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Lateral Skin Stretch Perception for Haptic Gait Retraining

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Background

Gait retraining is a noninvasive intervention where patients modify their gait kinematics in order to alter the contact forces in the knee joint. One strategy for patients with early stage knee OA is to shift the mechanical loads from the degenerated medial compartment to the unaffected lateral compartment of the knee [1].

Skin stretch is an interesting candidate for tactile feedback and can be used in tandem with current vibration systems. Unlike vibration, skin stretch can provide magnitude and directionality simultaneously using a single actuator [2].

In this study, we wanted to determine suitable locations on the lower limb to place a skin stretch device and also what the speed, displacement, and force requirements of such a device would be.

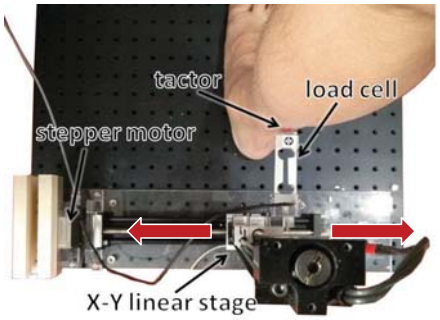

Fig 1. The two axis linear stages rendering lateral skin stretch in the horizontal direction. The Loadstar RAPG-001M-A load cell is shown.

Method

Nine locations were chosen. Eight test subjects (six males and two females, range 20-30 years) volunteered to participate in this experiment and signed an informed consent in accordance with the ethics committee of the University of Auckland.

Each subject was seated in a chair with one of the nine locations of interest attached to the tactor via thin double sided tape. Each set of the experiments consisted of 32 different stimuli based on the four displacements of 0.2, 0.5, 1.0 and 2.0 mm, four speeds of 0.5, 1.0, 2.0 and 4.0 mm/s and the two directions (left and right) of interest. For each of the nine locations, each subject completed five test sets of the 32 stimuli. Accuracy rate was calculated by (total correctly perceived stimuli)/(total rendered stimuli) with 1.0 being the highest.

Results

Accuracy rates for each stimuli, for each location, were compiled from the results of all the test subjects. Locations 4, 5, and 6 (Fig 2), showed high overall accuracy rates of at least 0.80 and also present a convenient location for a haptic skin stretch device.

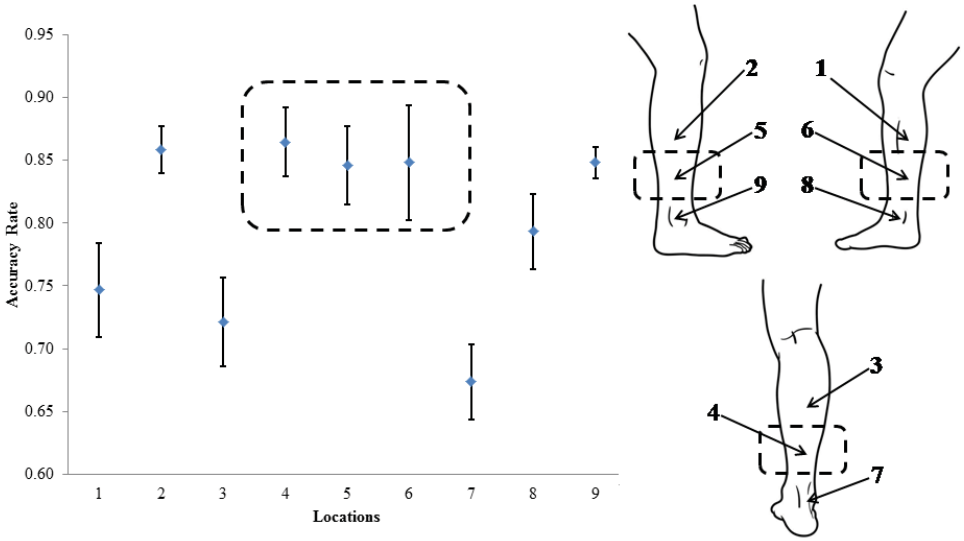

Fig 2. Accuracy rates for each location based on each of the eight subjects. Dashed boxes highlight the three locations: calcaneal tendon (upper), fibularis longus (lower), and soleus, as having among some of the highest sensitivity to skin stretch and also convenient locations for a haptic feedback device.

Summary

This study provides insight into which locations are suitable for applying a skin stretch stimuli as well as the magnitude of the displacement and speed of stimuli that are required to enable accurate sensation of skin stretch. This informs us of the requirements our actuators will need to meet in order to be effective.

The next stage is to test the efficacy of a portable skin stretch device for tracking foot progression angles.

References

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[2] K. Bark, J.W. Wheeler, S. Premakumar and M.R. Cutkosky, "Comparison of skin stretch and vibrotactile stimulation for feedback of proprioceptive information," in Haptic interfaces for virtual environment and teleoperator systems, 2008. haptics 2008. symposium on, pp. 71-78, 2008.

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