STOCHASTIC RESONANCE ELECTRICAL STIMULATION TO IMPROVE POSTURAL CONTROL IN KNEE OSTEOARTHRITIS

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INTRODUCTION

Knee osteoarthritis (OA) is associated with reduced postural control, which may put those with knee OA at greater risk of falling. Adults with knee OA have reduced knee proprioception (joint position sense), suggesting reduced proprioceptive sensation about the knee [1]. Proprioceptive acuity is a key component of postural control. Stochastic resonance (SR) stimulation has been theorized as a means by which sensory input may be enhanced. Studies have shown improvements in postural control when plantar, trunk, or ankle stimulation (electrical or mechanical) were applied [2,3,4]. Knee sleeves have also shown some ability to improve postural control in knee OA [5]. However, the application of SR stimulation in combination with a knee sleeve in knee OA subjects has not previously been investigated as a means of improving postural control.

The purpose of this study was to determine whether the application of SR electrical stimulation (ES) combined with a knee sleeve would improve measures of static balance in knee OA subjects.

METHODS

Fifty-two subjects (30F, 22M) with mild to moderate radiographic knee OA (KL grade 1-3) were recruited for participation. After giving their informed consent about the risks of participation, subjects were asked to maintain single leg standing balance for a period of 20 seconds within each trial. Postural control was assessed during 6 conditions with 3 trials within each condition. The first and sixth conditions were control conditions where no ES and no sleeve were applied (NE:NS). The second through fifth conditions were presented in a counterbalanced manner and included: no ES and sleeve (NE:S), 75% ES and sleeve (E75:S), 100% ES and sleeve (E100:S), 150% ES and sleeve (E150:S).

Prior to testing, a neoprene knee sleeve was fit to each subject and two pairs of SR ES electrodes were placed 2 cm above and below the tibio-femoral joint line on the medial and lateral aspects of the knee. SR stimulation consisted of a Gaussian white noise (zero mean, 0-1000Hz) signal with amplitude based on subject’s threshold for SR ES detection. Subject’s threshold for detection was determined for both inferior and superior electrode pairs prior to testing. Subsequent testing incorporated these threshold values at 75%, 100%, and 150%.

Postural control outcome measures included Center of Pressure (COP) mean velocity, displacement range, and standard deviation in the medial-lateral (ML) and anterior-posterior (AP) directions. Additionally COP total path length was measured. Periods of non-test leg touchdown were detected and excluded from the subsequent calculation of outcome measures.

A paired t-test assessed differences between the two control conditions (NE:NS1 and NE:NS2, p<0.05). The two control conditions were then averaged (NE:NSave) and used in subsequent analyses. Differences between the remaining five conditions were assessed with a repeated measures analysis of variance (ANOVA, p<0.05).

RESULTS AND DISCUSSION

A significant effect of the treatment conditions was observed (p<0.05) with significant reductions in the COP total path length for all treatment conditions (NE:S, E75:S, E100:S, E150:S) relative to the control condition (NE:NSave) (Figure 1).
These results are consistent with previous studies showing improved measures of postural control with the use of a knee sleeve. The absence of a significant additive improvement in balance with SR ES in this study may be due to the nature of sensory impairment in knee OA. SR ES aims to improve mechanoreceptor sensitivity. However, in a population with mechanoreceptor degradation resulting from OA, sensitivity improvements may not be possible.

Additionally, it is possible that any improvements with SR were masked by improvements resulting from the knee sleeve. Lastly, it is possible the sensitivity of specific mechanoreceptors necessary for proper postural control was not enhanced due to electrode placement and amplitude of the SR ES signal.

CONCLUSIONS

The results of our study demonstrate the ability of a neoprene knee sleeve to reduce some static postural sway measures during a single-leg stance task in those with knee OA. However, the addition of SR ES appeared to have no significant added benefit.

Questions remain regarding the clinical significance of small improvements in the COP velocity and normalized total path length while wearing a knee sleeve. Future work should focus on optimization of both the stimulus placement and the detection threshold procedure for knee OA subjects in order to achieve a maximal effect of the SR ES.

REFERENCES


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