Simulation of an active ankle prosthesis of one degree of freedom

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In this paper is presented the design of an active ankle prosthesis with a single degree of freedom (DoF) actuated by a linear actuator. The analysis is focused in the plantar base that shall allow the impacts absorption in gait cycle with the aim to replace the human lower limb of a person who has suffered ankle amputation. For the design it has been simulated the natural motion of a human ankle which trajectory is known for previous studies based in a biomechanical analysis of the same. For the static structural analysis has been used finite elements software ANSYS, obtaining data of stress, deformation and security factor which allow choose and couple properly the ideal linear actuator for the kind of patient and, the properly thickness of the plantar base with which the prosthesis will be built to avoid mechanic failures.

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Contents

Amputation of a limb is a permanent and traumatic event that changes people's lives. Amputations occur for different reasons, can be caused by diseases such as cancer, diabetes, vascular diseases, injuries caused by accidents. Diabetes is one of the diseases with the highest amputation rate in patients due to the damage caused by the disease in the arteries (Niemann 2016). Currently, there are about 1.9 million amputees according to the Amputee Coalition of Washington, DC and it is estimated that 185,000 new amputations take place every year. In base of the statistical data of the European Union, it is estimated that there are about 3 million amputees and 290,000 new amputations every year in these countries (Micera 2016). In Ecuador between 2007 and 2015 there were 1061lower limb amputations, according to the National Institute of Statistics and Censuses (INEC 2017). Through the kinematic study of the prosthesis, is determinate that a spherical joint allows realize rotational movements of the ankle both in the sagittal plane as in the frontal plane (Masum, Bjaumik, and Ray 2014). Kinetic and kinematic properties of human limbs can be analyzed through software to determinate ankle motion and compare with the foot orientation and the tibial coordinate system (Sinitski, Hansen, and Wilken 2012). Other authors propose improve performance of an ankle prosthesis using a stiffness analysis of the forefoot and hindfoot during gait cycle (Adamczyk, Roland, and Hahn 2017). In context with the analysis

(Adamczyk, Roland, and Hahn 2017). In context with the analysis previously made by the authors mentioned above, the study of an ankle prosthesis is based in gait cycle, stiffness and torques that are generated in the ankle joint but it's not considered the deformation and stiffness of the planar base, for this reason this study propose the design of an ankle prosthesis with an linear actuator, obtaining data of stress, deformation, security factor and convergence analysis through a static structural simulation realized using ANSYS software for finite elements analysis, with the aim to maintain the natural trajectory generated by a human ankle to avoid failures in healthy joints, due to the gait cycle also depends of the motion of plantar base.

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