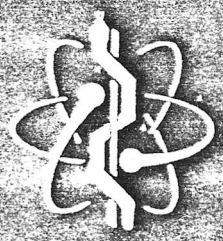
Medical & Biological Engineering & Computing



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INVESTIGATION OF SENSORS FOR SENSORY FEEDBACK IN NEUROMUSCULAR ELECTRICAL STIMULATION SYSTEMS

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Introduction Spinal cord injuries deprive subjects not only of motor functions but also of sensory ones. To restore tactile sensation, the Neutomuscular Electrical Stimulation system (NMES) should be equipped with sensory feedback not only to control the movement but to provide sensations to the subject.

Materials and Methods Sensors necessary for providing sensory feedback can be the same as used in NMES programs. For gait control, foot contact feedback is necessary and for grasp regulation, force feedback is essential. The system is comprised of an insole with three Force Sensing Resistors (FSRs) attached to the heel, 1 st. and 5 th. metatarsal heads, to give information about heel strike, stance phase, and toe off. In this manner the subject does not need to look at the ground. The second sensor consists of a glove with FSRs attached to the distal phalanxes of the thumb, index and long fingers. With this device the subject could learn to control the forces to grasp different objects.

Results Both sensors were tested on normal subjects. The instrumented insole was effective on the state of foot support monitoring, indicating heel strike, toe off and force variations during stance phase (Fig.1). The instrumented glove showed the variation of forces applied during object grasping (Fig.2).

Conclusions The above sensors are promising alternatives toward sensory feedback. They can send a signal to an artificial proprioception system to provide gradual sensations to the subject. Most importantly, they are low cost systems, cosmetically acceptable and easy to use, thus being suitable for practical daily use.

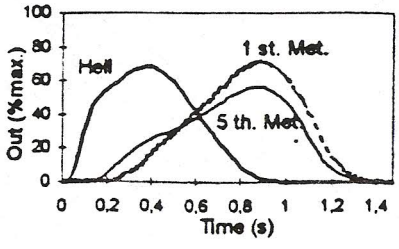

Figure 1 - Normalized foot contact force

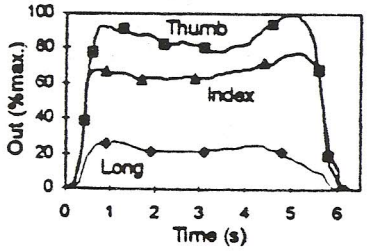

Figure 2 - Normalized grasp force

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