Conference or Workshop Item

Title: Recommendations for high intensity upper body exercise testing

Creators: Talbot, C., Kay, A. D., Walker, N. and Price, M.

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Introduction: For given submaximal and maximal peak power outputs aerobic responses to upper body exercise are different to those for lower body exercise (Sawka, 1986: Exercise & Sport Sciences Reviews, 14, 175-211). However, much less is known regarding responses to exercise intensities at and around peak oxygen up take (VO_{2peak}). **Purpose:** The purpose of this study was to determine the metabolic responses during arm crank ergometry (ACE) below, at and above peak oxygen uptake and to help establish exercise testing guidelines for high intensity upper body exercise. **Methods:** Following institutional ethical approval fourteen male students (Age 21.1, *s* = 6.1 years and 2.44 s=0.44 VO_{2peak}) volunteered to take part in this study. Each participant exercised on a table mounted cycle ergometer (Monark 894E, Monark Exercise AB, Sweden). After habituation peak minute power (PMP) was calculated from an incremental test. Subsequently each participant completed four continuous work tests (CWT) to volitional exhaustion at 80%, 90%, 100% and 110% of PMP. All tests were completed at 70 rev·min^{-1} with a minimum of 48-h between tests and the order was counterbalanced. Each CWT was preceded by a 5 min warm-up, loaded with a mass corresponding to the participants 80% PMP for 20 s at minutes 2, 3 and 4. Oxygen uptake (VO_2), respiratory exchange ratio (RER), heart rate (HR) and ratings of perceived exertion for the arms (local (RPE_L) and cardiorespiratory strain (RPE_{CR}) were recorded at 1 min, 2 min and at volitional exhaustion. The EMG responses at three sites (flexor carpi ulnaris, biceps brachii and triceps brachii lateral) were recorded using double-differential (16-3000 Hz bandwidth, x300 gain), bipolar, active electrodes (MP-2A, Linton, Norfolk, UK). Electromyographic data were sampled at 1000 Hz and filtered using a 20 to 500 Hz band-pass filter (MP150 Data Acquisition and AcqKnowledge 4.0, Biopac, Goleta, CA). The EMG signals for each muscle were root mean squared (RMS) with a 500-ms sample window. The signal was then normalised, prior to each CWT, as a percentage of the mean of 3 sets of 10 duty cycles completed during the warm-up (see above) when the participants 80% PMP for 20 s was applied. Time to exhaustion (T_{lim}) was recorded as the performance outcome measure. Data for T_{lim} were analysed using one-way analysis of variance. Differences in EMG, VO_2, RER, HR, RPE_L and RPE_{CR} were analysed using separate two-way analysis of variance with repeated measures (trial x time). All analyses were performed using the Statistical Package for Social Sciences (17.0; SPSS Inc., Chicago, IL). Individual differences in means were located using Bonferroni post-hoc correction. Significance was accepted at $P < 0.05$. **Results:** As resistive load increased T_{lim} decreased (611 s=194, 397 s=99, 268 s=90, 206 s=67s, respectively; $P < 0.001$, ES = 0.625). Post-hoc analysis revealed that T_{lim} using 80%PMP was longer than for 90%, 100% and 110% PMP trials ($P < 0.001$) and 90% was longer than both 100% and 110% PMP trials ($P = 0.079$, $P = 0.001$). At exhaustion VO_2 was similar across trials ($P = 0.413$, ES = 0.053), although 80% PMP VO_2 tended to be less (2.10 s=0.32 l·min^{-1}) than for 90% (2.29 s=0.37), 100% (2.33 s=0.49) and 110% (2.26 s=0.34). Also, 80% PMP VO_2 was less than VO_{2peak} ($P = 0.013$). There were differences in RER at T_{lim} ($P < 0.001$, ES = 0.593) with values increasing with % PMP (1.15 s=0.07, 1.26 s=0.07, 1.36 s=0.10, 1.40 s=0.09, respectively). There were no differences across trials for HR at T_{lim} (~173 (12); $P = 0.834$, ES = 0.016) and HR was proportional to %PMP at 1 min, and 2 min. For flexor carpi ulnaris there was an increase in activation as exercise intensity increased ($P < 0.001$, ES = 0.245). There were a similar responses for biceps brachii and triceps brachii demonstrating an increase in activation with exercise intensity ($P < 0.001$, ES = 0.137, $P < 0.001$, ES = 0.163, respectively). No differences for RPE_L and RPE_{CR} were observed at T_{lim}. **Discussion:** There was a clear response of T_{lim} with intensity as expected for lower body exercise (Hill et al., 2002: Medicine and Science in Sports and Exercise, 34(4), 709-714). Despite differences in T_{lim} across exercise intensities VO_2, HR and RPE were similar at exhaustion indicating a functional cardiorespiratory maximum had been reached. As indicated by the RER an increased activation of the anaerobic metabolism with greater exercise intensities (100% and 110%) is likely and therefore this may represent a greater anaerobic component at these two intensities. The increase in EMG activity with intensity could indicate an increase activity with an increase in exercise intensity. **Conclusion:** It is recommended that due to the combination of muscle activation, oxygen uptake and T_{lim} that an exercise intensity of 90% or 100% of PMP could be used for high intensity upper body exercise testing.