Single stage versus multi-stage exercise tests for estimating aerobic fitness (VO$_{2\text{max}}$)

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Single stage exercise tests (SSET) are tests where only one workload (e.g. speed or power or load) is employed for the entirety of the test. For example, the Queens College Step Test$^1$ requires participants to step up and down on a bench at a set height and stepping speed for a set time (3 minutes). The estimation of VO$_{2\text{max}}$ is then based on the rate of recovery of heart rate following the exercise: the quicker the recovery then the higher the estimated VO$_{2\text{max}}$. Another example is the self-paced 6 minute walk test (6MWT) where participants are instructed to walk as far as possible for 6 minutes, essentially a single stage test.

Multi-stage exercise tests (MSET) normally start at relatively low workloads, and then increase in exercise intensity at regular intervals (say 1, 2 or 3 minutes). They can progress up to the point of exhaustion (maximal = VO$_{2\text{max}}$), fatigue (near maximal = VO$_{2\text{peak}}$), or stop earlier (submaximal). This depends on the actual test protocol, the knowledge, skills and competencies of the exercise professional, and the health and exercise capacity of the client.

There are many advantages of multi-stage tests over single stage tests and I will outline just a few of them here. Let’s take a hypothetical example below where an individual underwent a 6MWT (SSET) on one day, and then a MSET on a treadmill on another day where he walked for 8 minutes (e.g. 1 min stages on a treadmill at a constant speed while gradient was increased each minute).

- Even if the 6MWT was administered according to the standard instructions and conduct of the test (see http://www.cscce.unc.edu/spir/public/UNLICOMMMSMSixMinuteWalkTestFormQxQ08252011.pdf), the 6MWT yields just one data point on the graph above and so there is no way of scientifically prescribing exercise at say 50%, 60% or 70% of VO$_{2\text{max}}$ or its close cousin VO$_{2\text{peak}}$.

- In contrast it is very easy to accurately prescribe exercise at any % of VO$_{2\text{peak}}$ or % of other physiological parameter (e.g. % peak workrate) for the incremental treadmill test. Note that it is VO$_{2\text{peak}}$ rather than VO$_{2\text{max}}$ in this example as the test was submaximal but the difference between VO$_{2\text{peak}}$ and VO$_{2\text{max}}$ for most individuals except for elite athletes is minimal.

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$^a$ Maximal oxygen uptake (VO$_{2\text{max}}$) is a widely reported measure of aerobic fitness. In the case that a plateau in oxygen uptake is not reached because the individual stopped at the onset of fatigue not exhaustion, then this is termed VO$_{2\text{peak}}$. In most situations, VO$_{2\text{max}}$ and VO$_{2\text{peak}}$ are similar.
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The 6MWT requires self-pacing on the part of the participant and so that is why I have displayed two possible data points for this test for this hypothetical client. In contrast, the set of 8 data points representing increasing exercise intensities for the treadmill test can be accurately extrapolated up to VO_{2\text{peak}} using the unique linear relationship for each individual client. This then reduces the errors for both estimating VO_{2\text{peak}} and prescribing exercise. In practice, there is very limited practicality when attempting to estimate VO_{2\text{peak}} based on 6MWT data in an individual client, and the 6MWT is better suited to characterise the fitness of large groups of individuals. I am not against the use of the 6MWT as a functional test, but it is not a substitute for a well conducted MSET.

There are examples of SSET that use a single exercise intensity that is either too hard (and therefore potentially exposes the individual to risk) or too easy for the individual and this makes these tests virtually unusable for these clients. Examples of this are some of the published step tests where the set height of the step might be too high for individuals with low fitness, and individuals with small stature are ‘penalised’ compared to those with long legs.

So I hope this short article will help to convince you of the worth of multi-stage exercise tests over single stage tests. Finally, there is only one thing worse than using single-stage exercise tests and that is not doing a test at all. How can you prescribe aerobic exercise if you don’t know the aerobic fitness (VO_{2\text{peak}} or VO_{2\text{max}}) of your client?

In other articles in this series, I will show you how easy it is to administer multi-stage exercise tests for most if not all of your clients.

Key Points

- Single stage exercise tests do not provide enough data for exercise programming
- Single stage exercise tests can require the individual to exercise at intensities that are either too hard or too easy
- Multi-stage exercise tests can provide a range of exercise intensities from which an individualised exercise plan can be designed
- Paced tests such as treadmill protocols are preferred over self-paced tests such as 6MWT

References