The Computerized Resistive Exercise ***Dynamometer***

by

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1. IDENTIFICATION AND SIGNIFICANCE OF THE INNOVATION

The goal of this proposal is to develop a computerized, feedback-controlled, portable, battery-powered, hydraulic dynamometer, which can be used in normal, reduced-g, and zero-g environments. The proposed device will provide a closed-loop feedback system to measure and control various muscular strength parameters. The innovativeness of this device includes:
(1) The ability to measure muscular strength without the limitations imposed by traditional weight-related devices
(2) Computerization of both the feedback control feature, allowing adjustment of the device to the individual rather than the individual accommodating the device, and customization of the diagnostic and exercise protocols with data storage capabilities
(3) Low-voltage
(4) Portability
(5) Compactness

The relevance of the proposed equipment for NASA lies in its ability to evaluate astronaut strength and endurance levels, as well as to design and follow appropriate exercise protocols in all gravitational environments. Data can be stored for later evaluation and for use in conjunction with other medical or physiological assessments in the continual effort to identify and counter the deconditioning caused by micro-gravitational conditions.

Physical fitness and good health have become increasingly more important to the American public, yet there exists no compact, affordable, accurate device either for measurement or conditioning human strength or performance. This deficit hinders America's ability to explore the frontiers of space as well. Without appropriate means to measure physical force requirements under zero-g conditions and without appropriate equipment for training for these task-related activities as well as against the deleterious physiological effects of micro-gravitational deconditioning, America's permanent manned presence in space will be severely restricted.

One of the ways the human body reacts to the reduced physiological and mechanical demands of microgravity is by deconditioning of the cardiovascular, musculoskeletal, and neuromuscular systems. This deconditioning produces a multitude of physical changes such as:
[1]. Loss of muscle mass, decreases in body density and body calcium, decreased muscle performance in strength and endurance, orthostatic intolerance, and overall decreases in aerobic and anaerobic fitness.

[2]. The biomedical reports from the Gemini, Apollo, and Skylab missions and the work of Thornton and Rummell have revealed a severe problem of reduced muscle mass and strength loss of the lower extremities following prolonged periods in microgravity. Since mission operations normally require relatively greater load demands for the arms and upper body than for the lower extremities, these findings were considered reasonable and not unexpected. However, the use of a bicycle ergometer on Skylab 2 was unable to provide sufficient aerobic exercise to maintain leg strength at earth-based, or 1-g, levels, since it could develop neither the type nor the level of forces necessary.

[3]. Devices which provided isokinetic resistance were employed on Skylabs 3 and 4 which resulted in higher leg force results than those generated in Skylab 2, but were limited to an inadequate level.

[4]. A review of the effects of strength training on human skeletal muscle suggests that the benefits of appropriate training would favorably counteract the negative effects of weightlessness. In general, strength training that uses large muscle groups in high-resistance, low-repetition efforts increases the maximum work output of the muscle group stressed.

[5]. Since resistance training does not change the capacity of the specific types of skeletal muscle fibers to develop different tensions, strength is generally seen to increase with the cross-sectional area of the fiber. This may suggest an important finding in the effort to reduce or prevent the loss of muscle strength associated with reduced-g exposures. It may be that resistance training with the resultant hypertrophy would be an effective countermeasure for strength loss.

[6,7,8]. Since the cause of space deconditioning is usually attributed to the absence of gravity, the development of countermeasures is essential to interrupt these adverse adaptational effects and to develop activities which will sustain normal, robust fitness, conditioning, and good health. While experiments on the Gemini, Apollo, and Skylab missions suggest that regular exercise was helpful in minimizing several aspects of spaceflight deconditioning, there is a lack of quantifiable measures of specificity and amount of physical exercise performed by crew members during flight. Quantification of optimal intensity, frequency, and duration of exercise during spaceflight is of utmost importance for manned missions, yet "no data exists that provides even the slightest clue as to what the forces and impact load of locomotion are in micro-gravity."

[9]. Countermeasures are efforts to counteract the physiological problems caused by exposure to zero-g by interrupting the body's adaptation process. Effective countermeasures will promote mission safety, maximize mission successes, and maintain optimum crew health. Specific recommendations required by space missions were