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Design of the Compliant Mechanism of a Biomechanical Assistive Device for the Knee

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Abstract : Compliant mechanisms are designed to deform in a controlled manner in response to external forces, utilizing the flexibility of their components to store potential elastic energy during deformation, gradually releasing it upon returning to its original form. This article explores the design of a knee orthosis intended to assist users during stand-up motion. The orthosis makes use of a compliant mechanism to balance the user's weight, thereby minimizing the strain on leg muscles during standup motion. The primary function of the compliant mechanism is to store and exchange potential energy, so when coupled with the gravitational potential of the user, the total potential energy variation is minimized. The design process for the semi-rigid knee orthosis involved material selection and the development of a numerical model for the compliant mechanism seen as a spring. Geometric properties are obtained through the numerical modeling of the spring once the desired stiffness and safety factor values have been attained. Subsequently, a 3D finite element analysis was conducted. The study demonstrates a strong correlation between the maximum stress in the mathematical model (250.22 MPa) and the simulation (239.8 MPa), with a 4.16% error. Both analyses safety factors: 1.02 for the mathematical approach and 1.1 for the simulation, with a consistent 7.84% margin of error. The spring's stiffness, calculated at 90.82 Nm/rad analytically and 85.71 Nm/rad in the simulation, exhibits a 5.62% difference. These results suggest significant potential for the proposed device in assisting patients with knee orthopedic restrictions, contributing to ongoing efforts in advancing the understanding and treatment of knee osteoarthritis.

Keywords : biomechanics, complaint mechanisms, gonarthrosis, orthoses.
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