Determining the precision of the MedGraphics VO2000 when measuring VO_2, VCO_2 and V_E

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Introduction

Measurement and analysis of physiological variables such as oxygen uptake (VO_2), carbon dioxide production (VCO_2) and minute ventilation (V_E) are essential to research in exercise physiology, medicine and numerous related fields. As technological advancements lend themselves to improvements in data acquisition and calculation, the need arises to confirm the validity and reliability of such metabolic measurement instrumentation. The purpose of the present study was to determine whether the MedGraphics VO2000 portable metabolic measurement system (Medical Graphics Corp., St. Paul, MN) was valid and reliable for determining VO_2, VCO_2 and V_E when compared to the MedGraphics CPX/D metabolic measurement system.

Methodology

Subjects

Twenty healthy subjects (12 male, 8 female) volunteered for the study. The mean age, height and weight were 27.7 years (+/-9.1), 176.5 cm (+/-10.4) and 76.4 kg (+/-11.3), respectively. Recruitment was performed by publicly displayed flyers and word of mouth in the university community. Upon giving written informed consent and completing a health status questionnaire, subjects performed a cycle ergometer protocol. The study was approved by the University of Minnesota Institutional Review Board.

Instrumentation

Volume of oxygen uptake, VCO_2 and V_E were sampled, measured and analyzed by two metabolic measurement systems connected in-series throughout all calibration and testing (MedGraphics VO2000 versus MedGraphics CPX/D). The two systems were arranged in-series to obtain identical gas samples from subjects and limit biological and environmental variability created from separate test sessions. In addition to a nose clip and mouthpiece, subjects wore alightweight headgear, which supported two preVent™ pneumotachometers (Medical Graphics Corp., St. Paul, MN). Gas sampling lines from the CPX/D oxygen and carbon dioxide analyzer (model 762014-202) and flow module (model 762030-202) were connected to the proximal pneumotach. A rubber coupler distally connected the second pneumotach to the first. Gas sampling lines from the VO2000 were connected to the second (distal) pneumotach.

Manufacturer recommended calibration procedures were followed prior to each test. Manual flow calibrations were performed individually on each system with a 3 liter syringe and gas calibrations were performed on the CPX/D and VO2000 with manufacturer recommended gases of known concentration. A value of 60 ml was entered into the CPX/D flow calibration to account for physiological dead space of an additional pneumotach. The standard CPX/D preVent pneumotach was used in lieu of the optional VO2000 pneumotachs. The "High" range pneumotach setting on the VO2000 was chosen to correspond with the subjects' anticipated flow range and match the range of the preVent pneumotach (+/- 18 L/sec). Minute ventilation values were corrected to STPD conditions.

Protocol

Protocol consisted of subjects pedaling an electronically braked ERG 401 cycle ergometer (Dimeq Corporation, Berlin, Germany) throughout multiple stages of increasing workloads. The first stage consisted of subjects pedaling at 50-60 rpm at zero watts for 4 minutes. After the 4^{th} minute, the workload increased 50 watts every 4^{th} minute until the subject could no longer maintain a pedal rate of 50 rpm or greater. After the first stage, subjects were encouraged to pedal at any rate comfortable since the cycle ergometer provided consistent workloads for each stage, regardless of pedal rate.

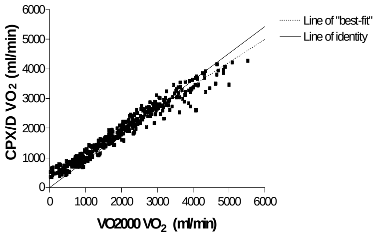
Statistics

Statistical analysis was performed using Graphpad Prism® (v. 3.02) and StatView® (v. 5.0) software. Pre-determined analysis consisted of using the correlation coefficient to examine the relationship between systems for each metabolic measurement (VO_2, VCO_2 and V_E). A repeated measures ANOVA was performed to measure agreement between systems. This type of analysis allows for assessment of the VO2000's precision. Significance level for the tests was preset at $p<0.05$.

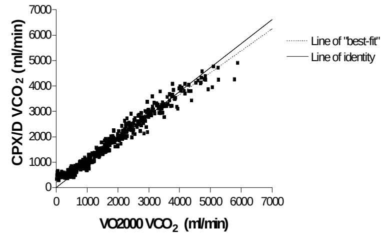
Data/Analysis

Figures A, B and C – Linear regression of all measurement points for subjects

A.



B.



C.

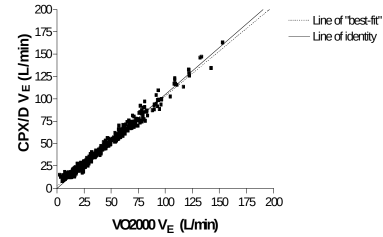
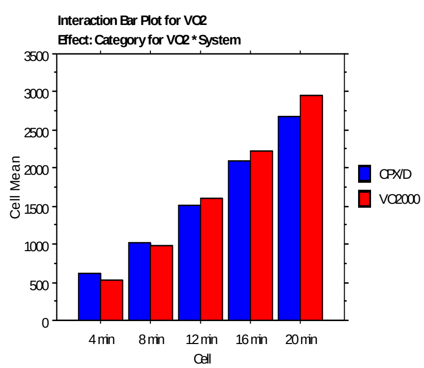


Table 1. Linear regression analysis

	Fig. A - VO_2 (ml/min)	**Fig. B - VCO_2** (ml/min)	**Fig. C - V_E** (L/min)
Variables			
Slope	0.777 +/- 0.00716	0.861 +/- 0.00720	1.01 +/- 0.00608
Y-intercept	333.0 +/- 15.8	220.0 +/- 15.6	2.56 +/- 0.288
X-intercept	- 429.0	-256.0	-2.55
95% Confidence Intervals			
Slope	0.763 to 0.791	0.846 to 0.875	0.994 to 1.02
Y-intercept	302.0 to 364.0	190 to 251	2.00 to 3.13
Goodness of Fit			
r	0.981	0.984	0.992
P value	< 0.0001	< 0.0001	< 0.0001

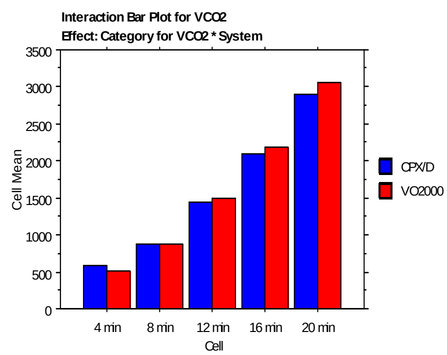
Figures D, E and F – Repeated measures ANOVA (Plots of last minute of each stage)

D.



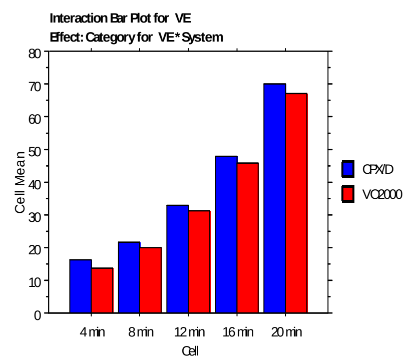
$p = .978$*

E.



$p = .747$*

F.



$p = .184$*

* P-values represent *all* minutes for subjects

	VO_2 (ml/min)	**VCO_2** (ml/min)	**V_E** (L/min)
Mean difference	-80.3	-28.7	2.70
95% confidence interval	-51.2 to –110.0	-52.0 to –5.40	2.40 to 3.06

Results

Correlation coefficient (r) values of 0.981, 0.984 and 0.992 for VO_2, VCO_2 and V_E, respectively, reveal a significantly strong relationship between the two systems. The results of the repeated measures ANOVA of VO_2, VCO_2 and V_E, between systems are represented graphically in figures (D), (E) and (F), respectively. There appears to be continuous agreement between systems from lower levels up to maximal levels of gas exchange and flow rate. A table of the mean difference between systems and a 95% confidence interval was also included to assess the agreement between the VO2000 and CPX/D.

Conclusion

The results of this study indicate that the MedGraphics VO2000 produces measures of VO_2, VCO_2 and V_E that are comparable to the MedGraphics CPX/D. The limits of agreement, or range of differences, are small enough to be confident that the two systems calculated similar VO_2, VCO_2 and V_E values, thus demonstrating its validity. The two systems were not significantly different during all stages, signifying precision throughout a wide range of measurements.