Clinical Nutrition (2006) **25**, 687–692

ELSEVIER

Clinical Nutrition

http://intl.elsevierhealth.com/journals/clnu

ORIGINAL ARTICLE

Validation of the VO2000 calorimeter for measuring resting metabolic rate ☆

Vivian Wahrlich[a], Luiz A. Anjos[a,b,*], Scott B. Going[c,d], Timothy G. Lohman[d]

[a]*Escola Nacional de Saúde Pública, Fundação Oswaldo Cruz, Rua Leopoldo Bulhões 1480, 24020-971 Manguinhos, Rio de Janeiro, Brazil*
[b]*Laboratório de Avaliação Nutricional e Funcional, Departamento de Nutrição Social, Universidade Federal Flumimense, Rua São Paulo 30, 415, Caixa Postal 100231, 24001-970 Niterói, Rio de Janeiro, Brazil*
[c]*Department of Nutritional Sciences, University of Arizona, 238 Shantz Building, Tucson, AZ 85721-0093, USA*
[d]*Department of Physiology, University of Arizona, 101 Ina Gittings Building, Tucson, AZ 85721-0093, USA*

Received 30 September 2005; accepted 4 January 2006

KEYWORDS
Deltatrac;
Resting metabolic rate;
Calorimeter;
Indirect calorimetry;
Oxygen uptake

Summary
Background & aims: Metabolic carts used in laboratory settings for the measurement of resting metabolism are cumbersome limiting their use in the field. The validity of a newly developed portable calorimeter (Medical Graphics VO2000) under resting conditions was assessed in comparison to a well-established reference system, the DELTATRAC^{TM}.
Methods: Gas exchange and energy expenditure were measured for 25 min consecutively using the two devices. Values of the last 20 min were averaged and used in the analysis. The order of device for the first subject was randomly chosen and the calorimeters were alternated thereafter.
Results: Among 33 subjects, acceptable measures of resting metabolism were obtained in 25 (11 men) aged 20–78 years because eight subjects (three men) either hyperventilated or did not adapt well enough to the facemask. $\dot{V}O_2$, $\dot{V}CO_2$, and RQ were not significantly different between devices. Small (2.8%) non-clinically relevant mean differences (-0.145 ± 0.341 MJ day^{-1}) were found. Results of the two devices were highly correlated ($r = 0.95$) yielding a more accurate estimate than predictive equations.

☆This paper was presented at the 52nd Annual Meeting of the American College of Sports Medicine, Nashville, TN, USA, June 1–4, 2005.

*Corresponding author. Laboratório de Avaliação Nutricional e Funcional, Departamento de Nutrição Social, Universidade Federal Flumimense, Rua São Paulo 30, 415, Caixa Postal 100231, 24001-970 Niterói, Rio de Janeiro, Brazil. Tel.: +55 21 26299856; fax: +55 21 26299847.
E-mail address: anjos@ensp.fiocruz.br (L.A. Anjos).

0261-5614/$ - see front matter
doi:10.1016/j.clnu.2006.01.002

Conclusions: The VO2000 calorimeter is a valid system to measure resting metabolism but the facemask may not be suitable for some people.

Introduction

There has been a renewed interest in the measurement and prediction of resting metabolic rate (RMR) after the World Health Organization recommended its use in the estimation of human energy requirements[1] based on the physical activity level of the populations.[2] RMR data have also been used to validate energy intake in epidemiological studies by identifying over and under-reporters.[3] For these applications, the RMR information must be as accurate as possible to avoid misleading nutritional recommendations and conclusions.

RMR is measured by indirect calorimetry under standard conditions in a controlled environment, in the post absorptive and resting state. In contrast, in most clinical and epidemiological settings, RMR is estimated using equations such as those recently proposed by the Joint FAO/WHO/UNU Expert Consultation on Human Energy Requirements[4] for international use. This set of equations was derived from compiled data from studies mainly conducted in the first half of the 20th century in small samples or specific groups of subjects that were not necessarily representative of the populations. Many studies have shown that these equations are not accurate to estimate RMR in different populations.[3] Therefore it is necessary to measure RMR at the population level to derive more accurate equations.

In the past few decades, simple, portable, inexpensive automated gas analysis systems have been developed which have allowed the collection of metabolic information, primarily during exercise[5] in clinical and research settings throughout the world. One of these systems, the VO2000, or its predecessor—the TEEM 100, has been validated during light, incremental, constant and maximal activities,[6–8] but no study has validated the system under resting conditions, i.e., controlling the environment, the time of measurement and the nutritional state of the subjects. Therefore, the purpose of the present study was to assess the validity of the VO2000 system to measure the energy expenditure in resting conditions against a well-established reference system used to measure RMR, the DELTATRAC™.

Materials and methods

Thirty-three native Brazilians, 20 years of age or older, were recruited via an oral presentation of the project to members of an informal Brazilian social club in Tucson, Arizona composed of students of the University of Arizona, their relatives and friends. Exclusion criteria included pregnancy, lactation, cardio-respiratory and renal diseases, diabetes and people taking medication that could affect RMR. The potential subjects were invited to visit the laboratory where all procedures were explained before the RMR measurements were scheduled. The project was approved by the Institutional Review Board of the University of Arizona and all participants gave written informed consent prior to participation.

The MedGraphics VO2000 Portable Metabolic Testing System (St. Paul, MN, USA) is a small, portable (740 g) device that uses a galvanic fuel cell O_2 analyzer and a non-dispersive infrared CO_2 analyzer. The gold standard RMR value was obtained by the DELTATRAC™ MBM-100 (Sensormedics, Yorba Linda, CA, USA), which uses a differential paramagnetic analyzer for oxygen detection and the carbon dioxide fraction is detected by infrared absorption. This calorimeter was specifically designed and has been validated to measure RMR.[9–11]

Calibration of the calorimeters was performed according to the manufacturer instructions. The auto-calibration procedure of the VO2000 system was performed daily before data collection. Once a week a known gas mixture (5.01 CO_2, 16.02 O_2, balance N_2) was introduced into the system to simulate a test. Every time the $\dot{V}O_2$ or $\dot{V}CO_2$ readouts were within 5% of the gas mixture concentration and thus indicating no need for a full gas calibration. The DELTATRAC™ calorimeter was calibrated with a known gas mixture (4% CO_2, 96% O_2) every morning before data collection.

The DELTATRAC™ system uses a canopy and the VO2000 calorimeter works either with a facemask or a mouthpiece with the possibility of three flow pneumotachs depending on the expected ventilation of the activity. In the present study, the low flow pneumotach (ventilations between 2 and 30 l min^{-1}) was used with a facemask.