

Gas Exchange Concentration Responses During Stress Test With Bruce Protocol Exercise

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1. Abstract

The objective of the present study was to determine the variability of the CO₂ concentration from respiratory gases, during a progressively increasing treadmill exercise test, with the purpose of assessing the possible error in determining the anaerobic threshold.

The anaerobic threshold represents the level of exercise with constant intensity at which lactic acid does not raise continuously during it or at which the oxygen requirement continuously exceeds oxygen supply to a limited extent. There are two known methods of describing the anaerobic threshold: from respiratory gas exchange parameters (AT) and from lactic acid measurements (LT). Both concepts are widely in use in sports physiology and coaching: performance diagnostic for endurance events, endurance capacity, guidance of training and monitoring training adaptations, talent-finding for endurance sports; as far as the clinical use is concerned, the anaerobic threshold is used for measuring the severity of cardiac diseases and for monitoring pulmonary rehabilitation programs.

Design: Parameters of sub-maximal exercise capacity, in particular ventilatory anaerobic threshold (VAT) have received increasing attention, since they might better reflect the subjective functioning than peak oxygen consumption (VO₂). However, VAT is often not measured, but calculated from parameters of peak exercise capacity. Therefore, this study evaluated whether this calculation is reliable.

Measurements were made on a number of 35 patients chosen for the stress tests by a cardiologist, in order to complete or set a diagnosis, using Biomedical Signal Acquisition Equipment. The measurements were made in the Stress Test Laboratory of the Cardiology Clinic of the County Clinical Hospital Sibiu. Measured VAT using CO₂ variation method, was compared with peak exercise capacity and with a calculated anaerobic threshold, using the Karvonen method. This method is commonly used in prescribing (endurance) exercise training during cardiac rehabilitation and is calculated with peak heart rate (HR) (Karvonen HR = HR at rest + 0.60 HR reserve). In addition, VAT and peak VO₂ were referred to subjective physical functioning, assessed with questionnaires.

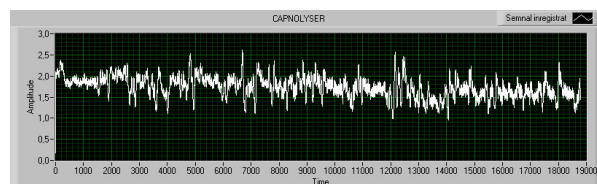
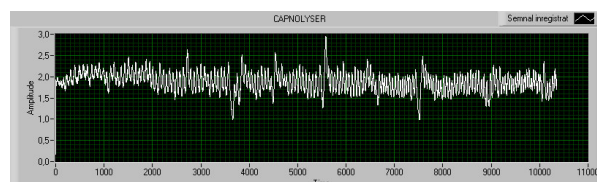
Conclusions: The estimated variation of the CO₂ concentration, relying on the intensity of the exercise, associated with VAT has a consistent and predictable

error, which depends on the protocol and on the criteria used to identify the appropriate intensity of the exercise. These tests are valuable, but when used to predict AnT, the term describes the approach taken should be used to refer to the intensity that has been identified, rather than to refer to this intensity as the AnT.

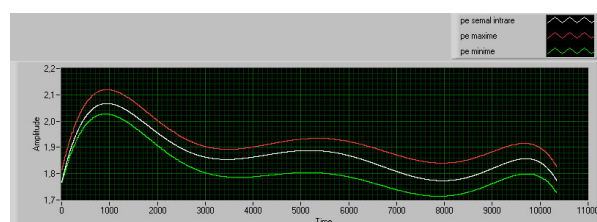
Key words: CO₂ variation method; ventilatory anaerobic threshold VAT; stress tests; data acquisition equipment; respiratory gases

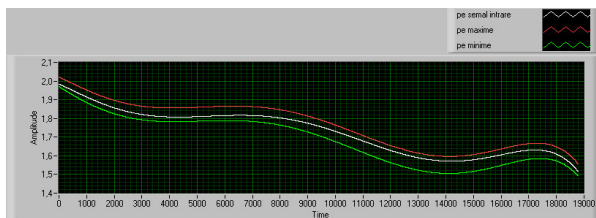
2. Introduction

As shown in [ILIE 1997], the ventilatory anaerobic threshold (VAT) can be determined through the measurement of the CO₂ concentration in the respiratory gases (CO₂ variation method). The measured parameters, as seen in picture no. 1, concerning the CO₂ concentration variation are the “end tidal” CO₂ concentration, red in picture no.2, the “inspir” one, green in picture no.2, and respiratory rate RR.



pic. 1.

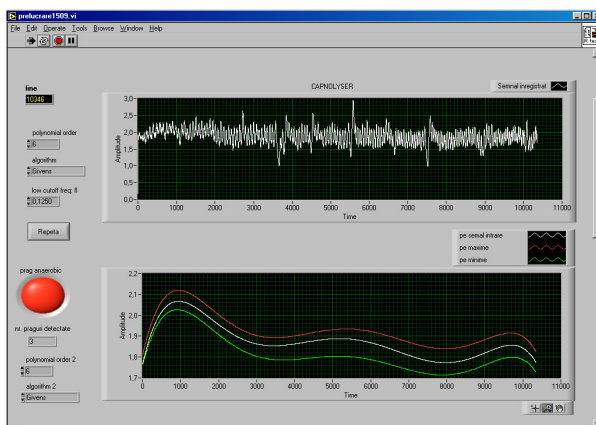




pic. 2.

3. Design

Through the measurements made on 35 patients chosen for the effort test by a cardiologist, in order to give or complete a diagnosis with the help of a Biomedical Signal Acquisition Equipment, the existence of multiple anaerobic thresholds has been detecting (picture no.3).



pic.3.

The ventilatory anaerobic threshold, for which the heart rate HR is close to the maximum value given by the Karvonen formula:

$$HR_{\max} = HR_{\text{at rest}} + 0.6 \cdot HR_{\text{at rest}}$$

is named from now on, **cardiac anaerobic threshold** (CAT). The calculation made on the recorded data indicated that the CAT can be relatively accurately determined.

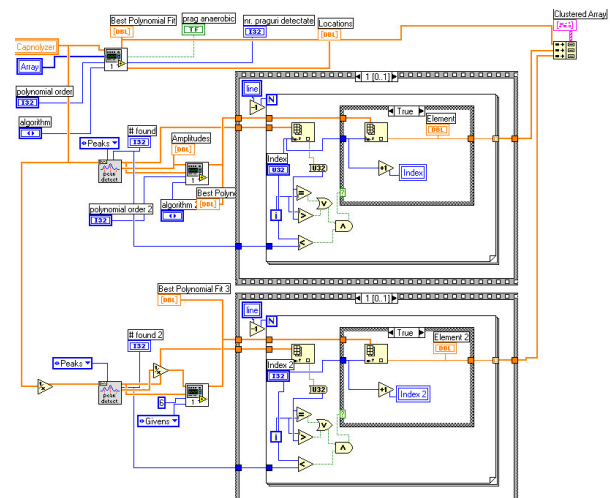
The determination method of the anaerobic threshold through the measurement of the CO₂ concentration (CO₂ variation method) is – in correlation with the measurement of the heart rate HR – accurate enough to determine the thresholds, especially the CAT.

The implementation of this method as a result a lower level of stress for the patient, which makes it more valuable; the implementations costs compared to those of other known methods (the determining of the lactic acid or lactate threshold LT or of the ventilatory anaerobic threshold through the respiratory gases in closed circuit VAT) are much lower.

4. Measurements

Measurements were made on a number of 35 patients chosen for the stress tests by a cardiologist, in order to complete or set a diagnosis, using Biomedical Signal Acquisition Equipment. The measurements were made in the Stress Test Laboratory of the Cardiology Clinic of the County Clinical Hospital Sibiu. The medical

protocol used for testing is Bruce Protocol Exercise, implemented in treadmill's memory. The data (signal) is processed by a LabView virtual instrument. The main screen is shown in picture no.4.



pic. 4.

The cardiac anaerobic threshold CAT is detected from the filtered peak signal, using the correlation between HR and the peaks of the seven points Givens polynomial interpolating signal.

5. Conclusions

This study sets:

The existence of multiple anaerobic thresholds.

A new ventilatory anaerobic threshold VAT, named **cardiac anaerobic threshold** CAT

A objective and a reliable "end point" for stress tests, in Clinical Stress Test Laboratories, and a criteria for effort capabilities, used in Sport Test Laboratories in order to determine the degree of training for the top sportspeople;

The estimated variation of the CO₂ concentration, relying on the intensity of the exercise, associated with VAT has a consistent and predictable error, which depends on the protocol and on the criteria used to identify the appropriate intensity of the exercise.

6. References

1. K. SVEDAHL, B.R. MACINTOSH
Anaerobic Threshold: the Concept and Methods of Measurement
the Can. J. Appl. Physiol. (April, 2002)
2. Dr. H.-CH. HEITKAMP
Anaerobic Threshold: Methods And Reproducibility
3. RILEY, M. S., and C. B. COOPER.
Ventilatory and gas exchange responses during heavy constant work-rate exercise.
Med. Sci. SportsExerc., Vol. 34, No. 1, 2002, pp. 98–104.

4.K.WASSERMAN

Anaerobic threshold and cardiovascular function
Monaldi Arch Chest Dis 2002; 58: 1, 1–5.

5. W. NIEUWLAND MD, M.A. BERKHUYSEN
PhD, D.J. VAN VELDHUISEN MD PhD, M.L.J.
LANDSMAN MD PhD, P. RISPENS MD PhD

Can the anaerobic threshold be calculated or should it
be measured in patients with coronary artery disease?

6. P.G. AGOSTONI, K. WASSERMAN, G.B.
PEREGO, M. GUAZZI, G. CATTADORI, P.
PALERMO, G. LAURI, G. MARENZI

Non-invasive measurement of stroke volume during
exercise in heart failure patients.

*The Biochemical Society and the Medical Research
Society*

7. W. L. BEAVER, K. WASSERMAN, B. J. WHIPP,
A new method for detecting anaerobic threshold by gas
exchange.

J. Appl. Physiol. 60, 2020±2027(1986)

8. T. JUNG, B. KOROTZER, W. STRINGER, A.
JONES, K. WASSERMAN,

Lactate concentration increase and transcellular fluid
flux during exercise.

Am. J. Respir. Crit. Care Med. 153, A647 (1996)

9. T.M. MCLELLAN, I. JACOBS.

Reliability, reproducibility and validity of the
individual anaerobic threshold.

Eur. J. Appl. Physiol. 67: 125-131, 1993.

10. B. ILIE, O. SPATAR, R. MANITIU

The determination of the anaerobic threshold
from breathing gases during effort test.

ECIT 97 :45-48, 1997.

11. I. MANITIU. B. ILIE

Studiu privind determinarea pragului anaerobic la
testul de efort din gazele respiratorii.

*Analele Universitatii Oradea, fascicola Electrotehnica
1997.*

12. F.C. HOPPENSTEADT, C.S. PESKIN

Modeling And Simulation In Medicine And The Life
Sciences.

Springer-Verlag 2002 ISBN 0-387-95072-9

13. D. ZDRENGHEA

Testarea De Stress In Cardiopatia Ischemica

Editura SINCRO 1992