Feasibility study of hybrid therapeutic electrical stimulation for walking in the hemiplegia


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Abstract: On gait training in several months after stroke onset, it’s useful to apply for therapeutic electrical stimulation on a rehabilitation program of the neuromuscular re-educational exercise. The practical surface electrodes system is developed, based on the experimental estimation of muscular output. The 3 dimensional joint torques were measured by strain-gage's sensor. Also, a reciprocal gait orthosis is also introduced as a new hybrid system, and to improve ambulation activity in the hemiplegic patients.

? . Introduction

The main objective of the therapeutic electrical stimulation (TES) is to artificially create such a smooth movement for multiple joint system, as normal as possible. It will be a new turn in the physical therapy, to indicate a new information of biofeedback system. On one hand, In practical use on the usual rehabilitation program, it is important to estimate a joint torque to move a limb artificially when the surface electrodes are used, and to make use of a suitable reciprocal gait orthosis. In this study, we investigated the feasibility of hybrid multichannel electrical stimulator for walking in the hemiplegia.

? . The surface electrodes system

On the estimation of the stimulating pattern, the followings steps are used: (1) IEMG discharge pattern in the comparatively slow walking, (2) torque output of the hip and knee joint by the 3 dim. torque measurement system, and (3) mathematical musculoskeletal system (Delp et al. 1994).

Firstly the size and the location of the stimulating electrodes is fixed to cover an active area by using a popular electro-physiological instrument. As an example, the frontal area of thigh are described in Fig.1. The electrodes of the hip flexor are placed on the rectus femoris muscle, and the long adductor muscle, including the sartorius muscle, and the iliacus muscle. Another flexor muscle is tensor fasciae latae muscle. On the next step, the output torques of stimulated muscle are quantitatively checked by the 3 dimensional force sensor, built by a strain-gage technique. It can be picked up the 3 components of torques of hip joint; flexion/extension, adduction/abduction, and incycloduction/excycloduction. by fixing the leg by the LLB. Lastly the stimulating pattern is examined by the mathematical musculoskeletal SIMM (Software for Interactive Musculoskeletal Modeling, SL Delp, JP Loan, 1994)

? . Experimental RGO

![Fig.1 An example of Electrode placement of the thigh](image)
TES is usually applied to control flexion/extension movement of the hip and knee joint, in addition to the foot joint. RGO is accounted for stability of the pelvis, and smooth movement of the center of gravity of the whole body. On the above patterned stimulation, for example, the subject is basically able to sufficiently flex hip joint by stimulating adductor longus muscle, sometimes adding pectineus, sartorius, and tensor fasciae latae muscle.

On the RGO, an air-cylinder actuator was applied to flex the hip joint in the paralytic limb. Foot switch with an electronic sound was used to adjust the duration of stimulating pattern. In addition to the regular assessment of rehabilitation program, the parametric factors of gait significantly showed effectiveness; step length, walking speed, symmetrical, etc.

**Fig.3 An experimental test of reciprocal gait orthosis**

**Conclusion**

1. The revised musculoskeletal system was successfully applied to generate the stimulating pattern, under experimental information of a three dim. torque sensor.
2. In gait training, a HTES system strongly showed to improve such circumdation gait, by assisting reciprocal motion of gait in the comparatively severe hemiplegia.

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