51 mm), which moved quasi-randomly across the computer screen at a constant velocity (20 mm/s). The cursor could be controlled by a computer mouse. The horizontal and vertical coordinates of both cursor and target were collected at 100 Hz and were used to calculate the following performance measures: percentage time on target (%TT), mean distance to centre of target (MDT) and standard error of the mean distance to target (SDT).

During the fatigue protocol subjects performed a wrist extension against a force transducer at 15% of their maximum wrist extension force during 10 minutes. The required force was shown with a line on a computer screen. Feedback of the actual force was plotted in the same figure. Subjects were instructed to keep the plotted actual wrist extension force as well as possible positioned on the line of the required force.

Before and after the fatigue protocol maximum wrist extension force was measured and subjects were asked to rate their perceived exertion using a Borgscale.

2.3. Statistical analyses

The reliability of tracking performance measures was tested by calculating the intraclass correlation between the two pretests. A two-way MANOVA for repeated measures was used to test for the effect of fatigue on performance measures %TT, MDT and SDT. Follow-up analyses were performed by univariate ANOVAs for repeated measures.

3. Results

When comparing the two tests performed before the fatigue protocol, all performance measures were found to have good reliability (ICC values were all larger than 0.90). Maximum wrist extension force was significantly lower after the fatigue protocol, and perceived exertion was significantly higher, indicating that subjects were indeed fatigued.

MANOVA for repeated measures revealed that performance was significantly affected by fatigue (p=0.022). Univariate analyses showed that MDT and SDT were significantly higher after the fatigue protocol, whereas %TT showed no significant change after the fatigue protocol (Figure 1).

4. Conclusions

The fatigue protocol significantly affected tracking performance. In the fatigued state, the cursor was further from the center of target (MDT) during tracking and the variability of the distance to target (SDT) was also larger. Despite the higher MDT and SDT, subjects were able to meet the task requirements by keeping the cursor positioned on target, since percentage of time on target (%TT) was unaffected by fatigue. However, a higher MDT and SDT indicate that subjects had more difficulty to work precisely after fatigue. Moreover, a higher SDT indicates that accelerations of the hand were higher during task execution after fatigue. These findings suggest that subjects were able to meet the task requirements, but probably at the expense of higher muscular effort.

In daily work with high precision requirements it should be considered that fatigue may affect task performance and muscular effort. This may underline the need for sufficient rest breaks (periods of muscle relaxation) during the working day or that, for instance, high precision tasks are performed at the beginning of the working day. Even though fatigue may not be visible by a decreased performance, the higher muscular effort may accelerate fatigue development through the working day, increasing the risk for hand-arm symptoms.
References


