Relation between Physical Activity and Oxygen Uptake Efficiency in Men with CVD

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Abstract

Purpose: The oxygen uptake efficiency slope (OUES) represents the rate of increase in $\dot{V}O_2$ in response to a given V_E during incremental exercise, indicating how effectively oxygen is taken in by the lungs, transported and used in the periphery. OUES, calculated using only submaximal exercise data is identical to the OUES calculated over the entire duration of a cardiopulmonary exercise test (CEPT) , and both maximal and submaximal OUE are significantly related to cardiorespiratory fitness (CRF) measured as $\dot{V}O_2$peak. Currently, little research has been published on how physical activity (PA) assessed by accelerometers is related to submaximal and maximal OUES. The purpose of this study was to determine the relation light (LIPA), moderate (MIPA) and vigorous (VIPA) intensity physical activity and maximal and submaximal OUES in men with cardiovascular disease (CVD).

Methods: A total of 56 men (mean (± SD): age of 59.3 ± 9.2 yr., VO_2 peak (L/min) 2.0 ± 0.50, VO_2 peak (mL/kg/min) 23.6 ± 5.8, were recruited during an induction to a community-based exercise referral program following completion of phase 2 cardiac rehabilitation program. Participants underwent a graded exercise test on a cycle ergometer with breath by breath open circuit spirometry after which they wore a wrist worn accelerometer (Actigraph) for 7 d. Absolute and relative submaximal and maximal OUES were calculated by plotting VO_2 in mL/min on the x axis, and the log transformed VE on the y axis (VO_2 = a $\log_{10}$ VE + b). Exercise data up to the ventilatory anaerobic threshold and maximal exercise were used to calculate submaximal and maximal OUE, respectively.

Results: Participants performed 584.49 ± 73.87 min of daily LIPA, 145.45 ± 60.85 min of MIPA and no daily min of VIPA. There was a significant relation between absolute submaximal OUES (r=0.386; p<0.01), submaximal OUES/Kg (r=0.296; p<0.05) and LIPA. There was a significant relation between maximal OUES (r=0.286; p<0.05), maximal OUES/Kg (r=0.279; p<0.05) and MIPA.

Conclusion: Submaximal and maximal OUE are related to levels of LIPA and MIPA, respectively. Submaximal OUES can potentially be used as an objective, effort independent test to estimate LIPA levels among men with CVD.

Introduction

Physical activity (PA), defined as level of activity above seated rest that results from skeletal muscle activation and leads to movement and an increase in energy expenditure is inversely associated with reduced morbidity and mortality from several chronic non-communicable diseases including cardiovascular disease (CVD). Cardiorespiratory fitness is an objective measure of habitual PA. Although VO_2peak is considered the gold standard measure of CRF it is not often attained in individuals with CVD undergoing CPET. A number of submaximal CRF indices may improve independent of changes in VO_2peak and are also used to assess functional capacity and may be related to PA.

OUES is an effort independent submaximal CRF parameter that is derived from the linear relation of VO_2 (y-axis) versus the logarithm of V_E (x-axis) during incremental exercise (Fig 1.). Given the tight linear relation the OUES creates between V_E and VO_2max throughout a progressive CPET, this calculation has been advanced as a measurement that requires only submaximal effort. A higher OUES slope is indicative of a higher function capacity. It is relatively independent of patient-achieved effort levels and reflects the absolute rate of increase in $\dot{V}O_2$ per 10-fold increase in ventilation and thereby reflects the integrated function and health of the pulmonary, cardiovascular and skeletal muscle systems.

The purpose of this study was to determine the relation light (LIPA), moderate (MIPA) and vigorous (VIPA) intensity PA and maximal and submaximal OUES in men with CVD.

Participants

Men (n=56) with documented CVD were recruited during an induction to a community based exercise referral program after completion of phase 2 (hospital based) CR program. Physiological and physical characteristics and cardiovascular events and medications are summarized in the table.

Table. Physiological and physical characteristics, cardiovascular events and medications

Variable	Values
Age (y)	59.3 ± 9.2
$\dot{V}O_2$ peak (L·min^{-1})	2.00 ± 0.50
$\dot{V}O_2$ peak (mL·kg^{-1}·min^{-1})	23.60 ± 5.80
VE (L·min^{-1})	65.68 ± 21.56
Peak workrate (watts)	135.71 ± 40.49
Peak heart rate (b·min^{-1})	134.21 ± 19.58
BMI (kg·m^2)	28.95 ± 3.73
Waist:Hip	0.97 ± 0 .040
Systolic blood pressure (mm Hg)	136.90 ± 17.32
Diastolic blood pressure (mm Hg)	84.58 ± 9.99
Resting heart rate (b·min^{-1})	67.24 ± 10.36
Cardiovascular Event	
MI	24 (42)
STEMI	14 (25)
NSTEMI	10 (17)
PCI	48 (85)
CABG	7 (12)
Medications	
Statins	52 (92)
Anti-platelets	49 (87)
Beta blockers	42 (75)
ACE inhibitors	25 (44)
ARB's	8 (14)

Values are mean ± SD and total number (percentage)

Methods

- Participants made a single visit to Dublin City University.
- Height, weight, hip and waist circumference were measured and participants performed a maximal cardiopulmonary exercise test (CPET) with a 12-lead ECG.
- Breath-by-breath gas collected during the CPET was averaged at 20 s intervals.
- OUES was calculated using the equation; VO_2 = a $\log_{VE}$ + b where the constant 'a' represents OUES, '$\log V_E$' represents the logarithm of V_E and the constant 'b' represents the intercept (Figure 1).
- The ventilatory breakpoint method was used to determine VAT (Figure 2).
- Exercise data up to the ventilatory anaerobic threshold (Figure 2) and $\dot{V}O_2$ peak were used to calculate submaximal and max OUES, respectively.
- Participants wore an accelerometer (Actigraph) continuously for 7 d and PA was classified as LIPA, MIPA and VIPA according to Freedson et al., (1998).

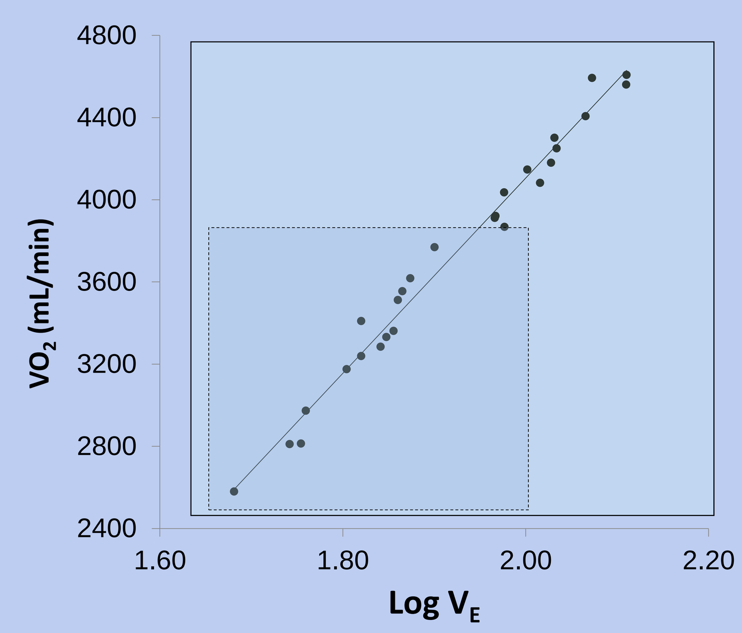

Figure 1. Max and submax OUES calculation

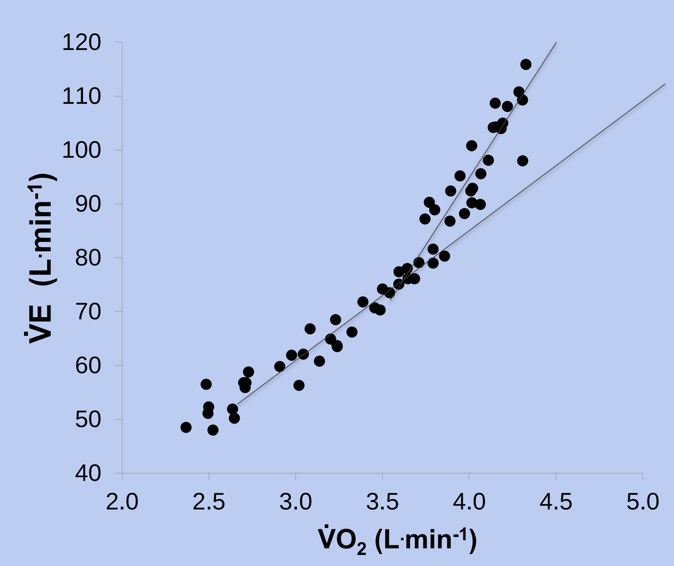

Figure 2. Calculation of VAT

Freedson, P. S., Melanson, E., & Sirard, J. (1998). Calibration of the Computer Science and Applications, Inc. accelerometer. Medicine and science in sports and exercise, 30(5), 777-781.

Results

- LIPA accounted for 78% of PA undertaken during waking hours.
- No VIPA was undertaken during the 7 d period.
- There was a significant relation between LIPA and both absolute submaximal OUES (r = 0.386; p<0.01) and submaximal OUES indexed to body weight (OUES/kg) (r=0.296; p<0.05).
- There was a significant relation between MIPA and both maximal OUES (r = 0.286; p<0.05), maximal OUES indexed to body weight (OUES/kg) (r=0.279; p<0.05).
- No significant relation between $\dot{V}O_2$ peak and either LIPA or MIPA.

Conclusion

Men with documented CVD accumulate their daily min of PA by undertaking primarily repeated bouts of LIPA. No VIPA was undertaken during the 7 d period. The findings indicate that measures of maximal/peak metabolic rate may lack external validity with the regard to the daily challenges faced by the O_2 transport and utilization pathways in men with CVD and a low functional capacity. The findings from the study present study indicate that submaximal OUES and OUES/kg are significantly related to LIPA and may be used as an objective, effort independent test to assess changes in LIPA levels among men with CVD.

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