Designing a wearable robot for Stroke patients; Clinical considerations for patients with Diabetes

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(1) Introduction
Diabetes is one of the major risk factors for Stroke[1]. It is estimated that over 30,000 people in Ireland are survivors of stroke, many of whom have significant residual disability including hemiparesis (48%)[2]. In most such cases of Hemiplegia intensive, task-oriented and repetitive physiotherapy may be necessary to modify neural organisation and recover functional motor skills[3].

(2) Rehabilitation Robotics in Stroke
Application of robotics in neurological rehabilitation was introduced almost two decades ago[4]. Rehabilitation Robotic tools are recently being used more by physiotherapists for patients with conditions like Stroke, Spinal cord injury, and Traumatic Brain Injury.

(3) Exoskeletons
“An exoskeleton is a wearable robot with joints and links corresponding to those of the human body”[5]. Exoskeletons can help patients with neurological disabilities improve their motor function and performance by providing task specific practice [6].

(4) Clinical Hypothesis
During the acute phases of Stroke, if a patient if fitted with a wearable robot (Exoskeleton) which could assist the patient in performing task oriented practice on the affected side, then this may expedite recovery. The wearable robot can be a great assistance to the physiotherapist, in planning and prescribing task-oriented practice.

(5) Design and Clinical considerations patients with Diabetes
“Is it not yet clear what characteristics should be incorporated in a therapeutic robotic assistant platform”[7]? A Review of literature suggests that Diabetes is not taken into consideration during the design process of Rehabilitation Robotic tools for Stroke.

As Diabetes is one of the major risk factors for Stroke patients, the Design process of Wearable Robots for Stroke patients should take into account clinical considerations for patients with diabetes.

Since patients with Diabetes may have associated Diabetic Heart Disease [8] and as the use of robot increases Cardiac Output, cardiac monitoring mechanisms and ease-of-access for Cardio-Pulmonary Resuscitation should be incorporated into the Design [9].

To facilitate more intensive task-oriented training practice, the wearable robot needs to be ergonomic, light and closer to the skin similar to an Orthotic device. As the wearable robots usage increases there could be repetitive shearing on the skin and repetitive movements of the Musculoskeletal system. Diabetic friendly Orthotic lining material should be used for points of skin contact, in the robot. Sweating and its effects on the skin must also chosen into account, while designing the external shells and the inner lining, the main optimal skin condition.

Rheumatological manifestations, such as adhesive capsulitis (frozen shoulder), Reflex sympathetic dystrophy, diabetic hand syndrome, Dupuytren's contracture and Neuroarthropathy are characteristically associated with Diabetes Mellitus [10], should be diagnosed and managed accordingly for use with the wearable robot. If patients develop any of these during the treatment process, then the effect of the robot on the affected joints should be carefully monitored and controlled accordingly.

1 in 10 of those with diabetes will have a foot ulcer at some point during the course of their diabetes [11]. If foot clinical manifestations such as Neuropathy, Ischaemia, Structural deformity, Ulceration are present then Orthotic / Podiatric Evaluation should be carried out prior to using the wearable robot.

Diabetic foot ulceration usually occurs at sites of abnormally high pressure [11]. Sensory Neuropathy and Autonomic Neuropathy should be taken into account and pressure monitoring mechanisms should be developed and incorporated into the wearable rehabilitation robot.

The presence of sensory neuropathy or tissue viability issues does not contraindicate the use of an intimately fitting Ankle Foot Orthosis provided the fit is optimal [12]. Should the Robot be intimately fitted, then neurobiomechanical considerations should be taken into account, similar to Orthotic Devices such as Ankle-Foot Orthosis and Saeb-Reach. Routine biomechanical and sensory evaluation should be mandatory before and after use of the wearable robot.

The function of the wearable robot is beyond an Orthotic device, The robot should sense the patient’s motor and sensory ability and vital signs constantly and should alert the Physiotherapist, if the threshold parameters for skin ulceration, preset-joint range of motion and normal ECG, exceed.

As the wearable robots evolve, their clinical usage would increase, and planning for clinical considerations during the design process stage, will eliminate therapeutic bottlenecks in the future.

References: