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THE BENEFITS OF LOWER EXTREMITY LOADING IN SPACE DUE TO THE SEATED EXECUTION OF ORDINARY CALF RAISES AND THE LEG PRESS ON HUMAN SUBJECTS

Abstract

An exercise regimen of the Multifunctional Dynamometer for Application in Space (MDS) was performed by a crew of 6 astronauts and cosmonauts during the "Mars-500" isolation project. This intensive testing focused on the capabilities, durability and efficiency of the exercise countermeasure device. It also provided valuable qualitative and quantitative feedback and revealed the potential and limitations of the overall construction. The evaluation of miscellaneous responses and basic discussions led to a further measurement on the device.

The leg press sled of the MDS is used for high intensive loading exercises (e.g. Leg Press, Leg Press Calf Raises). This setup leads to greater generation of loads on certain bone sites during countermeasure exercises compared to other devices. Especially, Leg Press Calf Raises are noted to generate high forces, which might lead to the preservation of distal tibia bone mass. Together with the common Leg Press exercise it should be performed dynamically in a single-legged mode, for better generation of osteogenic stimulus. These two exercises are chosen because they are spine-protective and allow the implementation of higher active forces on certain structures without harming the trunk. They mainly affect the lower limb as target area of intensive loading by not transmitting high loads throughout the whole body (e.g. Squat).

In this study our aim is to calculate the load on the tibia and femur due to the ground reaction forces resulting from exercises performed on the MDS. The study group consisted of 26 healthy subjects (13 women, 13 men) and the data acquisition included a full motion analysis via a motion capturing system and force recordings using a ground force plate. The modelling of the lower limb is based on the principles of classical mechanics, considering the fact that external generated forces like ground reaction forces are caused by internal forces like muscle forces.

The calculated average load on tibia is up to 6.6 times body weight during Leg Press and 8.8 times body weight during Calf Raise. Even though calf raise produced higher load on tibia, the Leg Press exercise cannot be excluded as it comparatively generated higher forces on the femur. Hence both exercises are recommended for the bones of the lower extremity.

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