Identification of specific somatosensation and location to predict postural control outcomes

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Introduction

Postural control is a complex motor skill requiring interaction of dynamic sensorimotor processes receiving information from the visual, vestibular, and somatosensory systems. Somatosensation has been reported to account for 50-70% of postural control performance in older adults and 30-40% in young adults.[1] Deficits in somatosensation are known to reduce postural control.[2] Somatosensation measures such as touch pressure sensation threshold (PT) and vibration perception threshold (VT) have been used to identify people with somatosensory deficit in the clinic. However, the appropriate threshold, site on the foot, and modality have not been established in relation to postural control.

Postural control can be assessed using the sensory organization test (SOT) and the motor control test (MCT) using the EquiTest platform.[3] The SOT weighs the individual's use of the visual, vestibular, and somatosensory inputs for postural control through manipulation of the individual's visual surrounding and support surface to determine an equilibrium score. The MCT computes the time for postural recovery after backward and forward translations to determine a latency score. Studies have shown people with postural control deficit have lower equilibrium and latency scores.[4] The purpose of this study was to identify the most relevant sites of somatosensation for postural control. We hypothesized that specific sites of the foot and ankle would have significant associations with equilibrium and latency scores.

Methods

In this study, 49 healthy adults (22M, 27F; mean age 42.0 ± 13.8 (SD) y.o.) were evaluated for postural control and somatosensory measures. Subjects with fall history, vestibular, orthopedic, or neurological disorders, knee or hip replacement, abnormal dizziness, low visual acuity, or using an assistive device for ambulation were excluded from this study. Subjects with abnormal SOT scores were excluded from this preliminary analysis.

PT was evaluated using a set of Semmes Weinstein graded monofilaments (Touch-Test Sensory Evaluator, North Coast Medical Inc., Morgan Hill, CA, USA). VT was evaluated using a handheld biothesiometer (Bio-Medical Instrument Co., Newbury, OH, USA). PT and VT were measured at 14 sites on the foot: the plantar surface of the great toe, 1st metatarsal, 3rd digit, 3rd metatarsal, 5th digit, 5th metatarsal, medial arch, lateral arch, the mid heel; the medial and lateral malleoli; and the dorsal surface of the 1st metatarsal, between the 1st and 2nd metatarsal, and the 5th metatarsal. A Smart-EquiTest platform (NeuroCom, Clackamas, OR, USA) was used for the SOT and MCT.

Bivariate correlations were used to quantify the relationship between postural control variables and somatosensory inputs. Linear regression modeling using the backward method was used to identify the most relevant site(s) for postural control outcomes. Data were assessed for multi-collinearity and the model that optimized the variance accounted and standard error of the estimate was identified ($p < 0.05$).

Results and Discussion

A total of 35 subjects were included in our analysis; 14 out of 49 were excluded due to abnormal SOT scores. The final linear regression model demonstrated the PT on the right 1st dorsal metatarsal and VT on the right 3rd metatarsal predicted the equilibrium score ($F(2, 32) = 4.28$, $p < .02$), with an R^2 of .21 (Figure 1). The PT on the right 1st metatarsal, left middle toe, left medial arch, left 5th dorsal metatarsal, and the VT on the left middle toe predicted the latency score ($F(6, 28) = 5.42$, $p < .01$), with an R^2 of .54 (Figure 1).

Somatosensory thresholds were moderately correlated to equilibrium and latency scores in healthy adults. The somatosensory system is only one component in postural control and is expected to only explain a portion of variance in postural control performance. This study provides baseline data for somatosensory measures in healthy adults and gives insight to somatosensory inputs of the foot relevant to postural control.

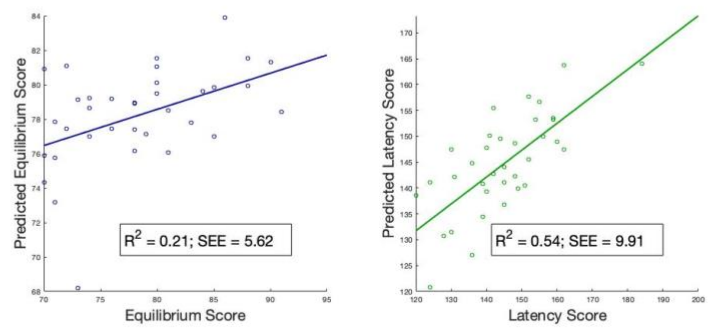

Figure 1: Equilibrium Score vs. Predicted Equilibrium Score and Latency Score vs. Predicted Latency Score.

Significance

This report is part of an ongoing study investigating the potential cut-points of PT and VT for predicting balance dysfunction in older adults and individuals with peripheral neuropathy to improve clinical fall screening algorithms. Future analyses will examine relationships in atypical populations as well as confounding influences of sensory re-weighting.

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