COMPARISON OF THE OPTIMAL CARDIORESPIRATORY POINT (OCP) IN HEALTHY INDIVIDUALS, COPD PATIENTS, AND HFrEF

Weder Alves da Silva [1]
Alberto Souza de Sá Filho [2]
Gaspar R. Chiappa [3]

ABSTRACT

The cardiopulmonary exercise test (CPET) plays a fundamental role in prognostic assessment. In this context, a new parameter known as the cardiorespiratory optimal point (COP) has recently emerged. The POC is defined as the lowest value of the ventilatory equivalent of oxygen (V'E/V'O2) in a given minute during incremental exercise and represents the point of maximum efficiency between the circulatory and respiratory systems. The present research consists of comparing the dynamics of the POC between control individuals (CTL), individuals with Chronic Obstructive Pulmonary Disease (COPD), and individuals with Heart Failure with Reduced Ejection Fraction (HFrEF). Furthermore, it seeks to investigate the potential correlation between POC and peak oxygen consumption (V'O2peak). The V'O2peak showed significant differences ($p < 0.001$) between the groups, with values of 1825.31 ± 621.75 for CTL, 1057.03 ± 350.45 for COPD, and 1334.52 ± 499.77 ml for HFrEF. Regarding the POC values, the CTL group (24.32 ± 4.10) showed a statistically significant difference ($P < 0.001$) compared to the other groups, DPOC (28.89 ± 6.78) and ICFEr (28.84 ± 5.53). However, when comparing the DPOC and ICFEr groups, no significant differences ($P = 0.998$) were found between them. The correlation coefficient between POC and V'O2peak was -0.578 ($P < 0.001$), indicating a negative association between the analyzed variables, POC and V'O2peak. POC tends to be higher in individuals with compromised health, specifically in those with HFrEF and COPD. Furthermore, there is a significant correlation between the POC variables and V'O2peak.

Keywords: Optimal cardiorespiratory point; Chronic obstructive pulmonary disease; Heart failure.

[1] Master, Evangelical University of Goiás (UniEvangélica), Email: proffweder@gmail.com
[2] Doctor, Evangelical University of Goiás (UniEvangélica), Email: doutor.alberto@outlook.com
[3] Doctor, Evangelical University of Goiás (UniEvangélica), Email: gaspar.chiappa@gmail.com

INTRODUCTION

The cardiopulmonary exercise test (CPET) is a valuable tool for prognostic evaluations of both healthy individuals and those with pathological conditions (1-3). The information derived from the CPET is crucial for assessing overall health. For example, peak oxygen consumption (V'O2peak), a variable measured during the CPET, serves as an excellent health indicator (4). However, it is worth noting that the CPET imposes a significant physiological demand and, for many individuals, it may be limiting or contraindicated (4-8).

Patients with chronic obstructive pulmonary disease (COPD) or heart failure with reduced ejection fraction (HFrEF), for example, often exhibit limitations in both ventilatory function and peripheral muscle strength. This leads to a reduction in physical effort tolerance due to the mismatch between the high ventilatory demands and the decreased ability to meet them (9).

In this context, a new index known as the optimal cardiorespiratory point (POC) has recently emerged. This can be described as the lowest value of the ventilatory equivalent of oxygen (V'E-V'O2) observed during incremental exercise within a specific minute. Essentially, it means the point at which the circulatory and respiratory systems reach their maximum efficiency, representing the minimum ventilation required to extract 1 liter of oxygen (10-12).

One of the main advantages of the POC is that its determination requires a relatively low level of effort during the CPET. Research indicates that the POC can be identified before reaching the first ventilatory threshold, typically within the range of approximately 30% to 50% of V'O2peak. As a result, it can be obtained through a submaximal test, which increases its practical applicability (11-13).

Therefore, the objective of the present research is to compare the dynamics of POC between control individuals (CTL), individuals with COPD, and individuals with HFrEF. Furthermore, it seeks to investigate the potential correlation between POC and V'O2peak.

METHODOLOGY

The present research is a cross-sectional study (51596221.4.0000.5076) that included 177 individuals with different health conditions in CTL (n = 49), COPD (n = 62), and HFrEF (n = 66) who met the pre-established eligibility criteria.

Study protocol

All participants underwent an incremental exercise test using a ramp protocol to evaluate aerobic function parameters during exercise. The CPET involves gradual and controlled increments in the workload until reaching the tolerance point (Tlim, in seconds). These tests were conducted on a cycle ergometer with an electronic brake (Corival 400, Lode) at a constant pedaling frequency of 60 revolutions per minute (rpm).

During the CPET, gas exchanges and ventilatory variables were analyzed breath by breath using a calibrated computer-based exercise system (CardiO2 System, Medical Graphics Corporation, USA).

For the calculation of POC, ventilation (V'E) and oxygen consumption data were used, specifically the lowest value of the ventilatory equivalent of oxygen (V'E-V'O2) at a given minute during the CPET, according to Ramos' recommendation (10).

Statistical analysis

The data are presented as mean ± standard deviation. The normality of the data was tested using the Shapiro-Wilk test. When appropriate, parametric data were compared using unpaired Student's t-test, ANOVA, and Bonferroni post-hoc test. For non-parametric data, the Mann-Whitney test or the Kruskal-Wallis test was used. The coefficients of variation for the POC and V'O2peak variables were obtained by the ratio between the standard deviation and the mean. Pearson correlation was used to test the association between POC and V'O2peak. All analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 20.0. The significance level was established a priori at $P \leq 0.05$.

RESULTS

The anthropometric characteristics of the three groups were not significantly different. The comparison of the TCPE test variables between the groups revealed significant differences in the values of V'O2peak and POC between the CTL, COPD, and HFrEF groups ($P < 0.05$). Moreover, the DPOC and ICFEr groups differed significantly only in the V'O2peak variable ($P < 0.05$). It is important to note that the V'O2peak was significantly higher in the CTL group than in the COPD and ICFEr groups (1825.31 ± 621.75 vs 1057.03 ± 350.45 and 1334.52 ± 499, respectively).

Moreover, the POC values were significantly lower in the CTL group than in the DPOC and ICFEr groups (24.32 ± 4.10 vs 28.89 ± 6.78 and 28.84 ± 5.53, respectively). This negative association was further supported by the significant correlation coefficient between POC and V'O2peak ($r = -0.578$, $P < 0.001$).

CONCLUSION

POC is a dimensionless variable, simple and easy to obtain, requiring only data from V'E and V'O2pico extracted during the CPET at a reasonably low intensity, before the first ventilatory threshold. Therefore, we can conclude that POC tends to be higher in individuals with impaired health, HFrEF, and COPD, and that there is a significant and negative correlation between the respective variables, POC and V'O2peak.

BIBLIOGRAPHIC REFERENCES

1. Albouaini K, Egred M, Alahmar A, Wright DJ. Cardiopulmonary exercise testing and its application. Postgrad Med J. 2007;83(985):675–82.

2. Herdy AH, Ritt LEF, Stein R, de Araújo CGS, Milani M, Meneghelo RS, et al. Cardiopulmonary exercise test: Background, applicability and interpretation. Arq Bras Cardiol. 2016;107(5):467–81.

3. Paolillo S, Agostoni P. Prognostic role of cardiopulmonary exercise testing in clinical practice. Ann Am Thorac Soc. 2017;14(1):S53–8.

4. Menenghelo RS, Araújo CGS, Mastrocolla LE, Albuquerque `F SS et al. iii Diretrizes da Sociedade Brasileira de Cardiologia Sobre Teste Ergométrico iii Diretrizes da Sociedade Brasileira de Cardiologia. Arq Bras Cardiol. 2010;95(5

Supl 1):1–26.

5. Guazzi M, Adams V, Conraads V, Halle M, Mezzani A, Vanhees L, et al. Clinical recommendations for cardiopulmonary exercise testing data assessment in specific patient populations. Circulation. 2012;126(18):2261–74.

6. Wasserman K, Hansen JE, Sue DY, Stringer WW, Sietsema KE, Sun XG, et al. Principles of exercise testing and interpretation: Including pathophysiology and clinical applications: Fifth edition. Principles of Exercise Testing and Interpretation: Including Pathophysiology and Clinical Applications: Fifth Edition. 2011. 1–592 p.

7. Laukkanen JA. Is Cardiorespiratory Optimal Point Measured During the Maximal Cardiopulmonary Exercise Test a Relevant Indicator of Sports Performance? Int J Cardiovasc Sci. 2018;31(4):320–2.

8. Ferreira Reis J, Gonçalves A, Brás P, Moreira R, Pereira-da-Silva T, Timóteo AT, et al. The prognostic value of the cardiorespiratory optimal point during submaximal exercise testing in heart failure. Rev Port Cardiol. 2022;41(9):751–8.

9. Neder JA, Jones PW, Nery LE, Whipp BJ. Determinants of the exercise endurance capacity in patients with chronic obstructive pulmonary disease: The power-duration relationship. Am J Respir Crit Care Med. 2000;162(2 I):497–504.

10. Ramos PS, Araújo CGS. Cardiorespiratory optimal point during exercise testing as a predictor of all-cause mortality. Rev Port Cardiol [Internet]. 2017;36(4):261–9.

11. Ramos PS, Ricardo DR, Araújo CGS de. Cardiorespiratory Optimal Point: a Submaximal Variable of the Cardiopulmonary Exercise Testing. Arq Bras Cardiol. 2012;99(5):988–96.

12. Silva CG de S e, Castro CLB de, Franca JF, Bottino A, Myers J, Araújo CGS de. Cardiorespiratory Optimal Point in Professional Soccer Players: A Novel Submaximal Variable During Exercise. Int J Cardiovasc Sci. 2018;31(4):323–32.

13. Oyarzo-aravena A, Arce-alvarez A, Salazar-ardiles C, Ramirez-campillo R, Alvarez C, Toledo C, et al. Cardiorespiratory optimal point as a submaximal evaluation tool in endurance athletes : An exploratory study. 2023;(February):1–13.