Submaximal versus maximal exercise testing for the estimation of aerobic fitness (VO$_{2\text{max}}$)

Before embarking on this topic, I want to make it clear that this short article excludes the situation of direct measurement of VO$_{2\text{max}}$ in facilities with expensive laboratory equipment and specialised staff (e.g. sports institutes, university laboratories). Instead, article addresses the more common scenarios of conducting exercise tests to either submaximal this or maximal intensities in gyms or studios and using predictive algorithms to estimate VO$_{2\text{max}}$ or its close cousin VO$_{2\text{peak}}$.a

The two main aims for aerobic fitness testing using predictive algorithms are to (i) estimate VO$_{2\text{max}}$ or VO$_{2\text{peak}}$ which is an indicator not only of aerobic fitness but also cardiovascular health$^{1,2}$ and (ii) use VO$_{2\text{max}}$ or VO$_{2\text{peak}}$ to prescribe exercise that is suited to the individual in terms of safety, comfort and effectiveness.

So does it matter if the test takes the individual all the way up to exhaustion (maximal = VO$_{2\text{max}}$) or fatigue (near maximal = VO$_{2\text{peak}}$), or if it stops short of these intensities? The first obvious consideration is the safety of taking a client all the way to exhaustion or fatigue. I will post another article on pre-screening of clients prior to exercise$^{3,4}$ and looking after clients during exercise, and that will help to cover the issue of safety.

There are advantages and disadvantages of both maximal and submaximal exercise testing, and these depend on the type of client that you have, your knowledge, skills, competencies and experience, and what you and your client are wanting to achieve in terms of fitness now and fitness to be gained in the future. In this short article, I cannot cover all scenarios, but offer a few points:

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| Maximal or near maximal tests | 1. Very small or absent gap between the final heart rate and true HR$_{\text{max}}$ which can improve the precision of estimations of VO$_{2\text{max}}$ using algorithms.  
2. The client has exercised up to (near) maximal intensity during the test, and if there were no adverse signs or symptoms, then the client is safe for the full range of exercise intensities when training. This includes HIIT.  
3. There are clients in whom actual HR$_{\text{max}}$ is significantly different to age-predicted HR$_{\text{max}}$ and so the actual HR$_{\text{max}}$ can be used to more accurately estimate VO$_{2\text{max}}$. | 1. Risk of adverse signs or symptoms arising at the higher intensities of exercise.  
2. Risk to clients with diagnosed or undiagnosed cardiovascular disease, especially when these tests are conducted outside of medical facilities and in the absence of immediate medical support. |
| Submaximal tests            | 1. Safer and more comfortable for clients who are not seeking to engage in HIIT or other forms of very high intensity training. | 1. There may be a large gap between the final physiological measures (heart rate, workload) and peak / maximal levels and this can sometimes affect the accuracy of algorithms to predict VO$_{2\text{max}}$. But my |

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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.

b HIIT = High Intensity Interval Training
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<td>2.</td>
<td>Suitable for clients who are using exercise to improve their health and are happy with mild to moderate intensity training.</td>
<td>method is to establish the linearity of the relationship between workload and heart rate and this minimizes this error.</td>
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<td>3.</td>
<td>Can be administered to clients with known adverse signs or symptoms to high intensity exercise and/or known cardiovascular disease, so long medical advice is sought and the test is stopped at or preferably before the onset of adverse signs or symptoms.</td>
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<td>4.</td>
<td>Suitable in most locations such as gyms and studios that are outside of hospital environments.</td>
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Some examples:

**Example 1.** A submaximal multi-stage exercise test that enabled the exercise professional to prescribe exercise safely and effectively. Typical exercise test for those who just want to be healthy and moderately fit.

**Example 2.** Here the submaximal multi-stage exercise test did not test for the full range of intensities of exercise and the client wanted a HIIT program. This test is invalid and needs to be repeated at higher intensities.

**Example 3.** A maximal multi-stage exercise test that provided the full range of exercise intensities for programming. This might be used for athletes and individuals who want a HIIT program.

**Example 4.** A client who experienced adverse signs or symptoms at the upper intensities of exercise. You can often still prescribe exercise at intensities below the sign- or symptom-threshold, but you need to involve the client’s primary care medical practitioner before proceeding with an exercise plan.
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In summary, there is no right or wrong when it comes to submaximal or maximal exercise testing. It comes down to the type of client that you have, your knowledge, skills, competencies and experience, and what you and your client are wanting to achieve in terms of fitness now and fitness to be gained in the future. But make sure that you prescribe exercise within the range of exercise intensities that you tested, or to flip that around, test for the full range of exercise intensities that you intend to use in your exercise plan.

Put safety as your number 1 priority and if you find or suspect that your client is experiencing adverse signs or symptoms during or following exercise, then stop, create a written record (e.g. letter to a doctor) and request that your client consults with their primary care medical practitioner before resuming or continuing with exercise.

Key Points
- There are 2 main aims with aerobic fitness testing:
  - estimate $VO_{2\text{peak}}$ or $VO_{2\text{max}}$
  - use this to design individualised aerobic exercise training plans
- There is no right or wrong when it comes to maximal or submaximal exercise testing, so long as safety is assured
- Prescribe exercise within the range of exercise intensities that you tested, or to flip that around, test for the full range of exercise intensities that you intend to use in your exercise plan

References