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BRIEF COMMUNICATION

Implications of Cardio-Respiratory Fitness on the Performance of Exercise Tests

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In 2016, the American Heart Association (AHA) produced a position paper on cardiorespiratory fitness (CRF) which defined CRF as the most important cardiac risk factor in the assessment of prognosis in a wide variety of clinical states [1]. The aim of the paper was to improve patient management and to encourage lifestyle based strategies designed to improve cardiovascular risk. The authors showed that:

- Cardiorespiratory fitness was a stronger predictor of patient survival than other clinical and exercise test variables in both men and women.
- Non-exercise cardiac risk factors clustered in unfit people.
- People unable to exercise to five METs were at the highest risk of premature mortality. (1 MET = 3.5ml/kg/minute of oxygen intake).
- Improvement in CRF from the least fit to intermediate CRF reduced the mortality risk more than an increase in CRF from the intermediate CRF group to the high CFR group.
- They showed that adding a measure of CRF to baseline risk factors better predicted mortality in a wide variety of subjects with various clinical presentations.
- That adding measures of CRF to prediction models, particularly those based on the Framingham Risk Score, improved estimations of risk of cardiovascular disease.
- That CRF can be reasonably well predicted from a standardised questionnaire.

In this Brief Communication, we expand on how CRF can be assessed and reported in exercise testing.

Keywords Fitness • Aerobic capacity • Exercise tests • Fitness questionnaires

Discussion

In Australia and New Zealand stress testing is frequently employed in the assessment of individuals with a variety of cardiac conditions. The commonest reason for a stress test is to detect the presence of myocardial ischaemia in patients with suspected or known coronary heart disease. This is usually performed by exercising in the upright position using a treadmill.

Supine exercise testing using a cycle ergometer or pharmacological stimulation is often performed in nuclear medicine laboratories using myocardial perfusion scanning.

The Bruce protocol is often employed for upright testing on a treadmill. This protocol involves 3-minute stages with increase in the speed and elevation of the treadmill following completion of the 3-minute intervals. The technique for performing the test involves minimal support from the handrails of the treadmill [2]. Bruce demonstrated a very close correlation between exercise duration in seconds and measured oxygen intake [3]. There were differences in the relationship between exercise duration and oxygen intake in men and women and also in those healthy individuals categorised as active versus inactive based on their level of

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habitual activity. These differences are contributed to by the level of haemoglobin and the magnitude of arteriovenous oxygen difference related to the extent of peripheral extraction of oxygen during exercise.

A properly performed Bruce Test involves not holding the handrail of the treadmill during each of the 3-minute stages. Completion of stage 1 of the Bruce Test implies 5 METs; stage 2, 7 METs; stage 3, 10 METs; stage 4, 13 METs. The adherence to minimal support from the treadmill handrails is variable with excessive handrail support invalidating prediction of oxygen intake. Several commercially available testing units do not use exercise duration for estimating oxygen intake but rely upon estimates of oxygen consumption from workload and gradient.

There are variations in exercise protocols used. Some protocols abbreviate the stages to 2 minutes. Continuous graded exercise such as the Bruce test increase workload every 3 minutes. Although 3-minute increments of workload do not achieve a plateau of oxygen intake at the end of each 3-minute stage, the increase in oxygen intake in the first and second minute is greater than the increase in oxygen intake in the third minute of the exercise test. There is scant information on the correlation between exercise duration and measured oxygen intake for these abbreviated protocols. The MET equivalents of the 2-minute exercise protocol overestimate the CRF and is not reliable.

Many laboratories perform stress tests evaluating myocardial ischaemia aiming to achieve 90% of age predicted maximal heart rates. However, the estimates of age predicted maximal heart rate are +/− 10–15% [1]. Thus a 50-year-old man undergoing an exercise stress test would have a predicted maximum heart rate of 220 − age = 170 bpm. Ninety per cent (90%) is approximately 150 bpm. For about a third of men, this would be maximal exercise and many such men could not achieve this heart rate due to chronotropic incompetence. At the other end of the spectrum, some men would have their CRF underestimated as they would have been able to perform several minutes more exercise. Bruce advocated symptom or sign limited maximal exercise testing not heart rate limited testing.

Our medico-legal experience shows that many exercise laboratories use pulse rate limited exercise tests or 2-minute increments in ''Bruce tests''.

The Veterans Specific Activity Questionnaire (VSAQ) [4]

A number of activity questionnaires have been developed to predict CRF. The best known and best validated of these is the Veterans Specific Activity Questionnaire (VSAQ). This provides a number of standard questions which can be completed quickly by the patient or a technician before the stress test is performed. A line is drawn below the activities which can be usually done with minimal or no cardiac symptoms. This defines the estimated CRF.

1 MET: Eating, getting dressed, working at a desk.

2 METs: Taking a shower, walking down eight steps.

3 METs: Walking slowly on a flat surface for one or two blocks (150–200 m), performing a moderate amount of work around the house, like vacuuming, sweeping the floors or carrying groceries.

4 METs: Light yard work, ie raking leaves, weeding or pushing a power mower, painting or light carpentry.

5 METS: Walking briskly ie 4 miles per hour (6.2 km/hour), social dancing, washing the car.

6 METs: Playing nine holes of golf carrying your own clubs, heavy carpentry, mowing the lawns with a push mower.

7 METs: Performing heavy outdoor work ie digging, spading soil, play tennis (singles), carry 60 pounds (27 kg).

8 METs: Moving heavy furniture, jogging slowly, climbing stairs quickly, carrying 20 pounds (9 kg) upstairs.

9 METs: Bicycling at a moderate pace, sawing wood, jumping rope (slowly).

10 METs: Brisk swimming, bicycling up a hill, walking briskly uphill, jogging 6 miles per hour (9.6 km/h).

11 METs: Cross country skiing, playing basketball (full court).

12 METs: Running briskly level ground, 8 miles per hour (12.8 km/h), continuously.

13 METs: Any competitive activity including those which involve intermittent sprinting, running competitively, rowing, backpacking.

The VSAQ nomogram was validated prospectively in 1,185 men referred for exercise tests for a variety of reasons. The VSAQ score was divided into <5 METS, 5-8 METS, and >8 METS. Expressed in tertiles, the age adjusted relative risks for the VSAQ were 1.0, 0.54 (95% CI 0.96–1.16), and 0.22 (95% CI 1.02–1.13). Each 1-MET increase in the VSAQ conferred a 10% survival value. The mean METs prediction from the VSAQ were similar to those calculated from the final speed and grade of the treadmill ($r = 0.68$, $p < 0.001$) [5].

Recommendation

We recommend that CRF be reported for each exercise test. The ideal method for measurement is to use the Bruce protocol and perform the test as originally described. If the standard protocol is not used we recommend that VSAQ be added to the test results to help interpret the prognostic and management significance of the results.

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