Master’s Program: Biomedical Engineering

Master’s Thesis

IMPROVEMENT, COMPLETION AND VERIFICATION OF AN ARTIFICIAL MUSCLE BIOMECHANICAL RACK (AMBR)

For receiving the Degree of Master of Science in Biomedical Engineering.

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SUMMARY

During spaceflight astronauts undergo different physiological adaptations. One of them is bone tissue density decay in the lower region of the leg. Engineering tools are needed to understand the mechanisms of bone (re-)modelling and to design proper countermeasures. A computer model involving the Finite Element Method (FEM) is being developed; it calculates muscle forces from a known bone deformation. For this purpose a biomechanical rig will be useful for verifying the results obtained from the computer model as well as to better understand the influence of muscle forces on the tibia bone.

This Master’s thesis describes the improvement, reconstruction and verification of an Artificial Muscle Biomechanical Rig (AMBR) which is capable of simulating specific lower leg muscle forces obtained from the FEM approach. Once these forces are applied the deformation on the chosen specimen is recorded to compare it with the initial deformation fed to the computer model.

The rack implements different mechatronic technologies in order to replicate muscle contraction and force application into a tibia-like specimen, as well as additional systems to record output data from the biomechanical tests.

The control system applies the desired muscle forces using pneumatic actuators. The process is managed through a valve system and force sensors. The operator, by using a custom-designed computer interface is able to define the force application parameters as well as to monitor the state of the biomechanical tests.

For recording reaction forces and moments a force plate was installed. To gather information on the specimen deformation when controlled forces are applied an innovative method developed at the German Aerospace Center, Deutsches Zentrum für Luft- und Raumfahrt (DLR), based on Motion Capturing was used.

Different tests focused on the functionality of the technologies used were made in order to know their accuracy and repeatability. Once their efficacy was proven, the necessary elements were integrated into a single-structure arrangement. Final tests showed that during operation all mechanisms were well integrated and didn’t hinder the function of the others. The final results show that the information obtained is appropriate and the data from future tests will help to validate the computer model.