Are metabolic equivalents (METS) an accurate method for estimating change in peak oxygen consumption after cardiac rehabilitation?

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**ARE METABOLIC EQUIVALENTS (METs) AN ACCURATE METHOD FOR ESTIMATING CHANGE IN PEAK OXYGEN CONSUMPTION AFTER CARDIAC REHABILITATION?**


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**Introduction**

Personalised cardiac rehabilitation (CR) exercise prescriptions should be based on an individualised assessment that includes determination of patients’ cardiorespiratory fitness (CRF) [ACPCIR, 2015]. Maximal cardiopulmonary exercise testing (CPET) is the “gold standard” method for determining CRF (Mozzani et al. 2013). However, CPET is not widely available in the UK and estimates of VO<sub>2peak</sub> are typically used.

Calculation of peak metabolic equivalents (METs) derived from workloads achieved during incremental exercise testing is a common approach to estimating VO<sub>2peak</sub>, a marker of CRF (ACSM, 2013; Buckley, et al. 2016). One MET is assumed to equate to a resting VO<sub>2</sub> of 3.5 ml kg<sup>-1</sup> min<sup>-1</sup> [Wasserman, et al. 2011]. Increases in functional capacity reported from sequential exercise tests may be expressed in METs. Peak estimated METs achieved during maximal exercise testing in turn, can be used to quantify changes in CRF following exercise interventions (ACSM, 2013; ACPICIR, 2015).

Large discrepancies between estimated (METs), and directly determined VO<sub>2peak</sub> have previously been reported (Froelicher et al. 1984; Kavanagh et al. 2002). Peak estimated METs may therefore, not accurately estimate VO<sub>2peak</sub> change following CR. Previous investigators have found no correlation (r=0.24; p=0.200) between VO<sub>2peak</sub> change and peak estimated MET change in 50 patients with coronary heart disease [CHD] (Milani et al. 1995). Stato et al. (2013) also present data indicating that the increase in directly determined VO<sub>2peak</sub>, following CR was approximately half (41.7%) of the 28.8% increase in peak predicted METs following CR among 180 CHD patients.

This study therefore investigated the accuracy of estimating changes in VO<sub>2peak</sub> in patients with CHD, by comparing patients’ directly determined VO<sub>2peak</sub> to VO<sub>2peak</sub> estimated through the American College of Sports Medicine leg cycling equation (ACSM, 2013).

**Methods**

**Selected Cohort**

27 patients with CHD

**Visit 1**

- Maximal CPET
- Cycle Ergometer – 25W increments every two minutes

**Visit 2**

- Maximal CPET
- Cycle Ergometer – 25W increments every two minutes

**Intervention**

Patients Referred to CR - Sessions: 13 range: 0 to 62

**Direct Determined VO<sub>2peak</sub>**

Breath-by-breath data averaged over final 30 seconds of CPET

**Estimated VO<sub>2peak</sub>**

Aerobic leg cycling equation: VO<sub>2</sub> = 11.8 x kg x m<sup>-1</sup> x M<sup>-1</sup> x 7.0

**Figure 1**

Key experimental stages of the study

- CHD = Coronary heart disease
- CPET = Cardiopulmonary exercise testing
- CR = Cardiac Rehabilitation
- BMI = Body mass index

**Table 1**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Visit 1</th>
<th>Visit 2</th>
<th>Mean Change</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Est V02peak</td>
<td>3.08</td>
<td>3.18</td>
<td>0.10</td>
<td>0.21 - 0.00</td>
</tr>
<tr>
<td>Est V02peak</td>
<td>3.74</td>
<td>3.98</td>
<td>0.24</td>
<td>0.35 - 0.13</td>
</tr>
<tr>
<td>Est V02peak</td>
<td>4.46</td>
<td>4.79</td>
<td>0.33</td>
<td>0.44 - 0.23</td>
</tr>
<tr>
<td>Est V02peak</td>
<td>5.21</td>
<td>5.57</td>
<td>0.36</td>
<td>0.47 - 0.25</td>
</tr>
</tbody>
</table>

**Figure 2**

- Linear regression showing the relationship between directly determined VO<sub>2peak</sub> and estimated VO<sub>2peak</sub> for visit 1 (panel A: r=0.958, p<0.001) and visit 2 (panel B); r=0.945, p<0.001

**Figure 3**

- Linear regression between directly determined VO<sub>2peak</sub> change and estimated VO<sub>2peak</sub> change between visit 1 and 2 (r=0.527, p<0.05)

**Figure 4**

- Bland-Altman plot showing mean bias (0.7 ml kg<sup>-1</sup> min<sup>-1</sup>), LoA (-4.63 to 5.9 ml kg<sup>-1</sup> min<sup>-1</sup>), with 95% CI (grey shaded area) between directly determined and estimated VO<sub>2peak</sub>

**Figure 5**

- Linear regression showing a significant, moderate negative correlation between ΔV02/ΔWR slope and estimated VO<sub>2peak</sub> measurement error

**Conclusion**

Estimated METs showed a high correlation with directly-measured VO<sub>2peak</sub> in a representative cohort of patients attending CR. However, the estimated MET changes observed following CR correlated less well with direct measure and showed poor measurement agreement. Estimated METs may not accurately reflect mean VO<sub>2peak</sub> changes following a CR exercise training intervention.

Our findings may in part, be due to poor aerobics efficiency. We found that ΔV02/ΔWR slope was negatively correlated with estimated VO<sub>2peak</sub> measurement error (r=0.46, p=0.001) indicating that estimates of VO<sub>2peak</sub> over-predict directly determined VO<sub>2peak</sub> when patients are aerobically ‘inefficient’. Inefficient cardiorespiratory responses to exercise such as delayed oxygen kinetics, may prolong dependence on anaerobic metabolism (Mozzani et al. 2009) during segmental work rate transitions. In such instances, the assumptions of linearity between work rate and VO<sub>2</sub> would not apply and work rate would not be indicative of VO<sub>2peak</sub>. Accurately predicting VO<sub>2peak</sub> changes in CHD patients, as evidenced by our findings and those presented by others (ACSM, 1994; Milani et al. 1995; Stato et al. 2013), poses significant challenges, particularly at an individual patient level.

Increasing VO<sub>2peak</sub> through structured exercise training improves survival (Vanhees et al. 1999) in patients with CHD and, consequently, improving VO<sub>2peak</sub> remains a key objective for CR practitioners. Practitioners need to have confidence in their outcome measures. Given that CR programme outcome data are often presented, there is a requirement to examine the suitability of METs to estimate directly-determined changes in VO<sub>2peak</sub>.

**References**


