May 26, 2021

🌐 Cardiodynamic variables measured by Impedance Cardiography during a 6-minute walk test are reliable predictors of peak oxygen consumption in young healthy adults

Fang Liu[1], Raymond Tsang[2], Alice YM YM Jones[3], Minchao Zhou[1], Kaiwen Xue[4], Miaoling Chen[1], Yulong Wang[1]

[1]1 Department of Rehabilitation, Shenzhen Second People's Hospital, the First Affiliated Hospital of Shenzhen University Health Science Centre;

[2]Department of Physiotherapy, MacLehose Medical Rehabilitation Centre;

[3]School of Health and Rehabilitation Sciences, The University of Queensland;

[4]The Shandong University of Traditional Chinese Medicine

| 1 | Works for me | | Share | dx.doi.org/10.17504/protocols.io.bupdnvi6 |

Alice YM Jones
The University of Queensland

ABSTRACT

This study incorporates ICG, a non-invasive and simple technology, to measure cardiodynamic variables during 6MWT, for prediction of VO_{2peak}. Our results suggest that inclusion of cardiac indices measured during the 6MWT more accurately predicts VO_{2peak}than using 6MWD data alone.

EXTERNAL LINK

https://doi.org/10.1371/journal.pone.0252219

DOI

dx.doi.org/10.17504/protocols.io.bupdnvi6

EXTERNAL LINK

https://doi.org/10.1371/journal.pone.0252219

PROTOCOL CITATION

KEYWORDS

cardiorespiratory fitness, predictors, impedance cardiography, healthy adults, 6MWT

LICENSE

CREATED

Apr 30, 2021

LAST MODIFIED

May 26, 2021

1   Invitation emails were sent via the student portal of all students registered at the School of Rehabilitation of a local university affiliated with the hospital where this project was conducted.

      1.1   Exclusion criteria were: (1) students with known cardiovascular, pulmonary or musculoskeletal disorders that might limit their participation in maximal ergometric exercise test; (2) pregnancy; and (3) any anxiety/depression psychiatric disorder.

2   Students responded to the invitation email were invited to the involved hospital to conduct a cardiopulmonary exercise test (CPET) and two consecutive 6MWTs spaced 30 minutes apart. The processes for 6MWT and CPET were explained, and signed informed consent was obtained.

      2.1   Testing order was determined randomly by drawing lots from an envelope.

      2.2   All participants were requested to avoid caffeine-containing products, nicotine, and alcohol at least 12 hours before attending the laboratory.

3   Variables recording - Cardiodynamic parameters including HR, SV, CO were recorded at one-second intervals by means of ICG (PhysioFlow® PF07 EnduroTM Paris, France) during 6MWT and CPET. Oxygen saturation (SpO_2) was recorded with the Heal Force pulse oximeter (POD-3, China). Systolic and diastolic blood pressure (SBP and DBP) was measured with the OMRON electronic blood pressure monitor (U30, China). Rate of perceived exertion (RPE) at the end of each test was recorded with the modified 0−10 Borg Scale.

4   6MWT - The 6MWT was performed in a 30-meter hospital hallway, following the standard protocol recommended by the American Thoracic Society (ATS). For each test, participants were asked to rest in a sitting position for 10 minutes before and after the 6MWT.

5   The cardiodynamic parameters (HR, SV and CO) were measured using the ICG at one-second intervals during both tests. The SpO_2 was recorded before and after each 6MWT. The SBP and DBP were measured at two-minute intervals during the 10-minute rest period, before and after each 6MWT. The RPE was recorded immediately at the end of each 6MWT.

6   CPET - Each participant also performed a progressive CPET in the hospital cardiopulmonary laboratory using a cycle ergometer (Ergoselect 200, Ergoline GmbH, Germany). Throughout the test, 12-lead electrocardiography was continuously recorded, and the participant was required to wear a mask and breathe through a calibrated volume sensor. Oxygen consumption, carbon dioxide consumption and respiratory exchange ratio (RER) were measured by the MasterScreenTM CPX, breath-by-breath metabolic cart (CareFusion, Germany). The gas analysis system was fully calibrated immediately before each test in accordance with the manufacturer's instructions. The HR, SV, and CO were also measured with ICG at one-second intervals during the CPET.

      6.1   The Garatachea 3-stage exercise protocol was adopted. The first stage commenced with participants resting for three minutes in an upright position on the cycle ergometer with hands rested on the handlebars. Stage 2 required pedalling with free load for three minutes at a speed of 60 revolutions per minute. During Stage 3 the participant continued pedalling at the same speed but with a load of 25W, increased incrementally by 25W per minute, until the subject, despite encouragement, could no longer maintain the required speed, or, the participant's respiratory exchange quotient (REQ) exceeded 1.1. Participants were asked to rate their sensation of fatigue using the modified Borg scale. The cool down

work rate was 15W at 60 revolutions per min for 3 minutes, followed by resting in a seated position.

7   Impedance cardiography ICG - The PhysioFlow® PF07 is a portable, non-invasive device that adopts real-time wireless monitoring of morphology-based impedance cardiography signals via a blue tooth USB adapter to measure HR, SV and CO at one-second intervals. Electrodes were applied as described by Tonelli and colleagues. The HR was derived directly from the ECG, SV was calculated from the cardiac ejection waveform and the CO was obtained by the multiplication of the SV and HR. ICG data from the last 10 seconds of the 6MWT were averaged as the peak cardiodynamic variables of the 6MWT, and data for CPET were computed similarly.

8   Statistical analysis - All statistical analyses were performed using the IBM SPSS for Windows, version 25 (Armonk, NY: IBM Corp). Demographic data and clinical variables of all participants were summarized using descriptive statistics. Variables of interval-ratio data meeting normality assumption were compared using independent t test for gender difference. Chi-square test was used for analysis of categorical data of different gender. The results from the 6MWT that produced a higher 6MWD were used for statistical analyses. A total of five multiple linear regression analyses were conducted. The first set of two analyses were performed to examine the unique contribution of HR or SV changes to the outcome variable 'change in CO', during the 6MWT and CPET. Forced entry regression method with HR change and SV change as predictor variables was used. The second set, which included three multiple linear regression analyses was conducted with VO2peak recorded during the CPET as the outcome variable to generate regression equations. In this set, the first regression equation was generated using age, gender, BMI, and HRpeak, SVpeak and COpeak measured during CPET as predictor variables. The second regression equation was developed with variables of 6MWD, age, gender, BMI, plus ICG recorded HR, SV and CO at the end of the better performed 6MWT as predictors for VO2peak. The third regression equation was created using 6MWD as the sole variable predicting VO2peak. A stepwise backward regression method was then adopted to determine the statistically significant predictor variables retained in the regression equations. The appropriateness and precision of the regression parameters were evaluated with the squared multiple correlation (R^2), the standard error of estimate (SEE), and partial SEE (SEE%), which was 'SEE:meanVO2peak' ratio expressed as a percentage. The predicted residual sum of squares (PRESS) statistic was computed to estimate the degree of R^2 shrinkage when the VO2peak regression equation was used for cross-validation across similar but independent samples. PRESS-derived R_p^2, SEEp and SEEp% were compared with those of the final regression models.

9   Sample size estimation - A sample size of at least 51 subjects was required for the multiple regression analyses using the PASS 15.0.5 (Kaysville, Utah: NCSS) for an estimated Cohen's effect size of 0.35 with 7 predictor variables, a level of significance of 0.05 and statistical power of 0.8.