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A COMPREHENSIVE REVIEW OF LOWER LIMB EXOSKELETONS

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Abstract

In line with the global transition toward sustainable engineering practices, lower limb exoskeletons are gaining attention for both their assistive capabilities and their environmental implications. Lower limb exoskeletons are wearable robotic devices intended to enhance mobility and support physical capabilities, particularly for the elderly and individuals with impairments. These devices are used in medical rehabilitation, industrial support, military applications and personal mobility assistance. They improve the quality of life by facilitating movement, reducing fatigue and preventing injuries during strenuous tasks. Beyond their biomechanical and functional advantages, these devices are increasingly assessed through the lens of sustainability and environmental impact. This review provides a comprehensive analysis of lower limb exoskeletons, including their classification, design principles, actuator technologies and control strategies. Particular attention is directed toward sustainable engineering considerations such as material selection, energy efficiency and life cycle aspects- focusing on the environmental trade-offs of titanium alloys, carbon fiber composites, advanced polymers and energy sources. Passive and quasi-passive systems are also examined for their potential to reduce energy consumption and reduced manufacturing complexity. These considerations outline how exoskeleton design influences device longevity and sustainability in waste reduction. By integrating environmental engineering perspectives into the design and deployment of assistive technologies, this work contributes to interdisciplinary efforts aimed at enhancing human capabilities while minimizing ecological footprints. It also highlights the need for lifecycle-conscious design strategies, that balance performance requirements with environmental responsibility across all stages of development.

Key words: exoskeleton, lower limb, review

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