THE EFFECT OF MUSCLE FATIGUE ON THE MUSCULAR RESPONSE TO A SUDDEN LOAD OF THE SPINE

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INTRODUCTION

Low back injuries are frequent among employees in the health-care sector. The combined effect of sudden unexpected trunk loading (SL) and accumulated fatigue of the erector spinae muscles (ES) has been suggested as a risk factor for low back injuries. SL incidents such as slips and falls are common among employees in the health care sector who handles patients (Radebold et al, 2000). Andersen et al (2001) reported that nursing aides in average were exposed to 2.5 (0-8) sudden trunk movements during a workday. Moreover, nurses working in a geriatric ward developed signs of neuromuscular fatigue (i.e. a significant drop in initial median frequency and slope of the EMG signal) in the ES muscle during an 8 hours workday (Ling Hui et al, 2001). Fatigue in the ES may affect the muscle spindle system and muscle reflex mechanism involved in the maintenance of spinal stability, thus leaving the spine vulnerable to external perturbations. The combination of SL’s and the development of lumbar muscle fatigue during a workday may in this way expose employees in the health care sector to an increased risk of low back injuries.

We investigated the effect of fatigue on the response of the ES muscle to SL’s elicited in an experimental set-up i.e. the EMG reaction time (EMG latency), the time needed to stop the trunk (stop time), and the distance of trunk movement.

METHODS

Fifteen males participated in the study. Their mean age, weight and height are summarized in table 1.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Mean ± SD</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>34.9 ± 4.9</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>81.2 ± 8.5</td>
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<tr>
<td>Height (cm)</td>
<td>182.7 ± 6.1</td>
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</table>

They participated on two separate days in a randomised cross-over design. The participants were exposed to 10 SL trials before (pre) and immediately after (post) a fatiguing procedure.

To obtain fatigue in the ES muscle, participants performed an isometric lumbar endurance test at 40% of MVC to exhaustion. Perceived exertion was assessed at 1-minutes intervals using the modified Borg scale ranged between 0 and 10. On a control day the participants repeated the procedure, and the endurance test was replaced by a five minutes break. The experimental set-up is illustrated in figure 1. The SL was generated via a load (60N) that momentarily can be attached to a wire running over a wheel thereby transmitting the external force to the upper part of the trunk. The SL was triggered at a random time. The trunk movement was measured by a potentiometer mounted on the wheel. The participant was fixed at the hip to get isolated trunk movements (Figure 1).

Surface EMG signals were recorded on the right and left ES at the level of L3 and T12. The raw EMG signals were pre-amplified, low-pass filtered at 450 Hz and sampled with a frequency of 1000 Hz. The data were high-pass filtered with a cut-off frequency of 10 Hz and finally the mean of ten trials was calculated. The shift in median frequency (MF) - that is a drop in initial median frequency and an increase in negative slope of the MF/time - calculated from the EMG power spectrum was used as an index of muscle fatigue along with the Borg scale data. EMG reaction time was determined from the EMG recordings as the time between the loading of the trunk and the EMG onset.

The stop time of the trunk movement was analysed automatically: the maximum of the curve representing the trunk movement was detected, and the point in time corresponding to 95% of this distance was read (Figure 2). The 95% level was chosen to describe the position of the peak of the trunk position curve, because the peak itself was relatively flat.

Figure 1: Set-up for generating a sudden load to the trunk.

Figure 2: An example of recorded data from a sudden loading. The figure shows 2 seconds of EMG data from right and left erector spinae recorded at the level of L3 and the movement of the trunk measured by the potentiometer. The sudden loading was triggered at the time 0. t95 is the time
corresponding to 95% of the maximum forward movement and equals 0.40 s.

Statistical analysis was performed by means of a univariate analysis on the differences between pre and post on the control and the fatigue day respectively. Participants were random factors and treatments (control and fatigue) were fixed factors.

RESULTS AND DISCUSSION

Mean endurance time was 294 s (SD ±219 s). Borg scale as well as significant reductions in MF (from initial values) of 28% (SD ±11 %) at L3 level and 23% (SD ±13 %) at the T12 level of the ES indicated severe muscle fatigue. Muscle fatigue did not lead to significant changes in stop time; stop distance and EMG reaction time (Table 2).

Table 2: Stop time (ms), stop distance (cm) and reaction time (react) (ms) (Mean ± SD).

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Fatigue</th>
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<tbody>
<tr>
<td>Stop time</td>
<td>306±42</td>
<td>318±43</td>
</tr>
<tr>
<td>Distance</td>
<td>4.36±0.71</td>
<td>4.47±0.72</td>
</tr>
<tr>
<td>L3 react</td>
<td>93.6±5.5</td>
<td>92.2±6.2</td>
</tr>
<tr>
<td>T12 react</td>
<td>94.0±6.2</td>
<td>92.5±9.5</td>
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</tbody>
</table>

Previous studies have indicated a fatigue-induced decline in fusimotor drive to muscle spindles (Duchateau & Hainaut, 1991) and a reduction in spindle discharge during sustained isometric contractions (Macefield et al, 1991). A reduced stretch reflex with a concomitant increase in stop time, stop distance and reaction time could thus have been expected. However, as the reaction times in table 1 indicate, the first EMG response to a SL was too slow to be a simple stretch reflex. The latency corresponds to a long latency reflex or a pre-programmed response, and interestingly long latency reflexes have been found to be relatively unaffected by muscle fatigue (Duchateau & Hainaut, 1991). Despite the assumed fatigue-induced changes in the spindles, the spindles are apparently capable of maintaining an appropriate triggering of long latency reflexes in response to a SL. Another explanation suggested by Duchateau & Hainaut (1991) is that the fatigue-induced decline in peripheral afferent feedback, which provides the motoneurones with less excitation, may be counteracted by a stronger descending supraspinal drive as a reflex compensation.

SUMMARY

Muscle fatigue did not lead to changes in either EMG response i.e. EMG reaction time, stop time or stop distance of the erector spinae muscle to a sudden loading elicited in an experimental set-up. REFERENCES