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Robotic Exoskeleton Response During Infant Physiological Knee Kinematics

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Abstract : Spina bifida is a type of neural tube defect that affects the nervous system and can lead to problems such as total leg paralysis. Treatment requires physical therapy and rehabilitation. Robotic exoskeletons have been used for rehabilitation to train muscle movement and assist in injury recovery; however, current models focus on the adult populations and not on the infant population. The proposed framework aims to couple a musculoskeletal infant model with a robotic exoskeleton using vacuum-powered artificial muscles to provide rehabilitation to infants affected by spina bifida. The study that drove the input values for the robotic exoskeleton used motion capture technology to collect data from the spontaneous kicking movement of a 2.4-month-old infant lying supine. OpenSim was used to develop the musculoskeletal model, and Inverse kinematics was used to estimate hip joint angles. A total of 4 kicks (A, B, C, D) were selected, and the selection was based on range, transient response, and stable response. Kicks had at least 5° of range of motion with a smooth transient response and a stable period. The robotic exoskeleton used a Vacuum-Powered Artificial Muscle (VPAM) the structure comprised of cells that were clipped in a collapsed state and unclipped when desired to simulate infant's age. The artificial muscle works with vacuum pressure. When air is removed, the muscle contracts and when air is added, the muscle relaxes. Bench testing was performed using a 6-month-old infant mannequin. The previously developed exoskeleton worked really well with controlled ranges of motion and frequencies, which are typical of rehabilitation protocols for infants suffering with spina bifida. However, the random kicking motion in this study contained high frequency kicks and was not able to accurately replicate all the investigated kicks. Kick 'A' had a greater error when compared to the other kicks. This study has the potential to advance the infant rehabilitation field.

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