Fitness Assessment and Exercise Training for Suborbital Scientist Astronauts

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Summary: There are no established physical fitness guidelines for suborbital scientist astronauts (SSAs). The purpose of this paper is to use existing scientific information from space medicine, exercise physiology [1], and acceleration physiology to prepare a physical fitness assessment and training program suitable for use by the SSA population.

With the possibility of repeat flights and numerous, diverse in-flight tasks, the importance of pre-flight conditioning will assume great significance for SSAs. We suggest the practical implementation of a muscle strength-based fitness assessment, which may lead to the evolution of an industry-wide fitness program ensuring SSA health, job performance, and safety.

Fitness Assessment: Evaluation of basic SSA fitness may be determined by an assessment of the following: multi-stage shuttle run for aerobic fitness [2, 3], push-ups for upper body endurance, grip strength, sit-ups for core endurance [4], and one-repetition maximums for large muscle groups in the lower body and chest. Since SSA occupation-specific fitness requirements must align with the physical tasks of the job and the demands of launch and re-entry it is necessary to quantify the physical demands of the job by means of biomechanical and psychophysical measures. Once the fitness demands of the job have been determined, more specific physical fitness tests can be established.

Fitness Guidelines: The Minimum Physical Fitness Guidelines will be developed as a series of fitness protocols chosen based on their ability to predict SSA aptitude to complete common suborbital tasks (e.g, payload operation, emergency egress, etc.) and to tolerate G-loading during launch and re-entry. By completing the predictive fitness protocols listed below, SSAs will demonstrate fitness levels necessary to meet the physical demands expected of SSAs on suborbital spaceflights.

1. 20 Meter Shuttle Run to predict maximum oxygen uptake (VO2max) for aerobic fitness.
2. Handgrip dynamometer to predict hand and forearm muscular strength.
3. Push-ups to predict upper body muscular endurance (non-stop until failure).
4. Sit-ups to predict abdominal muscular endurance (in 60 seconds).
5. One-repetition maximum assessment for bench press, squat, and leg press.

Table 1: Examples of Minimum Performance Targets

Test Item #	Men (age 35)	Women (age35)
1. Shuttle Run	Level 8	Level 5
2. Handgrip	149 kgf	99 kgf
3. Push-ups	19	9
4. Sit-ups	19	15
5. Bench press Squat Leg press	Personalized based on 1 repetition maximum assessment	

Discussion: Based on a health appraisal and fitness evaluation, a suborbital-specific fitness program will be developed that will reflect the physical conditioning required to work as a SSA. These fitness guidelines would not replace any additional FAA flight physical requirement for crew or passengers.

The G tolerance of SSAs flying repeated missions will be particularly crucial. Therefore, methods to increase G tolerance are of vital importance. Studies have demonstrated that G tolerance is increased by 39% following 11 weeks of muscle strength training [5]; the outcome of this research is incorporated into the SSA fitness program.

References: [1] Fitness Canada (1987). *Canadian Standardized Test of Fitness (CSTF) Operations Manual*. 3rd Ed. [2] Léger, L. & C. Gadoury (1989). Validity of the 20 m shuttle run test with 1 min stages to predict VO2 max in adults. *Can J of Sport Sciences*. 14:21-26. [3] Paliczka, V.J., A.K. Nichols, and C.A.G. Boreham (1987). A multi-stage shuttle run as a predictor of running performance and maximal oxygen uptake in adults. *Br J of Sports Medicine*. 21:163-165. [4] Stevenson, J.M., *et al.* (1988). *Development of Minimum Physical Fitness Standards for the CF: Phase II. School of Physical and Health Education*, Department of Mechanical Engineering, Queen's University, Kingston, ON. [5] Tesch P.A., H. Hjort H, and U.I. Balldin (1983). Effects of strength training on G tolerance. *Aviat Space Environ Med*. 54(8):691-5.