Exhaled Breath Temperature Predicts Maximal Exercise Performance In A Population Of Males With COPD

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Research Article

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Abstract

Background: Patients with COPD present with debilitating symptoms that negatively impact both physical and mental quality of life.

Objective: Examine the physiological variables of Spirometry, Gas Diffusion and Exhaled Breath Temperature (EBT) in an attempt to predict maximal exercise performance in a group of male subjects with COPD.

Methods: 62 male subjects with a clinical diagnosis of COPD (GOLD Stages 1-2), aged between 40-70 years were included. A Stepwise multiple regression model was constructed to assess variable suitability. The regression model was compared to the actual Peak VO_2 data using a two-tailed Student T test.

Results: The stepwise model revealed that peak oxygen uptake (peak VO_2) was predicted best by the following variables: Exhaled Breath Temperature ($^{\circ}\text{C}$), Height (m), Age (Years) and Diffusing Capacity ($\text{mmol}\cdot\text{min}\cdot\text{kpa}$). Adjusted R-Squared = 0.5 RSE = 4.28.

Conclusions: That exercise tolerance was predicted reasonably well from measurements of exhaled breath temperature, lung function and gas diffusion in this group of patients with COPD. This study adds to the growing literature displaying the utility of Exhaled Breath Temperature as a biomarker.

Introduction

Loss of exercise capacity in adults with COPD has been attributed to deterioration in lung mechanics, peripheral and respiratory muscle function and nutritional status ¹. As exercise capacity lessens traditional means of assessing maximal capacity can prove difficult and many clinicians opt for sub-maximal testing such as the 6 minute walk or incremental shuttle. Furthermore; standard respiratory testing; Spirometry, Gas Diffusion and well as newer techniques such as Exhaled Breath Temperature (EBT) have been shown to be useful tool in monitoring disease progression ².

We examined multiple physiological variables in an attempt to predict maximal exercise performance in a group of male subjects with COPD.

Methods

In this retrospective single centre quality improvement / methodology study, 62 male subjects with a clinical diagnosis of COPD (GOLD Stages 1-2), aged between 40-70 years were included. This study was approved by the Clinical Effectiveness Unit St Barts Health NHS Trust (ID: 10015).

All subjects underwent measurements of spirometry and gas diffusion using an electronic gas analyser which was calibrated as per manufacturers recommendations per to use (MasterScreen PFT, Vyaire Medical Products Ltd, Basingstoke, UK). All subjects performed a maximal cardiopulmonary exercise test

using an electrically-braked cycle ergometer (VIA sprint 150 cycle ergometer, Vyaire Medical Products Ltd, Basingstoke, UK) following an individualised incremental ramp protocol up to exhaustion. All tests achieved at least two of the following criteria to be considered maximum: Post-exercise blood lactate levels $\geq 8 \text{ mmol}\cdot\text{L}^{-1}$, $\text{VE}_{\text{peak}} / \text{MVV} \% \geq 85$, or a respiratory exchange ratio ≥ 1.05 ³.

Cardiopulmonary exercise tests were performed with gas exchange and ventilatory variables being analysed breath-by-breath using a calibrated computer-based exercise system (Vyntus CPX Metabolic Cart, Vyaire Medical Products Ltd, Basingstoke, UK). The O_2 and CO_2 analysers were calibrated before each test using a reference gas (12% O_2 ; 5% CO_2 ; nitrogen balance). The pneumotachograph used was also calibrated, with an automatic differential flow profile. The hand held breath thermometer *X-Halo*, was used to capture EBT (Delmedica Investments Ltd). The subject breathed in a relaxed pattern continually for about 3 minutes until temperature plateau was reached ⁴. Contraindications included severe dyspnoea, cough, wheezing, accessory muscle weakness or any significant facial or oral abnormality that would inhibit forming a tight seal around the mouthpiece with the lips.

Statistical Analysis

Statistical analysis was performed using the software Graphpad 8.0 (Graphpad Software Inc, USA). All variables from the pulmonary function test showed normal distribution when analysed by the Shapiro Wilk's test. A Stepwise multiple regression test revealed that peak oxygen uptake (peak VO_2) was predicted best by the following variables: Exhaled Breath Temperature ($^{\circ}\text{C}$), Height (m), Age (Years) and Diffusing Capacity ($\text{mmol}\cdot\text{min}\cdot\text{kpa}$).

A two-tailed Student T test compared the output of the Peak VO_2 regression model to the Actual Peak VO_2 results. Significance was set at $p < 0.05$. Results are presented as mean $\pm$ standard deviation. Based on similar studies a sample size of 62 individuals would be needed to provide an $>80\%$ power with a 2-sided alpha of 0.05 ⁵.

Results

The subject demographics, pulmonary function and peak cardiopulmonary exercise data are shown in Table 1.

Table 1: Demographics, Pulmonary Function And Peak Cardiopulmonary Exercise

Height (m)	1.7	±	0.1
Weight (Kg)	79.9	±	12.8
Age (Years)	56.5	±	6.9
Smoking Pack Year	42.6	±	25.1
BMI	26.2	±	3.5
FEV ₁ (L)	2.6	±	0.7
DL _{CO} (mmol.min.kpa)	7.0	±	2.0
Exhaled Breath Temp. (°C)	33.8	±	0.8
Peak VO ₂ (mL/kg/min)	21.0	±	6.0
Regression Model VO ₂ (mL/kg/min)	20.9	±	4.4

BMI: Body Mass Index, FEV₁: Forced Expired Volume in 1 Second, DLCO: Lung Diffusion Factor, VO₂: Maximal oxygen consumption during exercise.

Stepwise multiple regression revealed that peak oxygen uptake (peak VO₂) was predicted best by the following equation: $VO_2 \text{ (mL/kg/min)} = 60.18 + 0.71 \cdot \text{EBT} - 24.55 \cdot \text{HT} - 0.48 \cdot \text{AGE} + 0.96 \cdot \text{DLCO}$. Adjusted R-Squared = 0.5 RSE = 4.28.

The regression model was compared to the actual Peak VO₂ data using a two-tailed Student T test (Figure 1 and Table 2). There was no significant difference between the Regression model compared to actual VO₂ data.

Table 2: Comparison Of Cardiopulmonary Exercise Data

	Model	Actual
Mean	20.9	21.0
Std. Deviation	4.4	6.0
Std. Error of Mean	0.6	0.8
Coefficient of variation	0.2	0.3
Minimum	12.7	13.3
Maximum	29.8	38.1

Discussion

Exhaled breath temperature has been used prognostically and for treatment monitoring in Asthma, COPD, Cystic Fibrosis and allergic rhinitis. EBT is an accurate assessment of airways inflammation and the degeneration of pulmonary capillary blood flow. Patients with COPD experience loss of exercise performance due to changes in breathing mechanics, hyperinflation and muscle atrophy resulting in a loss of functionality and decline in quality of life.

EBT has been shown to measure increases in heat fluctuations during exercise in patients with asthma^{6,7} as well as healthy control subjects⁸. It has also been shown to detect subtle changes in pulmonary blood flow heat flux in COPD^{9,10,11} and therefore it was felt to be an appropriate variable to use during the construction of the predictive regression model for maximal exercise. The T-Test showed that the model did not differ from the actual exercise data, in fact the model had a smaller standard deviation (4.4 Vs 6.0), smaller standard error (0.6 vs 0.8) and co-efficient of variance (4.4 vs 6.0). The regression models resultant Adjusted R-Squared and residual standard error was 0.5 and 4.28, demonstrating a reasonable fit for accuracy.

Conclusion

We conclude that exercise tolerance was predicted reasonably well from measurements of exhaled breath temperature, lung function and gas diffusion in this group of patients with COPD. However, more work is required to improve the precision and reliability of the model therefore improving its usefulness in individual patients.

Declarations

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None

Author contributions

AE - Devised the topic of the manuscript, Drafted sections of the manuscript, Finalised the manuscript

Additional Information (including a Competing Interests Statement)

None of the authors have any competing interests to declare.

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Figures

Stepwise regression model Vs actual Maximal exercise performance

Figure 1

Regression model compared to the actual Peak VO₂ data using a two-tailed Student T test.