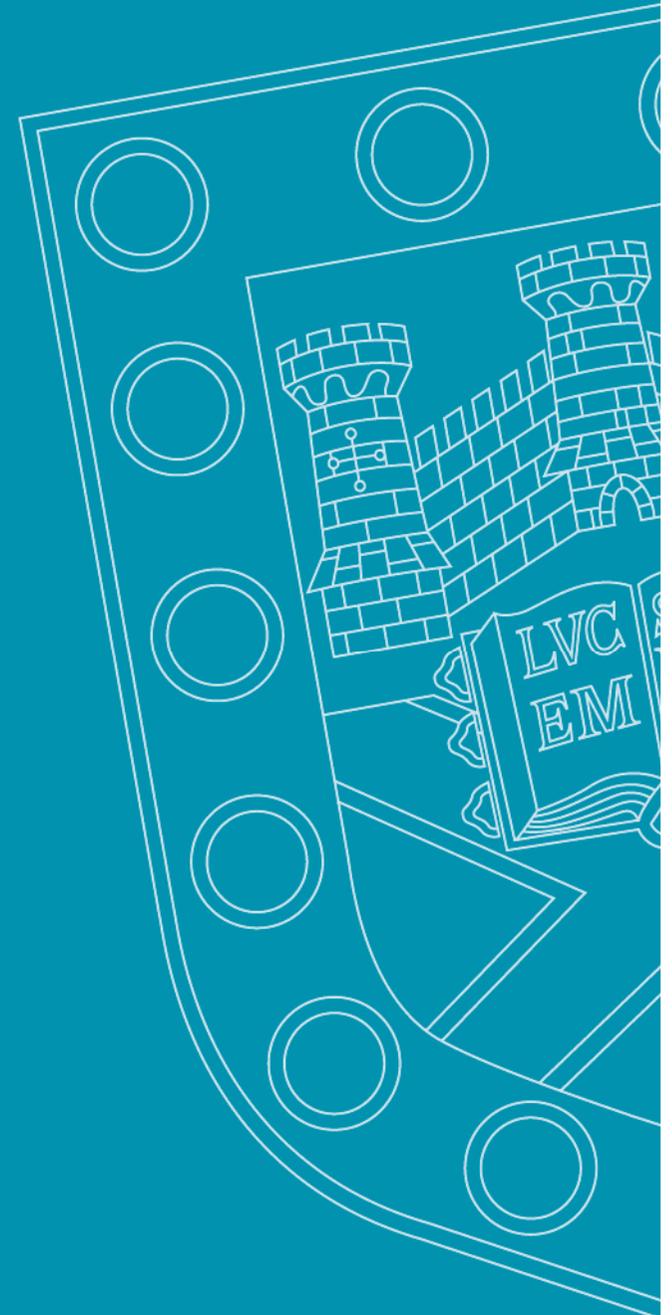




Cardiopulmonary Exercise Testing in Cystic Fibrosis

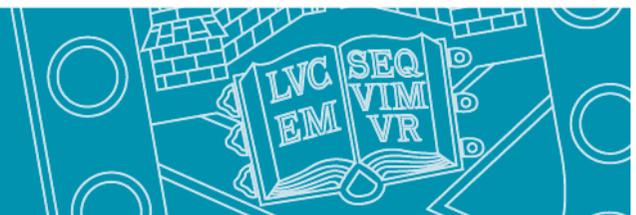
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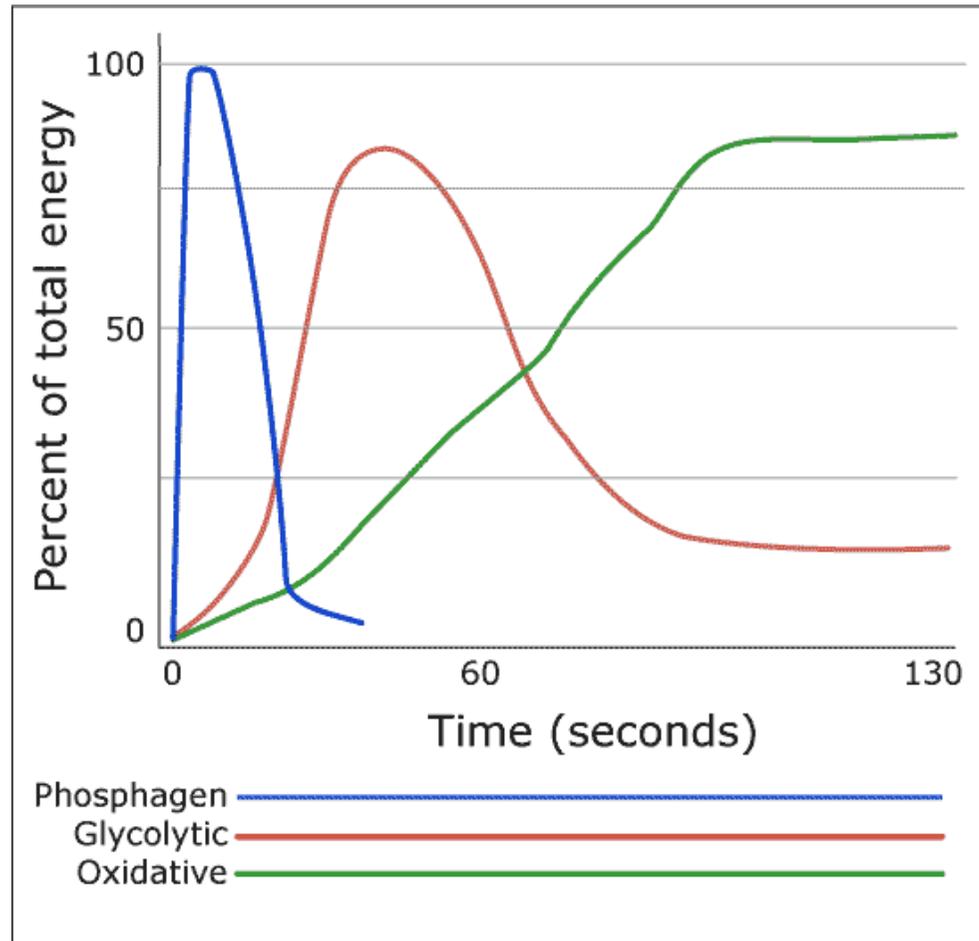


Cardiopulmonary Exercise Testing

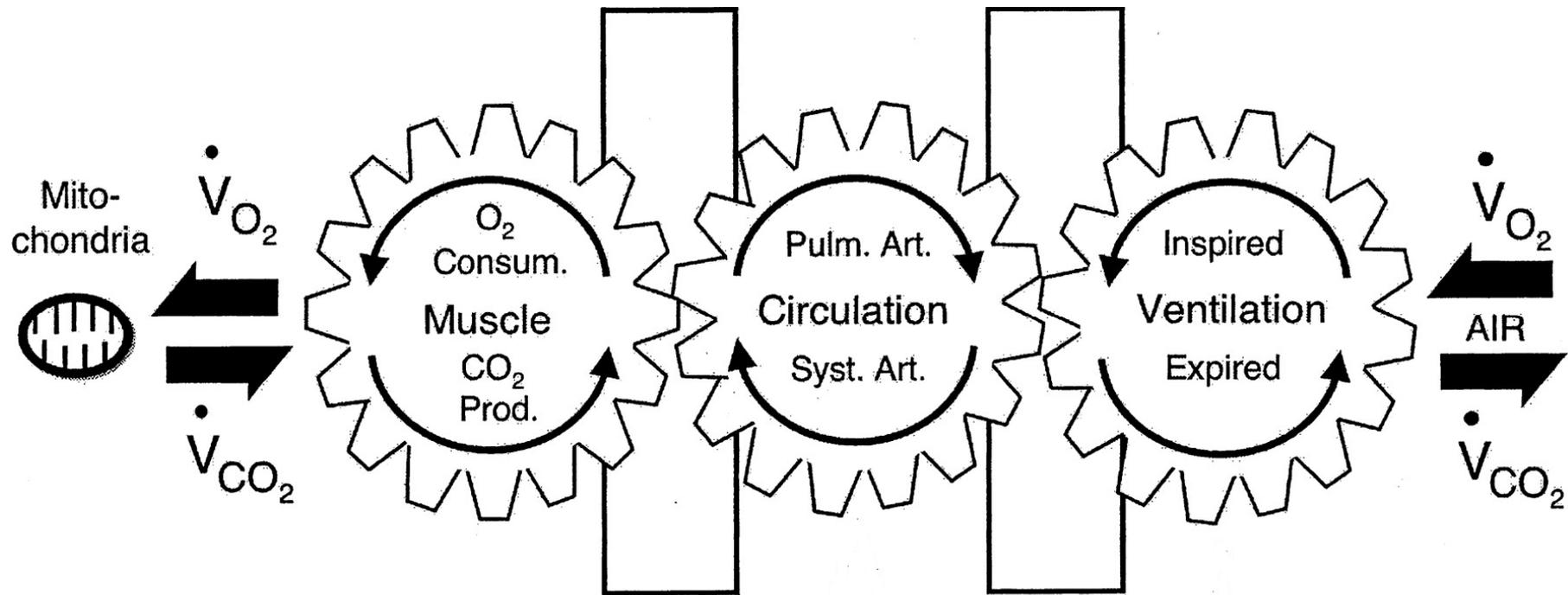
- Cardiopulmonary Exercise Testing (CPET)
 - What? Why? How?
- Key Parameters
 - VO_2 , VCO_2 , HR, V_E , RER
- Applicability to Clinical Settings
- Demonstration



Energy Systems



Energy Systems



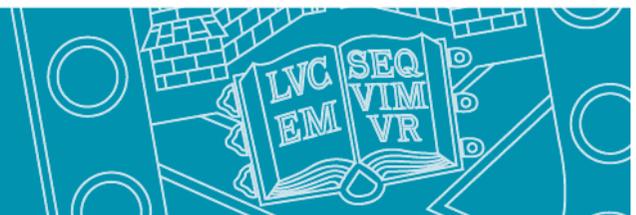
Cardiopulmonary Exercise Testing

- CPET allows the simultaneous study of the functional capabilities of the respiratory, cardiovascular and muscular systems
- This can at rest and during the transition to a maximal metabolic rate (aerobic capacity – VO_{2max})
- Allow the assessment of exercise capacity and causes of fatigue
- Allows reserve capacity of the body to be stressed, particularly in terms of its ability to deliver oxygen to peripheral muscles
- *Many diagnostic tests are done at rest – why?*



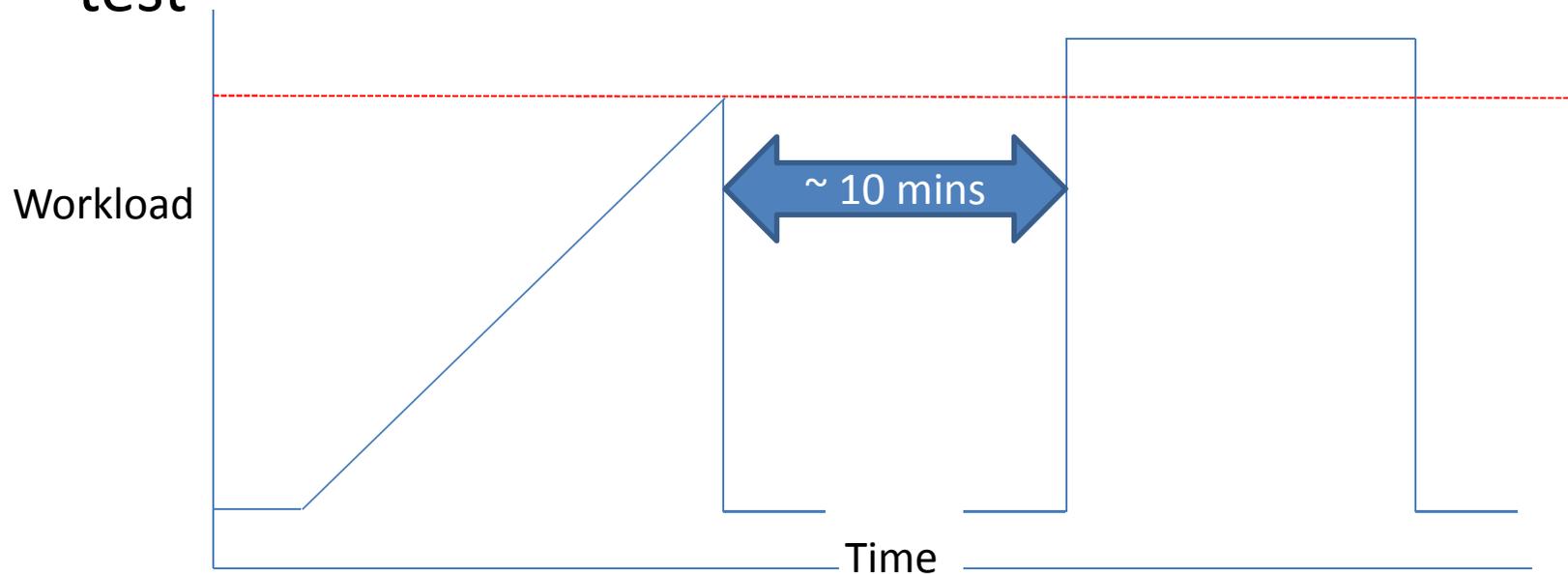
Cardiopulmonary Exercise Testing

- Bike v Treadmill
 - Bike allows for an easier quantification of work-rate and is better for extremely dyspnoeic or uncoordinated patients
 - Treadmill may elicit a higher VO_{2max}



Cardiopulmonary Exercise Testing

- Two-Phase Ramp Test
 - Intensity increases as a linear function of time
 - Verification via 110% of maximal workload from first test

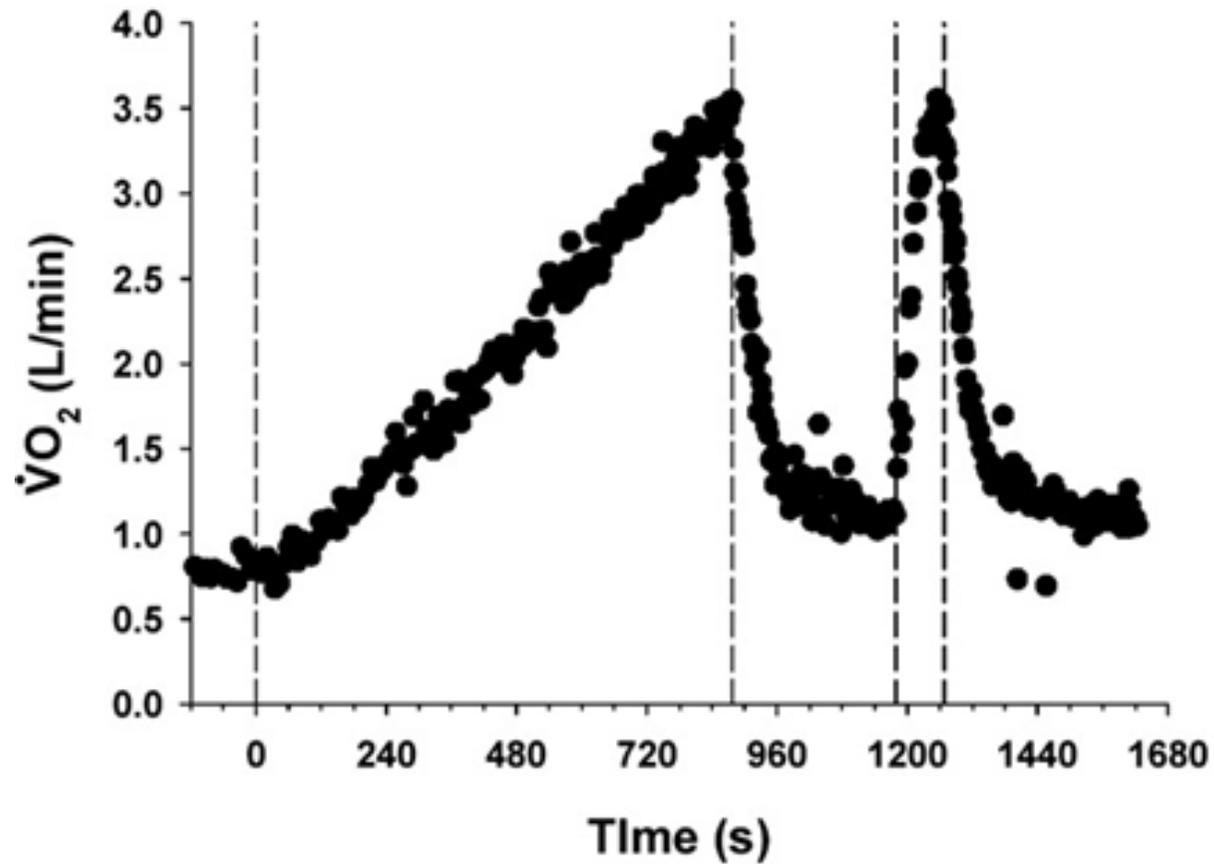


Cardiopulmonary Exercise Testing

- Why?
 - Many 'secondary characteristics' are invalid
 - Heart Rate
 - RER
 - Lactate
 - RPE/RPE
 - Can result in early termination of test



Cardiopulmonary Exercise Testing



Cardiopulmonary Exercise Testing

- Measures
 - Gaseous Exchange, via means of a facemask
 - VO_2 , VCO_2
 - Heart Rate



Key Measures

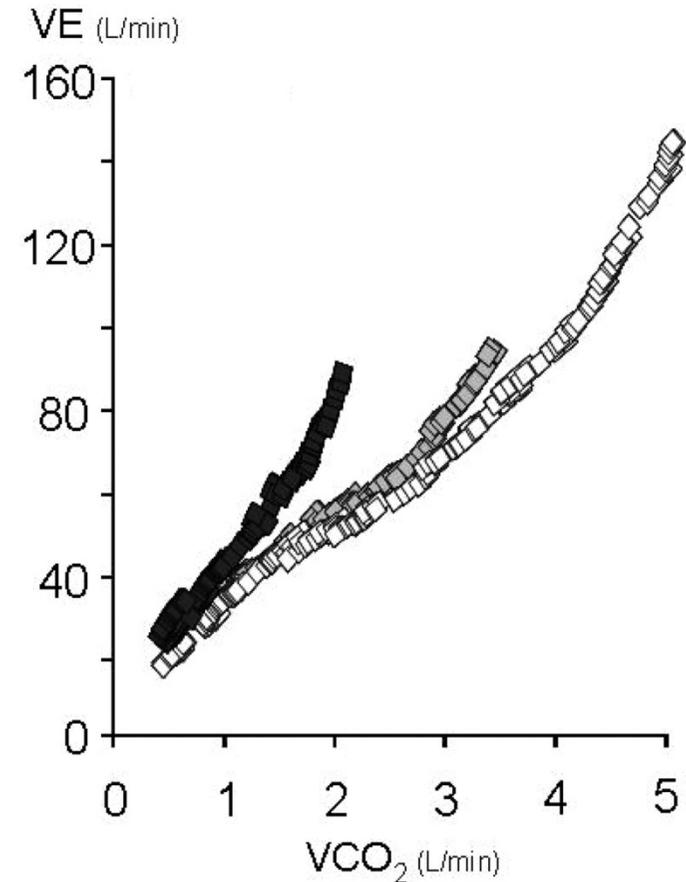
- VO_2
 - The volume of oxygen utilised in metabolism
 - VO_{2max} is the maximum rate that ATP can be synthesised aerobically
 - Ranges from 35-43 ml/kg/min in healthy UK children
 - Range from 24-44 ml/kg/min in CF children
 - High VO_{2max} is associated with a decreased risk of mortality



Armstrong et al. 1991; Saynor et al. 2013; Nixon et al. 1992

Key Measures

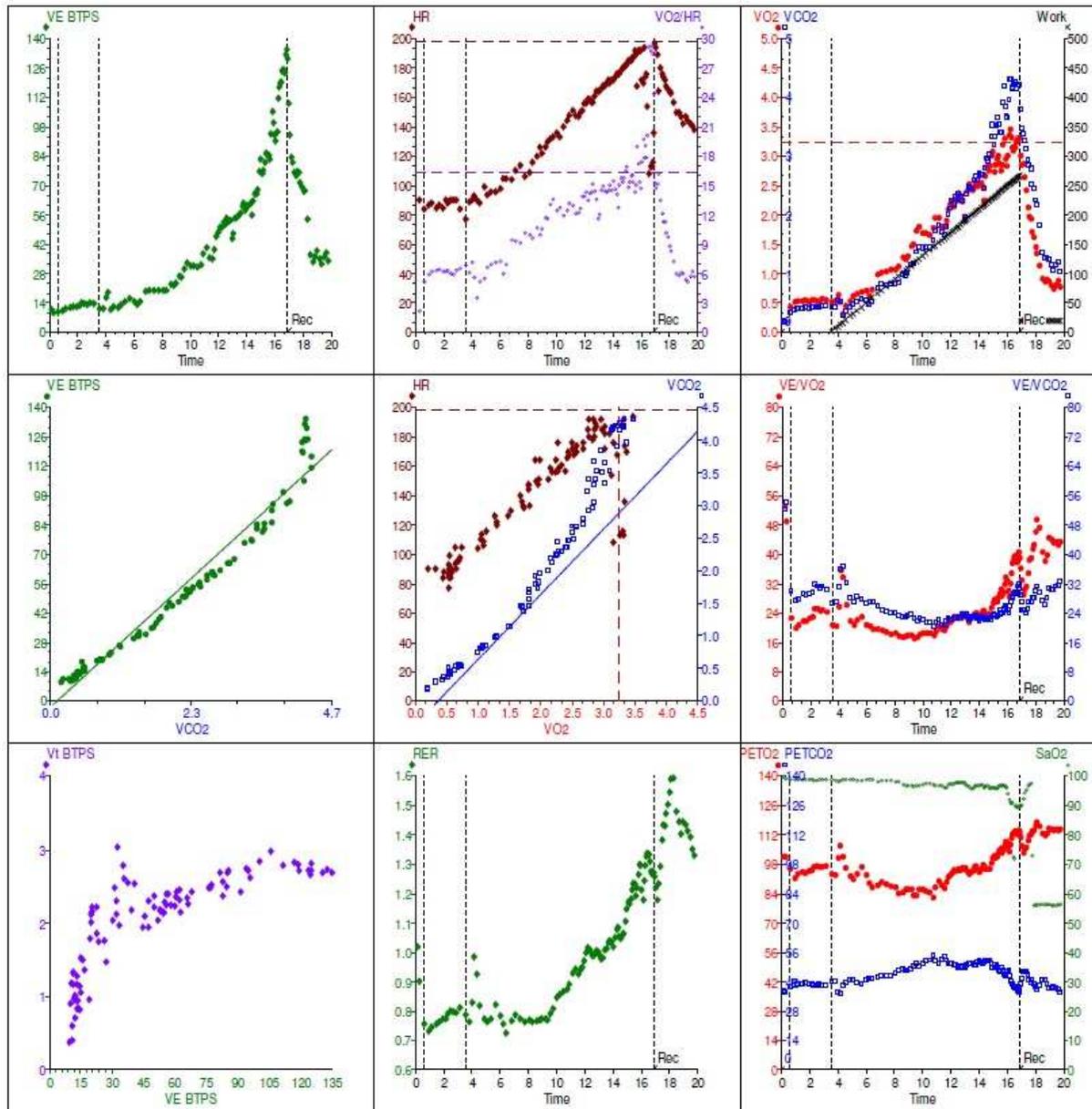
- V_{CO_2}
 - Volume of CO_2 exhaled
 - Extreme exercise results in anaerobic metabolism, with lactic acid produced as a by-product (acidemia)
 - When plotted against V_E , we obtain a V_E/V_{CO_2} ratio
 - Poor V_E/V_{CO_2} implies ventilation is wasted on dead space, possibly due to poor perfusion at the alveoli
 - May also indicate a low $PaCO_2$ driving diffusion i.e. hyperventilation in cardiac patients



Key Measures

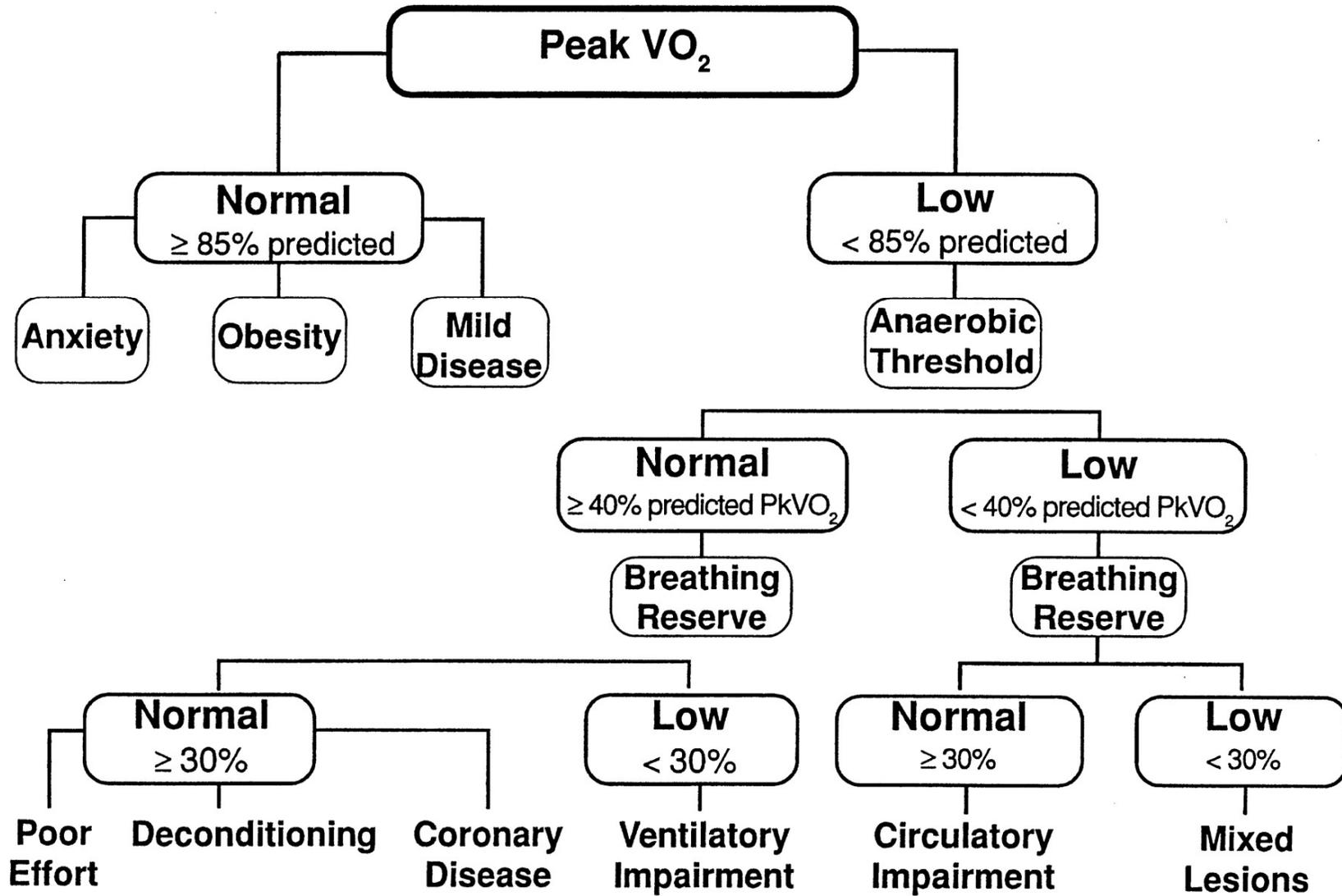
- Heart Rate
 - During CPET, patients should be reaching 80% of their age-predicted maximum
 - $220 - \text{Age in years} = \text{Max HR}$
 - HR will rise at differing rate depending upon cardiac function
 - Poor LV function will result in rapid HR increase
 - Heart Rate Reserve (HRR) will be high if a patient fails to reach 80% of their predicated maximum. Exercise may be limited by something other than cardiac function, i.e. peripheral vascular disease

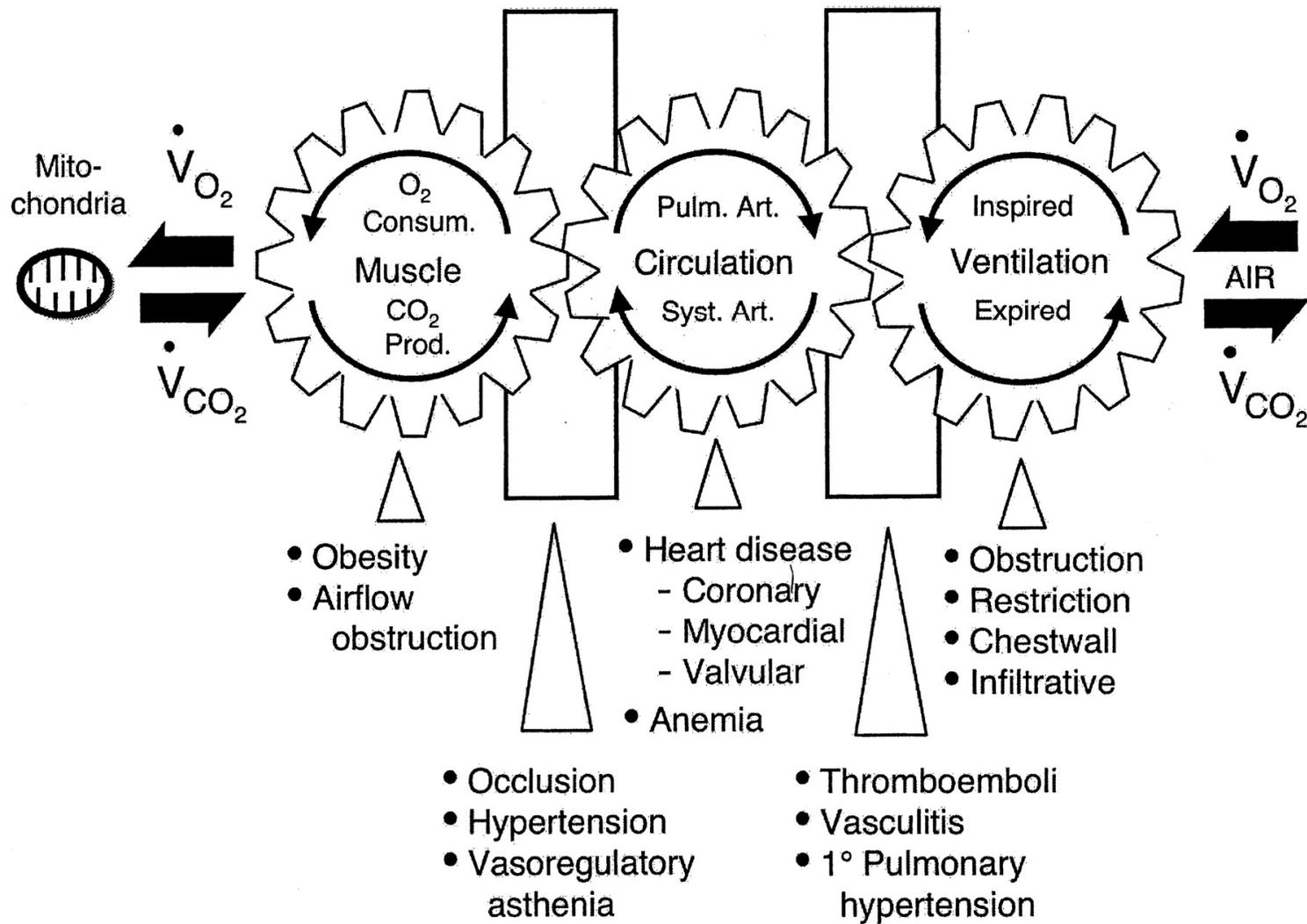




9 plot display highlighting cardiovascular, ventilatory and metabolic responses to exercise







Applicability

- A CPET is useful in the following situations:
 - Differential Diagnosis
 - If cause of dyspnoea is unknown, CPET can serve to define specific limiting organ system
 - Disability Evaluation
 - Provides objective assessment of exercise capacity and impairment
 - Rehabilitation
 - Allows for prescription of appropriate exercise intensity
 - Assessing Preoperative Risk
 - Provides objective assessment about cardiopulmonary reserve during heightened metabolic stress



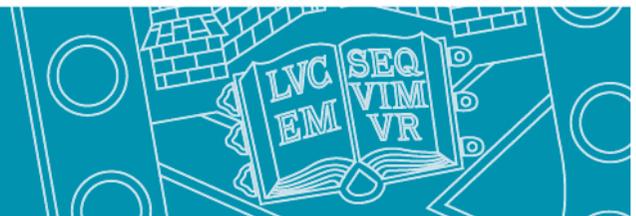
Applicability in CF

- A CPET is useful in the following situations:
 - Prognosis
 - Risk of hospitalisation
 - Indicator of QoL



Applicability

- Why CPET instead of other tests?
 - Sub-maximal exercise tests are common in clinical settings
 - Shuttle-Walk Test
 - 6-Minute Walk Test
 - Correlation approximately 50-65%
 - Can under predict VO_{2max} by 6 ml/kg/min (up to ~ 35% error)
 - Discrete results
 - These tests can be 'beaten'
 - CPET cannot be 'beaten'



Applicability

- CPET is considered the ‘Gold Standard’ in terms of exercise testing
 - “CPET complements other clinical and diagnostic modalities, and by directly quantitating work capacity improves the diagnostic accuracy of impairment/disability evaluation”
 - American Thoracic Society
 - “Direct measures of VO_2 are reliable and reproducible and provide the most accurate assessment of functional capacity”
 - American Heart Association
 - “Unequivocal evidence...is not yet available, and for this reason we cannot make a formal recommendation for this practice. However...exercise testing can provide guidance on prognosis and individual patient counselling inpatients 10 years and older”
 - European Cystic Fibrosis Society



Cessation

- When to stop a CPET?
 - CPET is done to fatigue
 - UNLESS....
 - Severe desaturation with an $SpO_2 \leq 80\%$ when accompanied by symptoms and signs of severe hypoxemia
 - Other signs of respiratory failure
 - Chest pain suggestive of pneumothorax or cardiac ischemia
 - Hemoptysis
 - Sudden pallor
 - Systolic blood pressure exceeding 250 mm Hg
 - Decrease in systolic blood pressure by more than 20 mm Hg or increase in diastolic pressure above 120 mm Hg
 - Loss of coordination, Mental confusion, Dizziness or faintness, Complex cardiac ectopy, Second- or third-degree heart block



Demonstration

