Original article

Evaluation of a short protocol for indirect calorimetry in females with eating disorders and healthy controls

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SUMMARY

Background and aims: To enable clinicians to identify the clinical picture and treatment progress and to adjust eating plans according to personal energy needs, it is important to know the patient's correct resting metabolic rate (RMR). Indirect calorimetry (IC) is the preferred method for assessment of RMR, but long duration of measurement increases the load on the patients, and reduces the effectiveness in clinical and scientific settings. Further; not all patients reach a valid RMR according to the suggested best practice protocol, with 5 min of steady state (SS) where respiratory gas volume exchange varies less than 10%. The aim of this study was to evaluate the possibility for an abbreviated RMR protocol and SS criterion.

Methods: Forty two women diagnosed with bulimia nervosa or binge eating disorder (eating disorder group, ED), originally recruited for an outpatient treatment study, and 26 age and gender matched healthy controls (HC) were studied during a single, prolonged IC measurement. Participants rested for 10 min in supine position wearing a two-way breathing facemask, before a continuous measurement period of 20 min. Results from a standard 5 min SS criterion was compared to an abbreviated 3 min SS criterion. Both SS-criteria were evaluated through three different SS protocols (<10% variation in respiratory gas exchange), being: 1) measurement during the first 3 or 5 min, 2) measurement after discarding the first 5 min, and 3) the lowest identified RMR during the 20 min of measurement.

Results: About 50% of the participants reached an early SS in both the defined SS minute criteria. Participants reaching a valid SS throughout the 20 min of measurement increased from ~90% to 100% with an abbreviated 3 min SS. With a 5 min SS criterion, the median (range) RMR for the 3 protocols were 1639.9 (1239.2), 1508.8 (1457.6) and 1500.6 (1328.8) respectively for the ED group, and 1702.2 (1239.4), 1608.4 (1076.4) and 1594.8 (1029.2) respectively for the HC group, (p > 0.05 for all between-group analysis). With a 3 min SS criterion, the median (range) RMR were 1533.6 (1298.2), 1461.2 (1406.1), and 1395.8 (1447.3) respectively for the ED group and 1681.7 (1332.4), 1613.7 (1266.0) and 1523.1 (1050.2), respectively for the HC group, (p > 0.05 for all between-group analysis). Lowest measured RMR was different compared to the other two SS protocols in both the ED- and the HC group, and for both the 5 min- and the 3 min SS criteria, respectively (p < 0.04). Furthermore, a SS of 3 min resulted in lower RMR compared to 5 min SS (p < 0.00) and an increased number of participants classified as hypermetabolic (RMRmeasured/RMRcalculated < 0.9).

Conclusions: An abbreviated measurement protocol to identify the lowest RMR using IC was not successful. Abbreviating the SS criteria from 5 to 3 min, resulted in a lower RMR, hence encouraging further examination of the validity of shorter SS criterion than practiced today. Registered in Clinical Trials by id-number NCT02079935, and approved by the Norwegian Regional Committee for Medical and Health Research Ethics with id-number 2013/1871. The trial in which control persons were recruited, is approved by the Norwegian Regional Committees for Medical and Health Research Ethics with id-number 2013/1871.

Abbreviations: ED, eating disorder; RMR, resting metabolic rate; BN, bulimia nervosa; IC, indirect calorimetry; EE, energy expenditure; SS, steady state; BED, binge eating disorder; RCT, randomized controlled trial; CV, coefficient of variation; VO₂, volume of oxygen; VCO₂, volume of carbon dioxide; HC, healthy control; RMR5, RMR achieved during the first 5 min of measurement; RMR3, RMR achieved during the first 3 min of measurement; DC, direct calorimetry.

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1. Introduction

The different diagnosis of eating disorders (ED) are characterized by eating and dieting behaviors such as fasting, restrictive eating and low energy availability, normal and/or chaotic eating pattern, weight loss and/or frequent weight fluctuations [1]. Resting metabolic rate (RMR) has been reported low in persons with anorexia nervosa [1–3], reduced [2–6], normal [7] or increased [8] in persons with bulimia nervosa (BN), and normal [14] in persons with binge eating disorder (BED). RMR is important in treatment of ED, not only as a tool for identifying the patients’ energy needs to design individual diets, meal plans and exercise programs, but also to identify the clinical picture and treatment progress [9–11].

Indirect calorimetry (IC) is the preferred method for the assessment of RMR in clinical and research settings [9,12–15]. It is assumed that the energy consumption measured for a short, defined period, gives a reliable estimate for the mean 24 h resting energy expenditure (EE) [16–18]. To reduce the vulnerability of IC to random bias from biological systems, technical- and methodological errors, achieving a steady state (SS) in the variability of gas exchange has been suggested [13,19–23]. A best practice protocol was suggested by Compher et al., in 2006, revised in 2015 [21,23], suggesting a rest of 10 min, then to discard the first 5 min of measurement and identify a SS of 5 min with a coefficient of variation (CV) for VO₂ and VCO₂ less than 10% [18,20,21,23,24]. However, results and practice have differed; some do not consider rejecting the first 5 min [19,25], while others indicate that no more than 5 min of rest is needed to achieve a valid measure [22,24,26].

The choice of 5 min as a valid SS with <10% variation in respiratory gas exchange seems arbitrary, and mainly based on the fact that a longer period (10 min) is too strict for most participants to achieve a SS [18]. A shorter SS period will result in a shorter protocol, that decreases the load for the participants, and increases the efficiency of practical (clinical) and scientific work. The potential for a shorter SS period, has previously been investigated [18,19,22,24,26,27]. However, results have been evaluated towards a variety of references, often being the mean RMR from a longer period of measurement [18,20,22,24,28,29]. None of these protocols have examined the lowest RMR or reflected the true 24-h RMR.

The main aim of the present study was to compare three different IC-protocols for RMR measurement, to explore the potential for an abbreviated protocol. Secondarily we aimed to explore the potential for an abbreviated SS period of 3 min in women with BN or BED, and in healthy female controls.

2. Materials and methods

2.1. Subjects

This study is part of a larger, randomized, controlled, outpatient treatment study for ED (The Physical Exercise and Dietary Therapy Study, the PED-t study), aiming to test the effect of a new treatment method. Recruitment procedure, and inclusion and exclusion criteria, have been described in details elsewhere [30]. The recruitment of participants for this original trial were semiannually, and participants recruited during autumn 2016 (42 out of totally 119 participants) were included in the present RMR study. To evaluate whether the outcomes in the present methodological study are population specific, and in order to keep a decent ratio of 2:1 between population of interest and control-population, a group of 26 age and gender matched healthy female controls (HC) were included. The women in this group were originally recruited as controls for another ongoing health- and exercise trial lead by our research group. The inclusion criteria for the HC group were being female between 18 and 40 years, a BMI between 18 and 30, being physically active (>2 training sessions per week), but not at a competitive level.

2.2. Ethical statement

All participants signed an informed consent.

The main study PED-t is approved by the Norwegian Regional Committees for Medical and Health Research Ethics the 16th of December 2013 (id: 2013/1871), and prospectively registered in Clinical Trials the 17th of February 2014 (id: NCT02079935). The trial in which control persons were recruited, is approved by the Norwegian Regional Committees for Medical and Health Research Ethics the 18th of January 2017 (id: 2016/1718), and prospectively registered in Clinical Trials the 24th of December 2016 (id: NCT03007459).

2.3. Protocol

Participants were asked to come to the laboratory after an overnight fast (12 h) between 07.30 AM and 10.00 AM. They were instructed to refrain from exercise the last 24 h, and to be passively transported to the laboratory. Participants were weighed in their underwear and height was measured with a fixed stadiometer (Seca scale, Mod: 877021094, S/N: 5877428124885). Participants laid down in supine position on a mattress, covered by a blanket and with head resting on a pillow.

RMR was measured by IC using a respiratory gas analyzer (Oxycon Pro, Jaeger, Germany). Ambient conditions were registered and the analyzer was gas and volume calibrated each morning prior to the measurements, according to the recommendations stated in the user manual from the manufacturer (user manual for Oxygen Pro, Jaeger, Germany). A total of 6 participants were measured each day. Gas exchange and ventilatory variables were measured continuously using the breath-by-breath method. Participants were instructed to rest for 10 min, wearing a two-way breathing mask covering their nose and mouth (2700 series; Hans Rudolph, Inc.). Thereafter, the measurement period started by connecting the mask to the gas analyzer, and data collection continued for a total of 20 min.

2.4. Analysis

All data output were given in 30 s intervals, and calculated as means per minute. To reduce errors caused by gas remaining in the tubes, the data from the first 30 s were erased from the analysis. A valid RMR was defined according to the current recommendation emphasizing the importance of a SS, being defined as 5 min periods with less than 10% CV for VO₂ and VCO₂ [17,18,21,23,27].
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