LUMBAR EXTENSOR FATIGUE CHANGES POSTURAL RECOVERY STRATEGY

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INTRODUCTION

Movements used to maintain standing balance in the sagittal plane following a postural perturbation have previously been described as a hip strategy, ankle strategy, or a combination of the two [1]. Numerous extrinsic and intrinsic factors affect which of these postural strategies are typically employed. To our knowledge, no studies have investigated fatigue in this regard. Therefore, the purpose of this study was to investigate the effect of lumbar extensor fatigue on postural recovery strategy in response to a balance perturbation.

METHODS

Twelve physically active males (20-22 years of age) participated in three experimental sessions, each consisting of four stages: warm-up, three unfatigued balance perturbations, fatiguing protocol, and a fatigued balance perturbation. The perturbation consisted of an anteriorly-directed impulse applied in the mid-sagittal plane at the level of the inferior margin of the scapulae. Typical perturbation characteristics were 170 N and 150 ms for the peak force and duration, respectively. Perturbations were designed to challenge the balance system while not eliciting a stepping response.

The fatiguing protocol consisted of multiple sets of back extensions and intermittent isometric maximum voluntary contractions (MVCs) to assess the level of fatigue [2]. The lumbar extensor muscles were fatigued over 14 minutes to 86%, 73%, and 60% of their unfatigued isometric MVC.

Triaxial ground reaction forces and body segment positions were collected from a force platform and a motion analysis system. Postural strategy was quantified using the trajectory of the center of pressure (COP) along with joint angles and joint torques for the ankle, knee, hip, and “low back” joints derived from inverse kinematics. A repeated-measures ANOVA was used to determine the effect of fatigue on recovery strategy.

RESULTS AND DISCUSSION

Results showed both pre-perturbation and post-perturbation changes in postural strategy with fatigue. Pre-perturbation changes involved a slight anterior lean prior to the perturbation, as evidenced by a 1.1 cm shift in COP position. Post-perturbation changes of the joint angles and torques were consistent with a shift toward more of a hip strategy. Specifically, there was a 3.2 Nm decrease in plantar flexor torque, a 10.2 Nm increase in hip extensor torque, a 2.5° increase in ankle plantar flexion, and a 6.3° increase in low back flexion (Figure 1). Correlations between pre-perturbation COP position and post-perturbation joint angles/torques were low, indicating that the changes in post-perturbation recovery strategy were primarily due to fatigue and not the difference in pre-perturbation COP position.

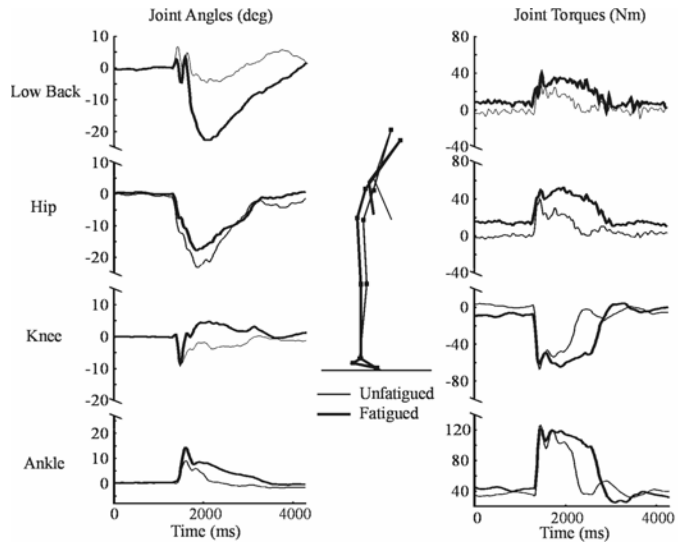

Figure 1: Representative joint angle and joint torque data during unfatigued and fatigued postural recoveries. Positive values indicate extension movement and extensor torque.

Results also suggested that certain subjects, classified prior to fatigue as employing a hip strategy in response to the perturbation, were more affected by fatigue compared to subjects classified as using a combination of hip and ankle strategies prior to fatigue. Increasing fatigue level exaggerated some, but not all, of the changes in postural strategy following fatigue.

CONCLUSIONS

Lumbar extensor fatigue elicited a change in postural strategy in response to a perturbation. Both pre- and post-perturbation postural compensations were identified and demonstrate a general shift toward increasing use of a hip strategy following lumbar extensor fatigue. These findings illustrate that neuromuscular fatigue can influence postural strategy similar to previously reported intrinsic factors.

REFERENCES

1. Horak, FB, Nashner, LM. *J.Neurophysiol*. **55**(6),1369-81, 1986.
2. Davidson, BS, Madigan, ML, Nussbaum, MA. *Eur.J Appl.Physiol Occup.Physiol.* in press, 2004.

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