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Exercise intensity domains determined by heart rate at ventilatory threshold: a comparison of the guideline-directed exercise intensity domains for cardiovascular rehabilitation prescription

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Background: Appropriate exercise prescription for cardiovascular diseases patients is a keystone for efficient and safe cardiovascular rehabilitation (CR). Exercise intensity prescribed according to the first and second ventilatory threshold (VT1 and VT2), identified by cardiopulmonary exercise testing (CPET), is considered the gold-standard method. However, because CPET is often not available, percentages of peak heart rate (%HRpeak) or heart rate reserve (%HRR), according to heart rate (HR) response during a conventional exercise test, are very commonly used.

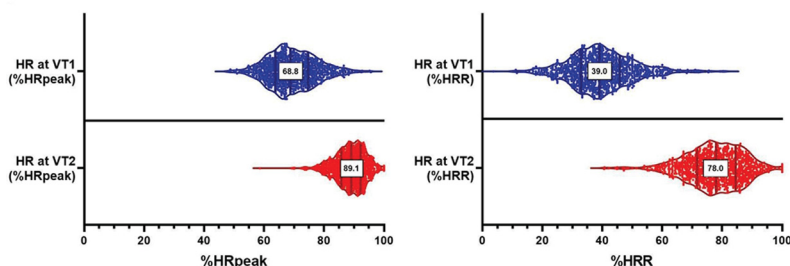
Purpose: To compare the HR at VT1 and VT2 identified by CPET with the recommended exercise intensity prescription domains according to the Brazilian, American, and European CR guidelines/recommendations.

Methods: This retrospective cohort study assessed 1,465 treadmill CPETs from adult patients with stable cardiovascular diseases. Inclusion criteria were available VT1 and VT2 identification, sinus rhythm during exercise, and had reached maximal effort (respiratory exchange rate ≥ 1.10). HR at VT1 and VT2 were compared with the exercise intensity prescription domains recommended by Brazilian CR Guideline 2020, European Position Statement 2022, and the American College of Sports Medicine Guideline 2017, according to the obtained %HRpeak and %HRR.

Results: After applying the inclusions criteria, a sample of 972 CPETs were included (mean age 57.7 ± 12.0 years, 80.8% males, 81.4% with coronary artery disease, and 26.6% with heart failure). VT1 and VT2 were identified, respectively, at 68.8% (63.8, 74.7) and 89.1 (85.8, 92.2) of the peak HR, and 39.0 (32.9, 45.8) and 78.0 (71.6, 84.5) of the HR reserve, indicating a greater heterogeneity of the latter (Figure 1). We found substantial heterogeneity between the measured %HRpeak and %HRR correspondent to the VT1 and VT2 and the estimated HR exercise intensity domains by compared international recommendations (Figure 2).

Conclusion: The disparities among currently established guideline-directed exercise domains limits the clinical validity of the use of %HRR and %HRpeak, and further strengthens the importance of performing CPET for an accurate exercise intensity prescription in CR. In the absence of CPET, HR values identified in our study at VT1 and VT2 could be used for guiding moderate-intensity exercise prescription for CVD patients, and the suggested range would be 69 to 89% of %HRpeak or 40 to 78% of %HRR. Current established exercise domains limits should be revised to improve HR-based prescription efficiency and safety.

Figure 1. Heart rate at first and second ventilatory threshold according to the obtained percentages of peak heart rate or heart rate reserve.



HR, heart rate; VT1, first ventilatory threshold; VT2, second ventilatory threshold; %HRpeak, percentages of peak heart rate; %HRR, percentages of heart rate reserve.

Figure 2. Distribution of individual responses' frequency of occurrence in correspondence to the recommended exercise intensity prescription domains.

Guideline	Brazilian Rehabilitation Guideline 2020			European Position Statement 2022				American College of Sports Medicine Guideline 2017			
	Low	Moderate	High	Low	Moderate	High	Very high	Low	Moderate	High	Very high
1st ventilatory threshold											
% Peak heart rate	55.5	40.9	3.6	2.6	73.1	23.4	0.9	25.2	57.4	17.4	0
% Heart rate reserve	84.1	15.7	0.2	54.4	44.2	1.3	0	54.4	40.9	4.6	0
2nd ventilatory threshold											
% Peak heart rate	0.2	21.5	78.3	0	1.2	55.5	43.3	0.1	1.7	93.3	4.8
% Heart rate reserve	1.1	57.2	41.7	0	20.1	57.4	22.5	0	3.8	89.0	7.2