Setting a VO2 Max Standard for NASA Astronauts during Spaceflight

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INTRODUCTION: Aerobic fitness is best measured by Maximal Aerobic Capacity or VO2 Max which is defined as a measure of oxygen utilization and transport. Increased Vo2 max indicates improved oxygen consumption during high level exercise and is widely accepted as a predictor of an individual's likelihood of successfully completing a demanding task. As such, agencies and organizations have adopted VO2 max as part of a comprehensive set of physical requirements. The purpose of this study is to review the literature and existing medical and occupational VO2 max data, to propose a VO2 max standard for NASA astronauts for training and spaceflight.

METHODS: To identify studies on VO2 max standards, guidelines, and approaches three databases were searched from 1970 to September 2017: Ovid MEDLINE, Ovid EMBASE, and the Web of Science. Identified studies were further evaluated for inclusion in the literature review. Studies pertaining to VO2 max and aerobic fitness standards and guidelines from various professions were included.

RESULTS: Normative Data in a large healthy population conducted in Europe suggests average VO2 max of 47.2ml/kg/min and 38.4ml/kg/min in men and women, respectively. High endurance athletes can achieve VO2 max upwards of 70. Firefighter literature suggests average VO2 max for fire fighters between 37.4 – 39.4 and 28.0 – 33.5 as the lower suggested cutoff for performance specific tasks. Similarly, the commercial diving literature suggests minimum VO2 max ranging from 35 to 45.5. Extravehicular activity (EVAs) from Space Shuttle/ISS missions indicated 32.9 as an acceptable task-based aerobic capacity, as published in the NASA-STD-3001 standards document.

DISCUSSION: Energy expenditure is dependent on the intensity of the activity and the activity itself; thus, VO2 max provides a marker of an individual's *fitness* to complete a given task. Although aerobic fitness is just one parameter necessary for astronauts to succeed in performance specific tasks, other factors held constant, higher work capacity may be achieved in those with greater aerobic capacity, thus allowing for higher sustained workload and margin of safety. This becomes particularly important as NASA begins to expand exploration capabilities to include destinations beyond low Earth orbit.

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