

How the test works !

Computer-Guided Cycle Ergometry for Enhancing Cardio respiratory Health & Task-Relevant Fitness

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Background

In brief, cardio respiratory capacity reflects total functional capacity, and it can be measured. Since it was first described by Robinson (Harvard Fatigue Laboratory, 1938), the most acceptable method for determining aerobic capacity involves the analysis of expired air collected during the final minutes of an exhaustive bout of treadmill exercise. Although we and other laboratories continue to employ this classic technique when research precision is required, it is unfortunate that the valuable information provided by this test is essentially limited to those volunteering as subjects for research purposes.

The scientists at the Harvard Fatigue Laboratory recognized this in the 1930's and they came up with the first method for estimating "relative cardiovascular fitness", the step test. This was used with some success for screening purposes during World War II, and in spite of its limitations with respect to validity, it is still recognized as one of the sub maximal exercise methods for estimating fitness (e.g. the Canadian military). In 1968 Kenneth Cooper wrote a book entitled "Aerobics" in which he promoted a 12-minute run for estimating cardio respiratory fitness. The test evolved into a 1.5 mile run which classified people into six fitness categories as a function of running time. The Air Force adopted this as the annual fitness test for all military personnel, and they stayed with it for more than 20 years.

In the late 1970's and early 1980's I was directed to study the work tolerance times of Air Force ground crew who were required to be able to perform critically important operational (physically demanding) tasks while encumbered with a chemical warfare protective ensemble. I fully expected the accumulation of metabolic heat to be the primary factor limiting work time, and I carefully monitored the core (rectal) temperatures of a large number of ground crew performing rapid runway repair activities during the spring and summer at Eglin Air Force Base. I was really surprised to find that it was the lack of physical fitness rather than heat stress that posed the greatest threat to mission success. Stated as plainly as I can, most (more than 65%) of the ground crew assigned to this activity could not work long enough to get hot. This was alarming because the Air Force had relied on the annual 1.5 mile run to identify unfit personnel, yet every one of the people who were physically unable to perform their required task on the runway had passed the Air Force fitness test – every year – and with no difficulty.

- It was clear that the 1.5 mile run was not valid as a fitness test, and it gave me the opportunity to suggest another approach, namely, cycle ergometry. Cardio respiratory capacity can be safely and validly estimates from cardio respiratory responses to a sub maximal but precise workload on a cycle ergometer.
- I applied this technology to the runway repair crew and demonstrated that physical performance capability could be accurately predicted from cycle ergometry scores. Those who scored better than average in aerobic capacity tolerated both the work and the heat stresses imposed by this activity for 60-90 minutes, without complaint, before needing a break to cool off. Those who scored significantly below average in aerobic capacity (even though they had always passed the 1.5 mile run for estimating this physiological parameter) were the ones who dropped out first; most in less than 35 minutes and several were unable to work even 15 minutes before quitting with complaints of severe fatigue and heat stress.

- The operational significance of using cycle ergometry to identify those most in need of physical conditioning was subsequently explained to all of the major commands, but it was the Air Force Civil Engineer that first tasked me to make it available to all Air Force fire fighters. Computer technology enabled me to provide this program in a way that it could be safely and validly administered by fire department personnel, and the program was adopted for all Air Force fire departments, worldwide, in march 1989. Subsequently, the Deputy Secretary for the Department of Defense directed the Air Force to provide this same program for all military fire departments, and this was initiated in 1990.

Cardiologists at the Air Force School of Aerospace Medicine were observing the success of cycle ergometry in military fire departments, and they questioned why the Air Force Fitness Office was not taking a greater interest in it. Commanders became concerned, the Air Force Surgeon General requested a briefing, and this computer-guided program for safely assessing cardio respiratory capacity by cycle ergometry was adopted as the official Air Force Fitness Program beginning 1 Oct 1992.

Perhaps the most important reason for the success of this program is that it provides each individual with a valid assessment of his/her present cardio respiratory capacity. In addition to the obvious value of this information in selecting individuals who are physically capable of performing strenuous physical tasks, the health information provided makes this test appealing to the individual for personal reasons. For the first time the individual can be provided with knowledge as to whether or not he/she is "deteriorating" more or less rapidly than normal with age. We have observed that this information provides a very powerful reason for one to take a serious interest in his/her cardio respiratory health and in a way to either enhance or maintain it.

The Method

A research-grade cycle ergometer allows the investigator to set a precise workload which can be selected according to the age and general physical condition of the test subject.

- The computer observes the subject's cardiovascular responses (i.e. heart rate) to this workload and, during the first three minutes of the test, makes adjustments in that load which are necessary to assure both safety and validity in achieving a measure of aerobic capacity.
- Once the computer has established that the workload is correct, the test continues for six minutes to assure that the heart rate will achieve a steady state; it is this steady state value that is entered into the formula for providing a measure of aerobic capacity (in ml of O²/kilogram of body weight/minute).
- The computer then generates a report, which explains the subject's present level of cardio respiratory capacity, and how that relates to what is known to be normal for individuals of the same age. It then generates a personalized training prescription which provides a detailed guide for the use of a variety of exercise equipment (i.e. cycle ergometer, treadmill, or stair climbing machine) for safely and effectively enhancing the individual's cardio respiratory health and fitness. The specifics of this training prescription with respect to exercise intensity and duration have been endorsed by the American Heart Association as being safe and effective without the need for either medical clearance or supervision.

It is often easier to motivate one to begin an exercise program than it is to motivate them to continue with it as a regular part of their lifestyle. We have found that the regular feedback in the form of progress reports is very effective in keeping people both interested and motivated to do what is necessary to achieve the health benefits of this program. The in-house capability of this entire program makes it economically feasible to provide this feedback at intervals frequent enough to assure optimal education and motivation in this effective method of preventive medicine.

Examples of Program Implementation

- **Task Relevance:** Technical Report Describing the Relationship Between Test Scores and Performance Capability

The Fire Service is a career field where employees are expected to be able to perform serious life- and property-saving tasks with a high level of time urgency. Those tasks can be the most strenuous required of any career field, and they must usually be performed while wearing the added burden imposed by protective equipment. Our work has determined the metabolic and strength requirements of several typical fire fighting emergency tasks, and we have demonstrated the relationship between cardio respiratory capacity and task performance. Thus, the score provided by six minutes of exercise on a precision cycle ergometer can clearly guide the Fire Chief in the proper assignment of people to a variety of physical tasks. It can also be invaluable in evaluating the physical readiness of entry-level applicants for positions in the fire department.

We have extended our research establishing the task relevance of this program to the civilian fire fighter career field in studies which have demonstrated the high correlation between cycle ergometry test scores and (1) the level of performance in "World's Toughest Fire fighter" competition, and (2) work tolerance time when performing standard work when exposed to normal summer weather conditions while wearing fire fighter protective garments, with and without a "breathable" moisture barrier. Again, as mentioned in the discussion of studies to determine the tolerance time of ground crew wearing chemical defense protective garments, it is the lack of cardio respiratory capacity rather than any heat imposed by a protective garment, which most limits an individual's capability to perform in such an environment.

It is distressing, but true, that many fire fighters are not particularly interested in demonstrating the ability to successfully perform emergency tasks. Some of them rely on labor organizations to shield them from physical fitness requirements. However, we have found that these fire fighters tend to look very seriously at test scores, which suggest that their functional capacity (and health) is deteriorating more rapidly than normal. Cycle ergometry provides this important information and it can be quite effective in motivating behaviour changes, which will enhance both health and fitness.

- **Program Effectiveness is Directly Related to its Perceived Importance to the Individual:** Case Study Example (AirServices Australia Divisional Officer).

This program was briefed and demonstrated at a meeting of all divisional officers (i.e. Deputy Fire Chiefs) representing all airport fire departments in Australia. One of these officers became keenly interested and asked if we would give him an assessment. The results of that test, accompanied by a personalized training prescription, were explained and that officer decided to follow that training guide. Approximately 10 weeks later we were asked to return to Australia to assist AirServices Australia in the implementation of this program for their fire departments.

- **Program Implementation:** This computer-guided program can be administered by a technician in the privacy and convenience of a standard office. The equipment and software are provided as a complete package that includes hands-on training, which certifies the personnel, designated to administer the program.

Our approach to assisting a fire department in the implementation of this quality program is as follows:

Option A:

1. We deliver and install all equipment and software, which will support a quality program for up to 150 fire fighters.
2. Next, we conduct an on-site training seminar to train and then certify up to six department-designated individuals who will be responsible for administering the program in their department.
3. Software carries a lifetime warranty; upgrades that may occur during the first three years of program implementation are provided at no cost.

This entire program, complete with all equipment, software and training is provided for a one-time cost.

Option B:

Where applicable:

1. Lease of equipment and software (pls. ask for details)
2. Test will be carried out, on an on-call basis, by a specialist co-operating partner