A REVIEW OF END-EFFECTOR REHABILITATION ROBOTS FOR SHOULDER AND ELBOW JOINTS

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INTRODUCTION

Stroke is a leading cause of disability, and more than 400,000 Canadians live with its effects. While lower limb function often recovers early, upper limb rehabilitation—particularly at the shoulder and elbow—remains challenging. End-effector rehabilitation robots (SEERRs) have emerged as promising tools to deliver intensive, task-specific, and motivating training while reducing therapist burden. This paper reviews SEERRs, focusing on structural and functional features and highlighting trends shaping future designs.

MATERIALS AND METHODS

A scoping review was conducted across Google Scholar, PubMed, Scopus, and IEEE using combinations of keywords including 'end-effector,' 'rehabilitation,' 'shoulder,' and 'elbow.' Publications, patents, and commercial documentation were included if they reported on robotic systems actively assisting both joints. Exoskeletons, passive devices, and non-clinical applications were excluded.

RESULTS AND DISCUSSION

Eighty SEERRs were identified from 1995–2024. Most used electric actuation (primarily BLDC motors) and linkage or cable-driven transmission. Planar (2D) designs dominate due to simpler mechanics, while few achieve full 3D movement because of bulk and gravity compensation challenges. Training modes range from passive to active-resistive, with impedance control common for safe interaction. Unilateral manipulation strategies (79%) prevail, though bilateral approaches show superior therapeutic benefits. Emerging trends include compact home-based robots (e.g., H-Man, ArmAssist), telerehabilitation for remote supervision, and highly backdrivable designs using direct or quasi-direct drive actuators. Despite progress, only ~25% of SEERRs reached commercialization, with InMotion Arm and ArmMotus EMU as notable examples.

CONCLUSIONS

SEERRs complement conventional therapy by enabling accessible, safe, and engaging rehabilitation. Future development should prioritize compact, cost-effective, and backdrivable designs that integrate home use, telerehabilitation, and regulatory compliance. A unified system addressing both shoulder and elbow rehabilitation remains an unmet need.

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