3D PRINTED STROKE REHABILITATION EXOSKELETON DESIGN

LIMITATIONS AND BARRIERS OF EXOSKELETON REHABILITATION ADOPTION

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SOCIOTECHNICAL SYNTHESIS

Despite numerous rehabilitation exoskeletons being designed and developed since 2000, many of them have never been used by target population. The technical topic addresses the faults and aspects of current exoskeletons that suffer with poor accessibility and a non-intuitive nature by considering the perspectives of the individuals using the device, which are usually not prioritized during the design process. The research will lead to the development of an exoskeleton that will assist stroke patients through their rehabilitation exercises and provide them with the means to regain muscular function. The STS topic investigates the relationships between social groups, objects, and beliefs that are relevant to understanding challenges of rehabilitation exoskeleton adoption. Joining the STS research with the technical research will allow for the identification and implementation of factors that make an exoskeleton design successful.

The technical report details the development of a 3D printed low-cost upper limb exoskeleton for stroke rehabilitation use. The device's unique qualities of being lightweight and more affordable properly address the concerns that current exoskeletons are expensive, require therapist supervision, and can only be accessed in a hospital setting. The exoskeleton consists of three degrees of freedom: flexion-extension of the shoulder, abduction-adduction of the shoulder, and flexion-extension of the elbow. The motions will be initiated and monitored by inertial measurement unit sensors and electromyography sensors. The sensors will send inputs to an Arduino, which will send commands to direct stepper motors and pneumatic artificial muscles. The motor housings, motor shafts, arm piece, and shoulder piece were modeled using computer-aided design software and 3D printed using PLA plastics.

At the end of testing multiple iterations of the proposed exoskeleton design, the pneumatic artificial muscles successfully performed to lift an elbow up to 60º and the motors were able to successfully communicate with the sensors' inputs. More testing would be needed to determine what range of motion the motors would be able to lift the arm when controlling the shoulder movement. Additionally, testing the device on a variety of subjects would be required to determine the variability of the sensors' signal strength.

The STS report seeks to analyze the reasons as to why there is such a low adoption and acceptance rate of rehabilitation exoskeletons by the target population. The limitations and barriers that are hindering the potential of exoskeletons were revealed by examining case studies on various exoskeleton and similar devices through the lens of Actor-Network Theory, a framework developed by STS scholar Michel Callon. The case studies ranged from personal perspectives of patients after they worked with an exoskeleton design, to therapists evaluating the success of exoskeleton-based rehabilitation, to engineers assessing the exoskeleton design development progress over the years. While the potential of rehabilitation exoskeletons survives through the hope of patients, new exoskeletons must properly address the common frustrations of previous exoskeleton designs to ensure high adoption rate.

Rehabilitation exoskeletons are facing a range of issues prohibiting its success for stroke patients. Engineers are not integrating the target populations' response to their technology before moving onto another design. Therapists would rather stick to the common rehabilitation methods. Stroke patients have too high expectations of the devices. The healthcare system does not properly support the high interest of patients nor make the technology more affordable.

While the use of exoskeletons in stroke rehabilitation is promising, a design is only valuable if stroke patients are able and willing to employ it. The relationships and conflicts between actors involved in making rehabilitation exoskeletons available should be involved in the design process.

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