Inadequate Loading Stimulus on ISS Results in Bone and Muscle Loss

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INTRODUCTION

Exercise has been the primary countermeasure to combat musculoskeletal changes during International Space Station (ISS) missions. However, these countermeasures have not been successful in preventing loss of bone mineral density (BMD) or muscle volume in crew members.

METHODS

We examined lower extremity loading during typical days on-orbit and on Earth for four ISS crew members. In-shoe forces were monitored using force-measuring insoles placed inside the shoes [1]. BMD (by DXA), muscle volumes (by MRI), and strength were measured before and after long-duration spaceflight (181±15 days).

RESULTS

The peak forces measured during ISS activity were significantly less than those measured in 1g for the same activities. Typical single-leg loads on-orbit during walking and running were 0.89±0.17 body weights (BW) and 1.28±0.18 BW compared to 1.18±0.11 BW and 2.36±0.22 BW in 1g, respectively [2]. Crew members were only loaded for an average of 43.17±14.96 min a day while performing exercise on-orbit even though 146.8 min were assigned for exercise each day. Areal BMD decreased in the femoral neck and total hip by 0.71±0.34% and 0.81±0.21% per month, respectively. Changes in muscle volume were observed in the lower extremity (-10 to -16% calf; -4 to -7% thigh) but there were no changes in the upper extremity (+0.4 to -0.8%) [3]. Decrements in isometric and isokinetic strength at the knee (range: -10.4 to -24.1%), ankle (range: -4 to -22.3%), and elbow (range: -7.5 to -16.7%) were also observed [3]. Knee extension endurance tests showed an overall decline in total work (-14%) but an increased resistance to fatigue post-flight. [3]

DISCUSSION AND CONCLUSIONS

Our findings support the conclusion that the measured exercise durations and/or loading stimuli were insufficient to protect bone and muscle health.

REFERENCES

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