A NEW MATHEMATICAL APPROACH INVESTIGATING PATIENT SPECIFIC FACTORS FOR THE DETERMINATION OF CLINICALLY USEFUL MARKERS OF CARDIOVASCULAR STATUS

V. Vartela\textsuperscript{1,*}, A. Tsanas\textsuperscript{2,3}, D. Tsiapras\textsuperscript{1}, P. Sfirakis\textsuperscript{4}, V. Voudris\textsuperscript{1}

* Asterisk denotes corresponding author.

\textsuperscript{1}2\textsuperscript{nd} Cardiology Division, Onassis Cardiac Surgery Center, Athens, Greece

\textsuperscript{2}Systems Analysis, Modelling and Prediction (SAMP) group, Department of Engineering Science and Mathematical Institute, University of Oxford, Oxford, UK

\textsuperscript{3}Oxford Center for Industrial and Applied Mathematics (OCIAM), University of Oxford, Oxford, UK

\textsuperscript{4}Transplantation and Mechanical Circulatory Support, 1\textsuperscript{st} Division of Cardiothoracic Surgery, Onassis Cardiac Surgery Center, Athens, Greece

We have no conflict of interest. A. Tsanas is funded, in part, by Intel Corporation and by the Engineering and Physical Sciences Research Council (EPSRC).
**Introduction:** Cardiopulmonary exercise-testing (CPX) is a tool to determine the functional capacity of patients with heart failure. We developed a model predicting the main CPX parameters from patient specific factors and clinical information.

**Methods:** We developed mathematical formulas linking the metabolic equivalent (METs), ratio of maximum expiratory volume to CO₂ production (VE/VCO₂) and maximum respiratory Oxygen uptake (VO₂,peak) of a symptom–limited CPX with the age, gender, height, weight, smoking habits, fitness, systolic pressures, diastolic pressures, and heart rate, recording values at rest and after maximum exercise from 188 subjects, aged 18–80 years (mean age 48.2 ± 13.7 years) who referred for a CPX. We used the Spearman correlation coefficient to assess the association strength of each patient specific factor with the quantities of interest and computed $p$-values and the robust iteratively reweighed least squares method to compute the linear regression coefficients relating the input variables with the quantities of interest. We report the out-of-sample mean absolute error (MAE).

**Results:** $p$-values indicate whether an input variable is significant in predicting the outcome measurement, and the Spearman correlation coefficients offer a preliminary indication of the association strength of each input variable with the quantities of interest (METs, VE/VCO₂, VO₂,peak). For each quantity of interest we only include the significant predictors ($p < 0.05$). The out of sample MAE were (mean ± standard deviation): 1.20 ± 0.42 for METs, 5.09 ± 0.95 for VE/VCO₂, 3.09 ± 0.65 for VO₂,peak.

**Conclusions:** We present a method linking cardiovascular disease markers with measurable quantities which offers a reasonable estimate of METs, VE/VCO₂ and VO₂,max, without requiring the patient to undertake the CPX.