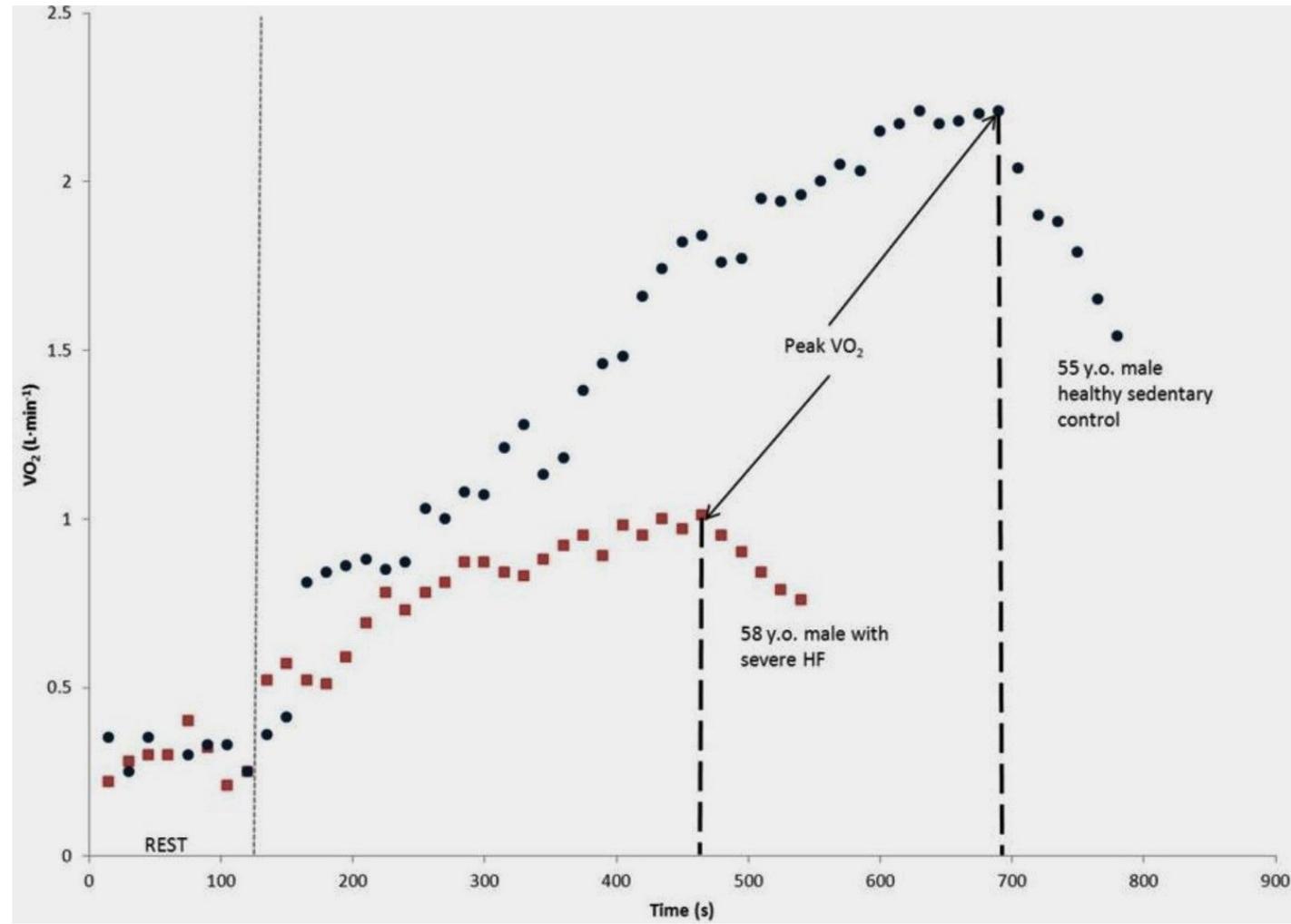


Figure 1. VO_2 versus time as an analog of work output in a normal subject and a patient with heart failure.



Santoro, C., Sorrentino, R., Esposito, R. et al. Cardiopulmonary exercise testing and echocardiographic exam: an useful interaction. *Cardiovasc Ultrasound* 17, 29 (2019). <https://doi.org/10.1186/s12947-019-0180>. Permission obtained.

Figure 2. Work rate (Watts) $\dot{V}O_2$ relationship in normal subjects and patients with heart failure. A: Normal slope is ~ 10 ml $\dot{V}O_2$ per Watt. B: At high work rates, the $\dot{V}O_2$ /Watts slope may plateau in HF patients. C: In severe LV dysfunction, $\dot{V}O_2$ may decline as blood pressure and cardiac output are reduced.

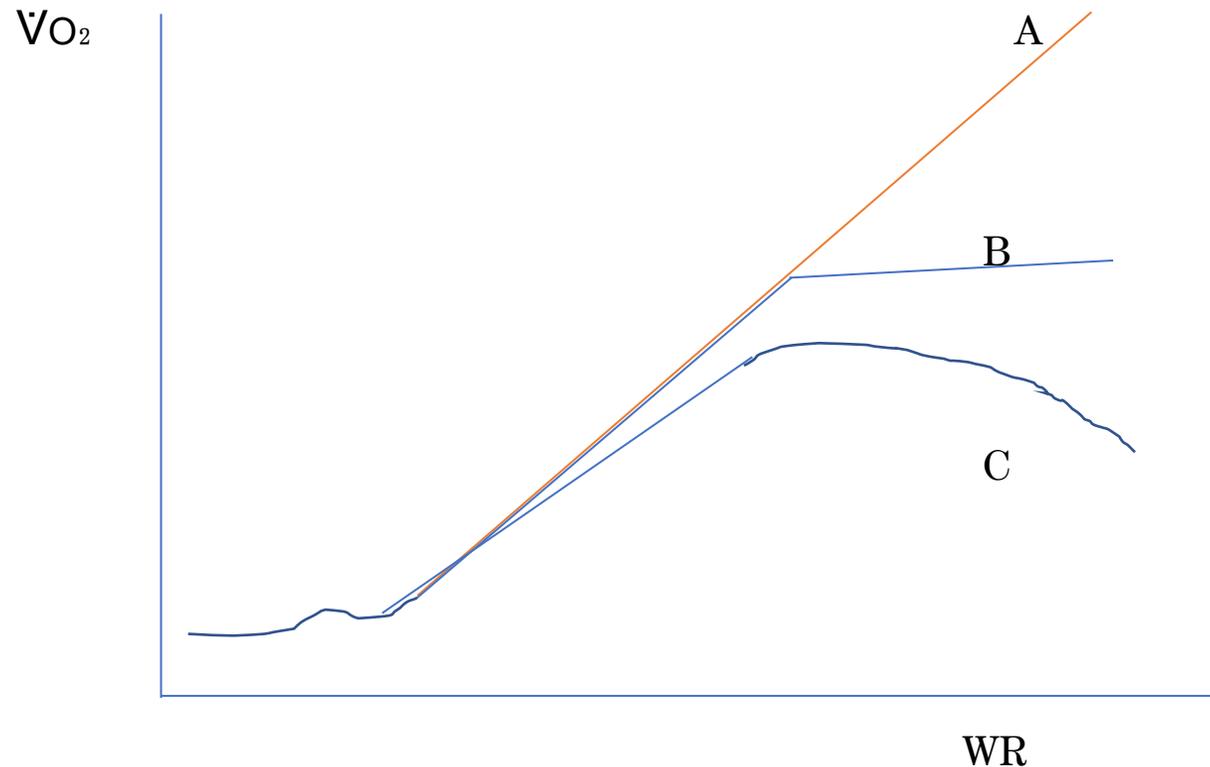


Figure 3. Identification of the ventilatory threshold (VT) by the V-Slope method. Patients with heart failure demonstrate a change in the V-Slope at a lower Vo_2 .

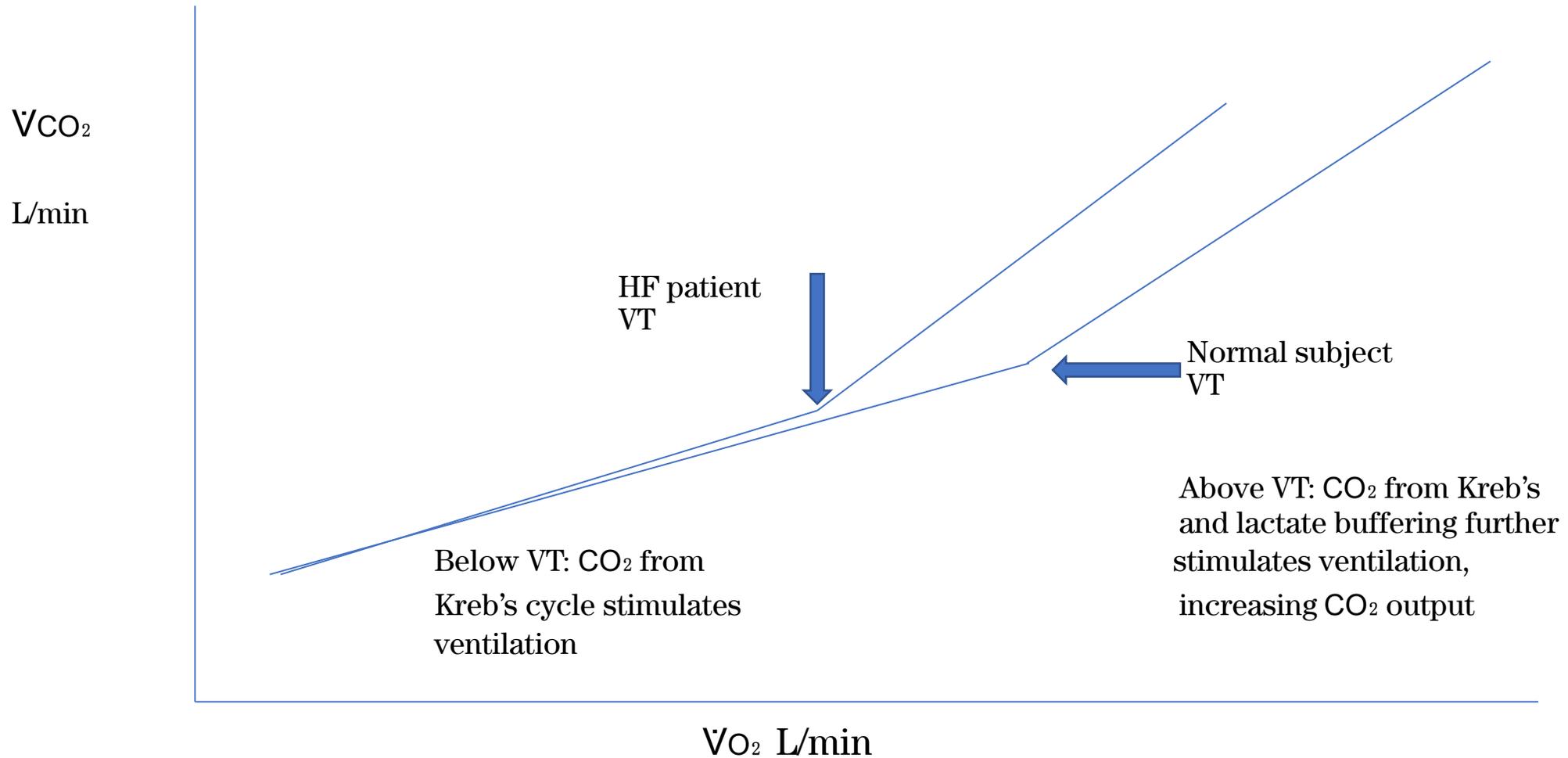
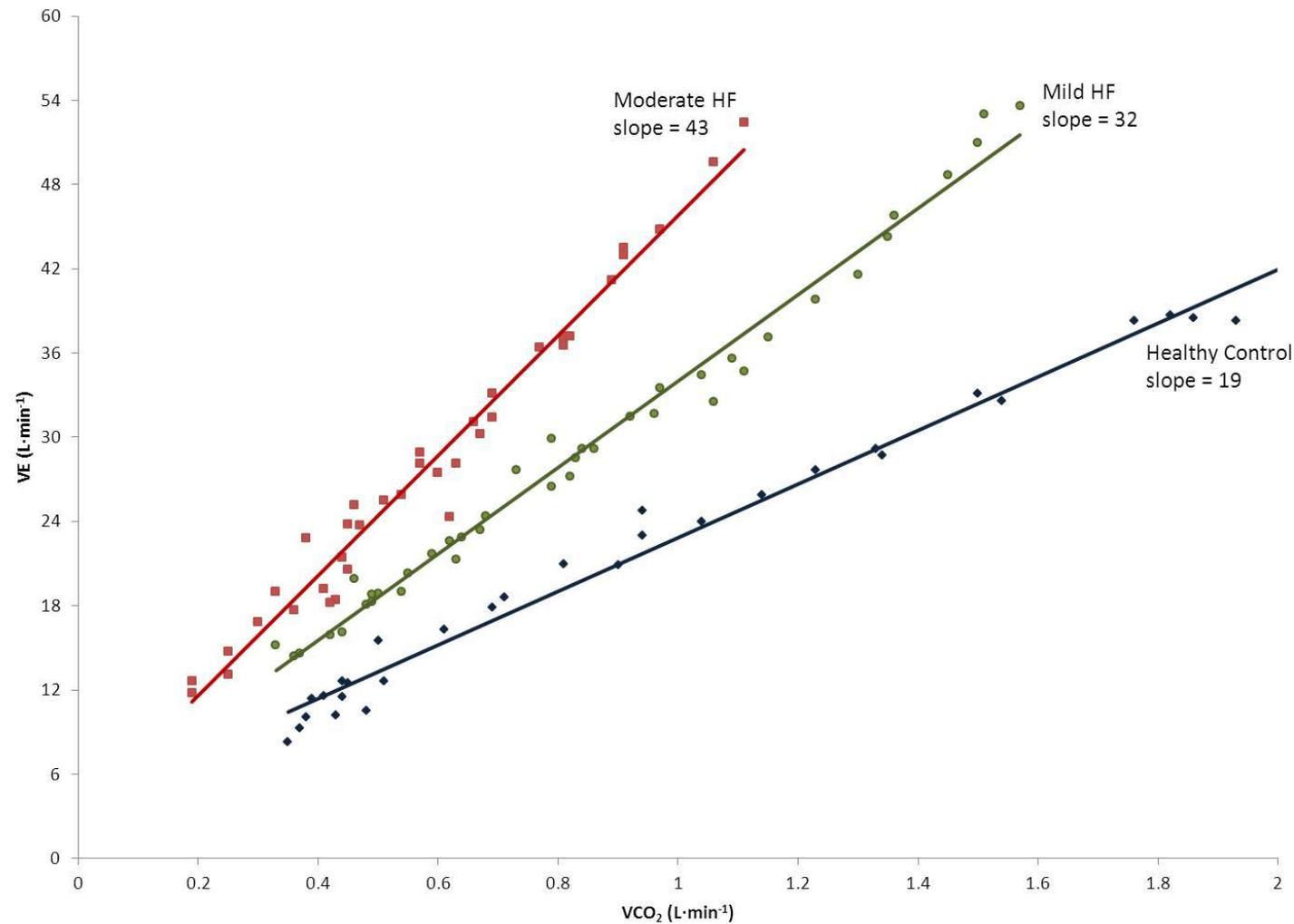
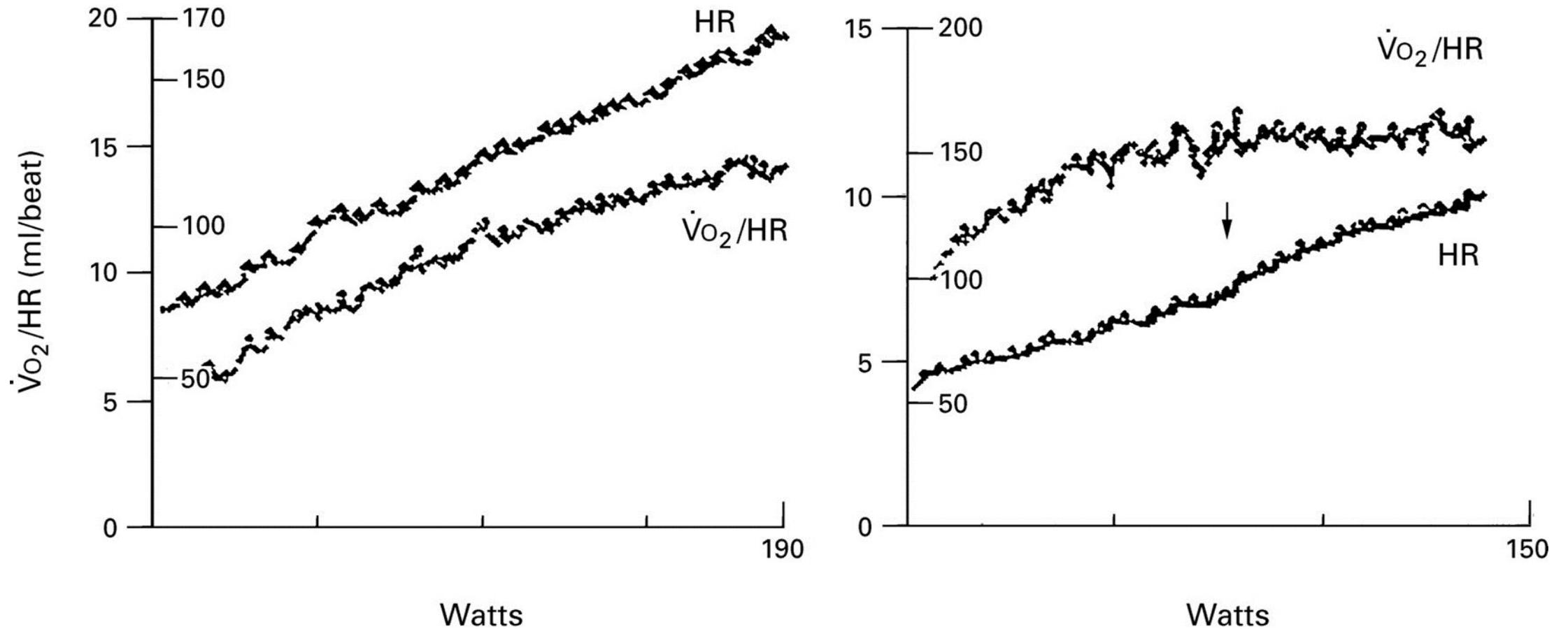


Figure 4. Ventilatory response (\dot{V}_E) as a function of \dot{V}_{CO_2} (\dot{V}_E/\dot{V}_{CO_2} slope) during incremental exercise in normal and patients with mild or moderate heart failure.



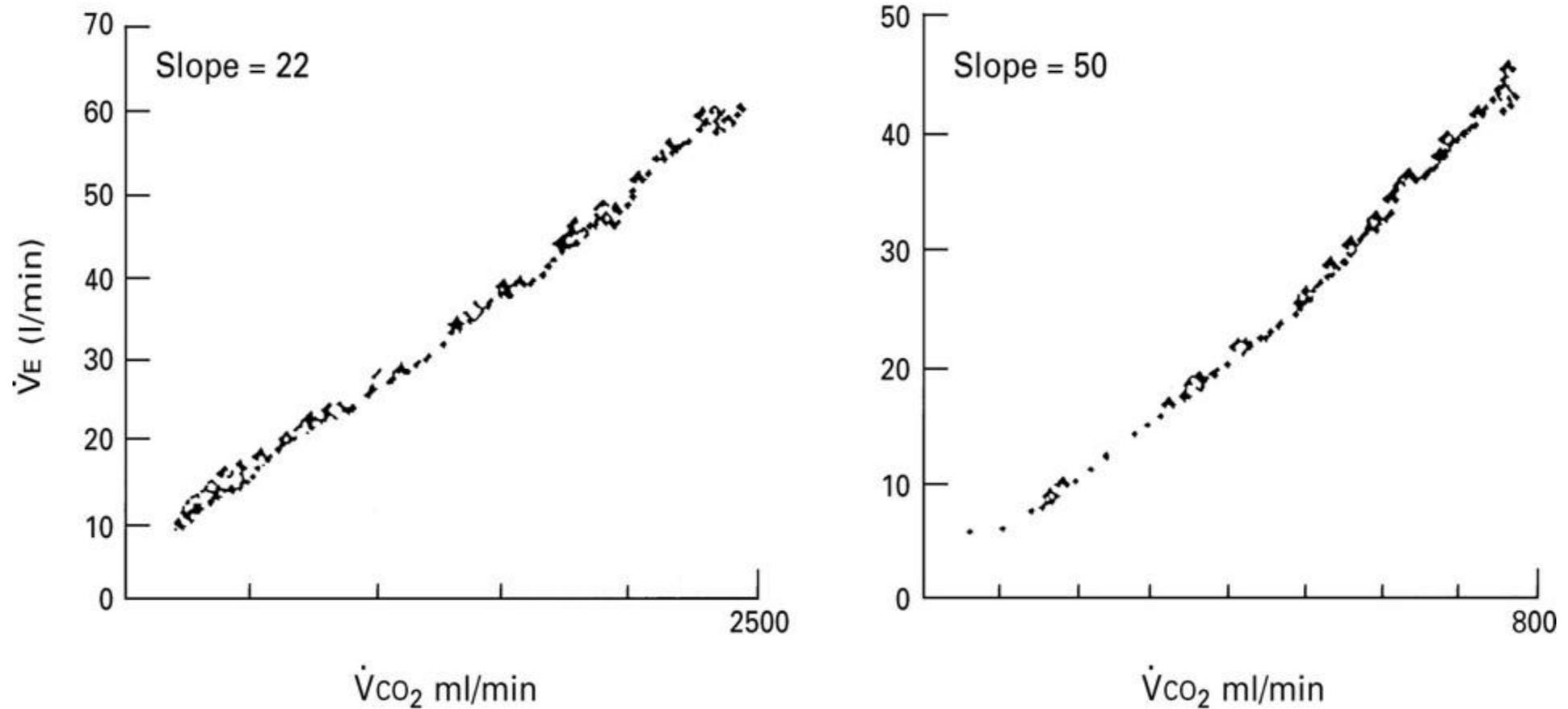
Santoro, C., Sorrentino, R., Esposito, R. et al. Cardiopulmonary exercise testing and echocardiographic exam: an useful interaction. Cardiovasc Ultrasound 17, 29 (2019). <https://doi.org/10.1186/s12947-019-0180>. Permission obtained.

Figure 5. Response of heart rate and oxygen-pulse (analog of stroke volume) to progressively increasing work rate in a normal subject (left panel) and in a patient with hypertrophic cardiomyopathy (HCM; right panel).



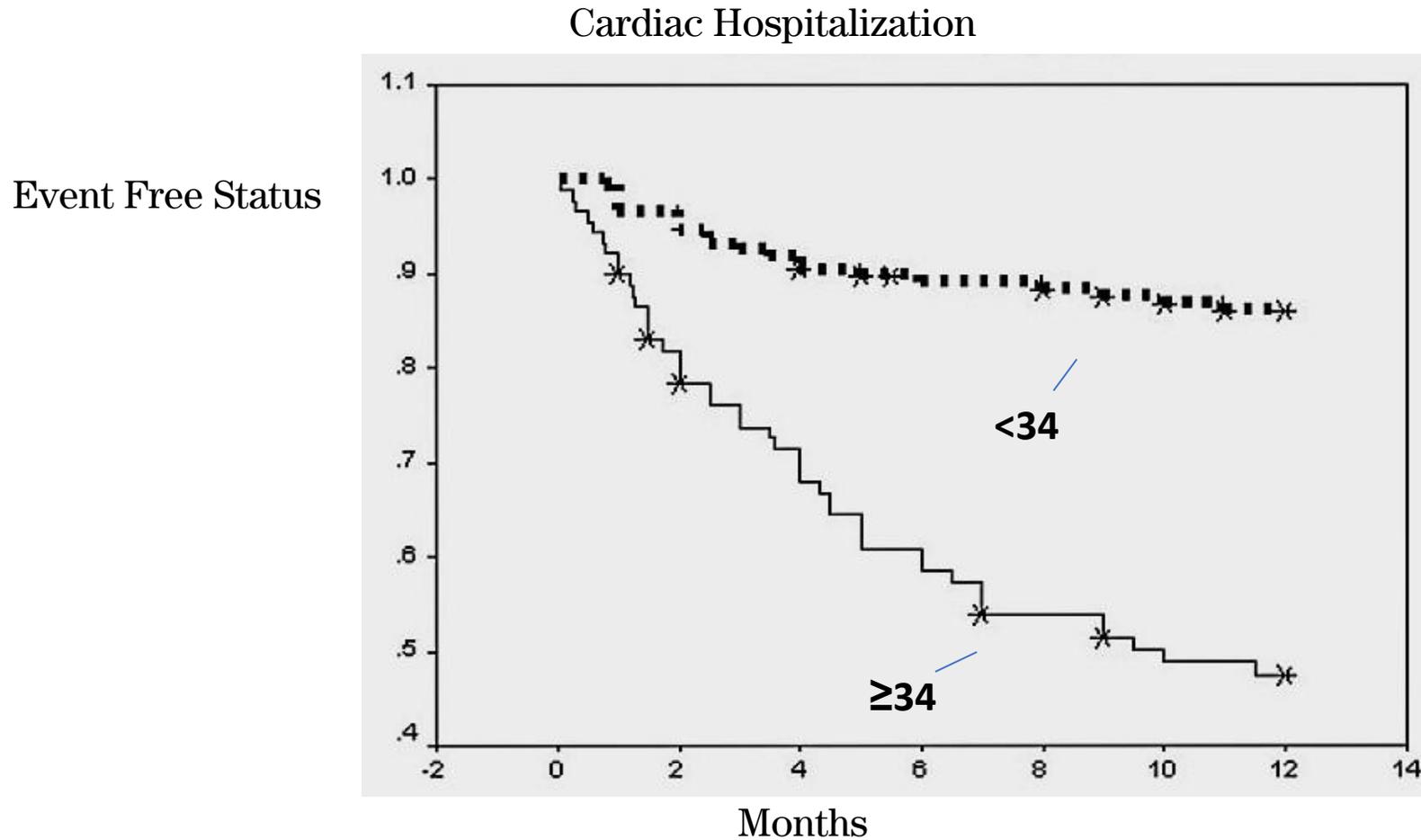
Jones S, Elliott PM, Sharma S, et al Cardiopulmonary responses to exercise in patients with hypertrophic cardiomyopathy Heart 1998;80:60-67. Permission obtained.

Figure 6. Profile of the ventilatory response as a function of \dot{V}_{CO_2} during incremental exercise in a normal subject and a patient with heterotrophic cardiomyopathy (HCM). Note the high slope in the patient.



Jones S, Elliott PM, Sharma S, et al Cardiopulmonary responses to exercise in patients with hypertrophic cardiomyopathy Heart 1998;80:60-67. Permission obtained.

Figure 7. Kaplan-Meier analysis for one-year cardiac –related hospitalization using \dot{V}_E/\dot{V}_{CO_2} slope threshold of 34.



Arena R, Myers J, Aslam SS, Varughese EB, Peberdy MA. Peak $\dot{V}O_2$ and \dot{V}_E/\dot{V}_{CO_2} slope in patients with heart failure: a prognostic comparison. *Am Heart J.* 2004 Feb;147(2):354-60. doi: 10.1016/j.ahj.2003.07.014. Permission obtained.

Figure 8. Flow-Volume loops measured at peak exercise in a normal trained subject (A). Patient B reported limiting dyspnea and ventilated low in the FVC where forced expiratory efforts encountered increasing resistance from progressively collapsing small airways. Patient C reported dyspnea described as inability to get a full breath. He ventilated high in the FVC and performed a high degree of elastic work, terminating inspiration near TLC.

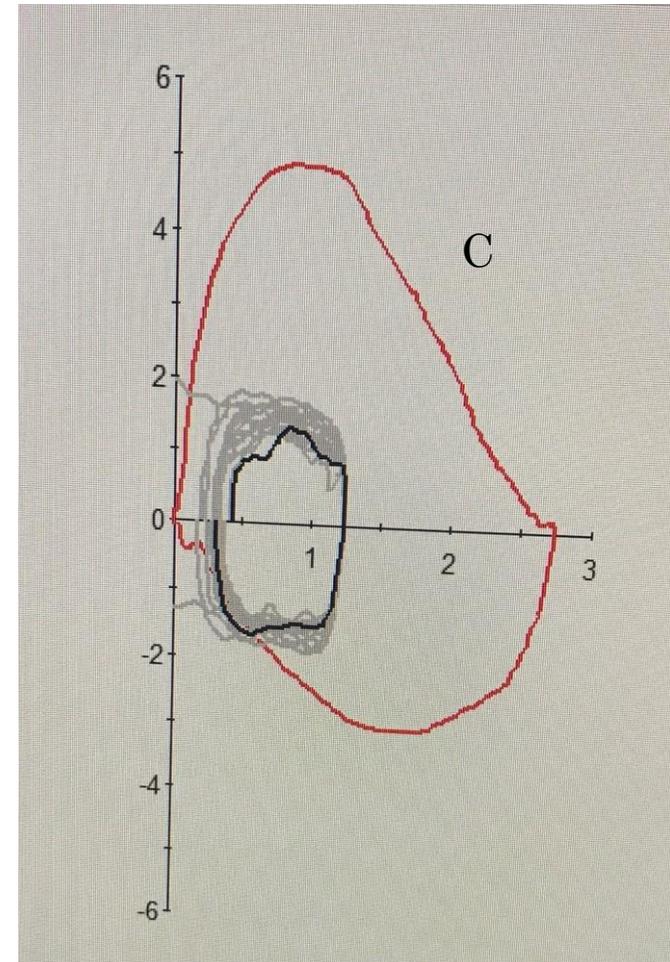
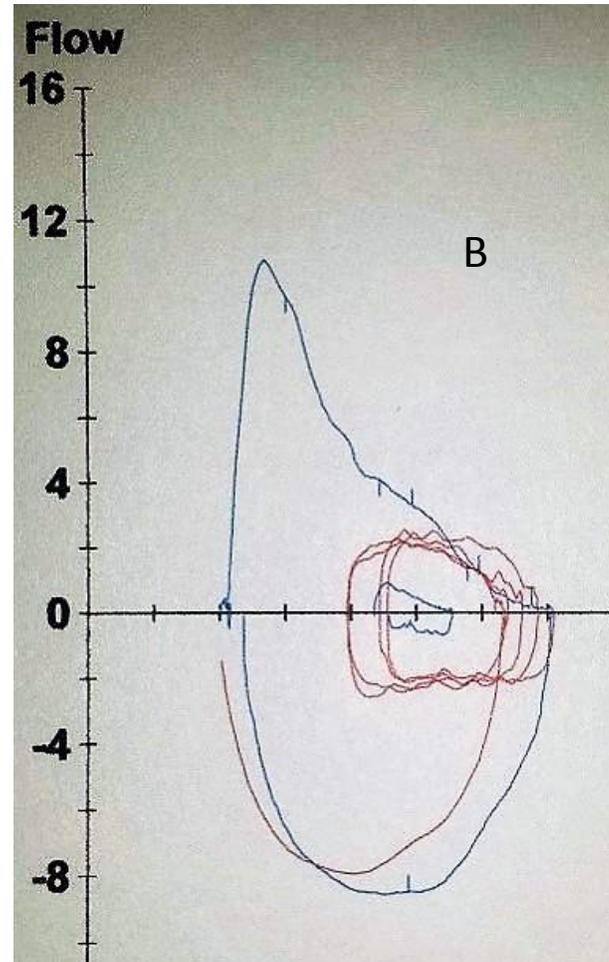
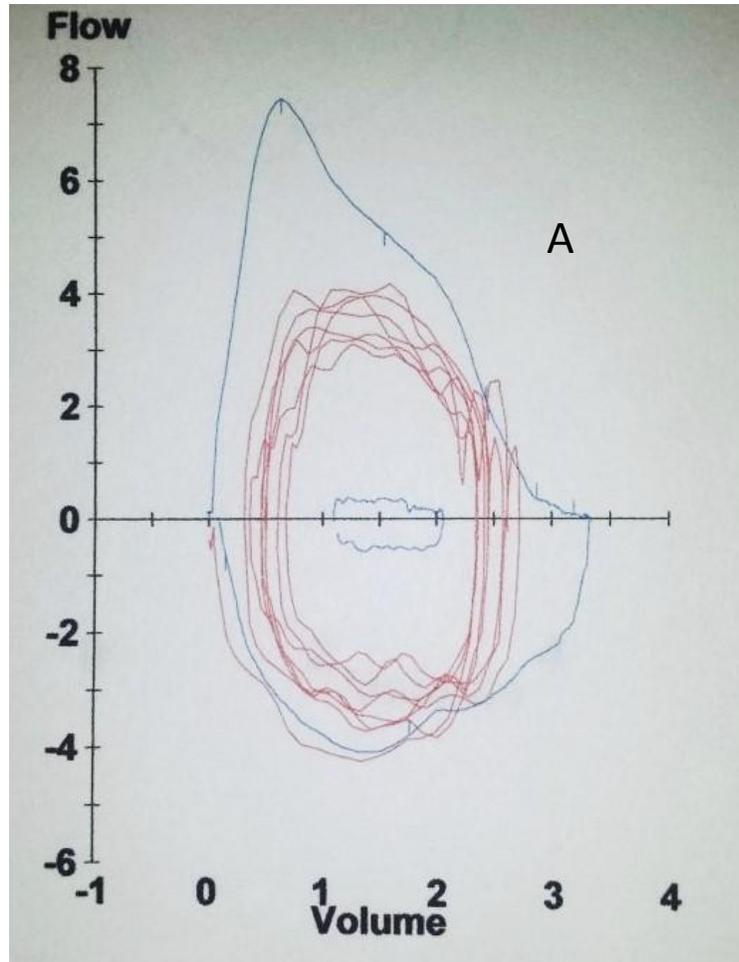


Figure 9: Exercise responses in normal subjects (N) and patients (P) with respiratory chain deficiency myopathy (RCM). Patients have: (A) lower peak $\dot{V}O_2$, work capacity, and slope of $\Delta \dot{V}O_2 / \Delta \text{work}$; (B) reduced slope of $\dot{V}O_2 / \text{HR}$; (C) ventilation threshold (anaerobic threshold) at a lower $\dot{V}O_2$; and (D) steeper $\dot{V}_E / \dot{V}CO_2$ slope.

