INTRODUCTION

Walking patterns of persons with knee osteoarthritis (OA) are increasingly being studied as a way of better understanding the role of joint mechanics in the development and progression of knee OA. Specifically, heightened impulsive loading is one biomechanical feature demonstrated in these patients [1,2]. Proprioceptive deficits with OA [3] may contribute to elevated impulsive loading, and it has been proposed that correcting these deficits may help to slow disease progression. While the use of knee braces and sleeves has produced a moderate improvement in proprioception, stochastic resonance (SR) stimulation, which has been shown to enhance mechanoreceptor sensitivity [4], may enhance these effects [5]. By improving sensitivity and therefore proprioception, it may be possible to positively alter gait biomechanics. Altering gait may therefore enable a person to more appropriately load their joint, thus delaying the progression of disease. Our goal is to determine whether impulsive loading rates during weight acceptance of gait are altered when subjects are presented with a subthreshold level of electrical stimulation at the knee in combination with a knee sleeve.

METHODS

Following approval by the Institutional Review Board, 22 subjects (7 males, 15 females) with minimal to moderate (KL grade 1-3) medial knee OA were recruited for testing.

Gait kinetics and kinematics were measured using an electromagnetic tracking system and force plate during four conditions combining the use of a neoprene knee sleeve and SR electrical stimulation (bipolar, Gaussian white noise). Each subject’s threshold for detecting the stimulation was determined prior to gait analysis and a level of 75% of threshold was used during subsequent testing in combination with a neoprene knee sleeve (E75:S). The four testing conditions were: no stimulation/no sleeve (control1 NE/NS1), counterbalance of two conditions: E75/S and NE/S, and no stimulation/no sleeve (control2 NE/NS2). Each subject was instructed to walk at a fast, self-selected speed barefoot down a 10 meter, level walkway. Five trials were completed for each of the four testing conditions. Ground reaction forces were acquired (1440Hz) unfiltered and normalized to subject’s body weight (N). Loading rate was calculated from the vertical ground reaction force (Fz) three ways over increasing time domains: 1.) Fz LR max (BW/s): Max slope from the 1st derivative of polynomial fit between initial ground contact and the peak heel strike transient HST 2.) Fz LR HST (BW/s): linear slope between initial ground contact and the peak HST and 3.) Fz LR to Peak (BW/s): linear slope between initial ground contact and the overall peak ground reaction force (Fz) (Figure 1).

Differences between the two control condition means (NE:NS1 and NE:NS2) were assessed followed by computing an average (NE:NSave) for subsequent analysis. One-way repeated measures analysis of variance was conducted to determine overall significant differences between the measured variable within the four treatment conditions (p<0.05). Tukey’s post hoc analysis was performed to determine further differences between conditions.

RESULTS AND DISCUSSION

No difference between the control conditions was found for any of the outcome measures. Walking speed was also not found to differ across conditions. While the loading rate from initial contact to overall
peak Fz (Fz LR to Peak) was not statistically different between conditions, both the Fz LR HST and Fz LR max demonstrated trends toward overall significance (p=0.093, p=0.084, respectively, Fig.2).

The trend for a decreased loading rate demonstrated in both the E75:S and NE:S conditions may be the result of a higher average knee flexion angle (p<0.001) seen at contact (13.2° and 12.9°, respectively) compared to that of the average control condition (11.1°). However, knee flexion angle at contact for the E75:S and NE:S groups did not significantly differ from each other. Our previous studies demonstrating an improvement in joint position sense with the stimulation and sleeve conditions in knee OA subjects [5] suggests the increased flexion at contact may result from enhanced proprioception with these conditions though we can not discount that passive tension of the sleeve may also have contributed to this response. The amount of knee flexion excursion from initial contact to maximum knee flexion of midstance was found to be significantly more for the average control (NE:NSave), though the maximum knee flexion of midstance was found to be equivalent among the conditions.

CONCLUSIONS

The NE:S and E75:S conditions demonstrated a trend toward decreasing loading rates and with additional planned subjects these differences may become statistically significant. This trend may be a result of increased knee flexion at contact as demonstrated in both of the treatment conditions. It is possible that the increased knee flexion seen at contact was improved by enhanced proprioception as a result of the knee sleeve and SR stimulation treatments. The current configuration of SR stimulation did not demonstrate an ability to enhance the effects of a sleeve alone.

REFERENCES


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