RESEARCH
Review

Evidence Analysis Library Review of Best Practices for Performing Indirect Calorimetry in Healthy and Non–Critically Ill Individuals

Susan Fullmer, PhD, RDN; Sue Benson-Davies, PhD, DCN, MPH, RDN; Carrie P. Earthman, PhD, RD, LD; David C. Frankenfield, MS, RD; Erica Gradwell, MS, RD; Peggy S. P. Lee, MSc, RD; Tami Piemonte, MS, RDN, LD/N; Jillian Trabulsi, PhD, RDN

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ABSTRACT

When measurement of resting metabolic rate (RMR) by indirect calorimetry is necessary, following evidence-based protocols will ensure the individual has achieved a resting state. The purpose of this project was to update the best practices for measuring RMR by indirect calorimetry in healthy and non–critically ill adults and children found the Evidence Analysis Library of the Academy of Nutrition and Dietetics. The Evidence Analysis process described by the Academy of Nutrition and Dietetics was followed. The Ovid database was searched for papers published between 2003 and 2012 using key words identified by the work group and research consultants, studies used in the previous project were also considered (1980 to 2003), and references were hand searched. The work group worked in pairs to assign papers to specific questions; however, the work group developed evidence summaries, conclusion statements, and recommendations as a group. Only 43 papers were included to answer 21 questions about the best practices to ensure an individual is at rest when measuring RMR in the non–critically ill population. In summary, subjects should be fasted for at least 7 hours and rest for 30 minutes in a thermoneutral, quiet, and dimly lit room in the supine position before the test, without doing any activities, including fidgeting, reading, or listening to music. RMR can be measured at any time of the day as long as resting conditions are met. The duration of the effects of nicotine and caffeine and other stimulants is unknown, but lasts longer than 140 minutes and 240 minutes, respectively. The duration of the effects of various types of exercise on RMR is unknown. Recommendations for achieving steady state, preferred gas-collection devices, and use of respiratory quotient to detect measurement errors are also given. Of the 21 conclusions statements developed in this systemic review, only 5 received a grade I or II. One limitation is the low number of studies available to address the questions and most of the included studies had small sample sizes and were conducted in healthy adults. More research on how to conduct an indirect calorimetry measurement in healthy adults and children and in sick, but not critically ill, individuals is needed.
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RESTING METABOLIC RATE (RMR) IS THE ENERGY expended to sustain normal body functions and homeostasis at rest and is generally the primary component of total energy expenditure.[1] It can be estimated or measured. Measurement of oxygen consumption (VO_2) and carbon dioxide (VCO_2) via indirect calorimetry (IC) is the more common method of measuring RMR.[1] An accurate measurement of RMR in healthy and non–critically ill individuals with IC is important for both clinicians and researchers.

In 2006, The Academy of Nutrition and Dietetics (Academy) Evidence Analysis Library published a systematic review of best practices to help practitioners identify the best procedures to accurately measure RMR with IC.[2] In 2010, a new Evidence Analysis Work Group was convened to update the Energy Expenditure section in the Evidence Analysis Library. The work group decided to re-examine only the measurement of RMR using IC for critically ill and non–critically ill individuals. Non–critically ill individuals are defined in the Evidence Analysis Library as: "those that do not have dysfunction of one or more organs/systems requiring dependence on advanced instruments of monitoring and therapy for survival." This systematic review is the analysis of literature in the non–critically ill population; recommendations for measurement of RMR in the critically ill population are published elsewhere. These recommendations/guidelines will help practitioners and researchers identify the conditions under which she or he can perform IC accurately and interpret the results properly. Aspects of IC that need further research are also identified.

METHODS

Evidence Analysis Team

The work group included six registered dietitian nutritionists with clinical and/or research experience. The Academy's Evidence Based Practice Committee oversaw the establishment of the Evidence Analysis Work Group. A thorough recruitment procedure was undertaken with requests for participation sent to members of the Academy dietetic practice groups, and known experts in this area. Once the applications were received, the committee reviewed and scored each candidate based on set of quantitative and qualitative criteria and potential for conflict of interest. When the work group convened in 2010, all members were orientated to the Academy's evidence analysis process. All work group members signed a conflict of interest disclosure form, as well as verbally declared any conflicts of interests before the start of each work group meeting, in accordance with Academy policy. Regular work group meetings were held via teleconference to complete question development, review the evidence, and develop conclusion statements reflecting consensus of the work group. A trained and experienced project manager facilitated these meetings with the assistance of the lead analyst.

Evidence Analysis Library Process

A complete description of the Evidence Analysis Process is available at the Evidence Analysis Library website.[3] Briefly, articles meeting the inclusion criteria were abstracted using Evidence Analysis Library worksheets, and reviewed for accuracy by Evidence Analysis Library analysts. Each article was assigned a quality rating (positive, neutral, or negative) based on a standardized rubric or quality criteria checklist developed and utilized by the Academy.[4] A summary evidence table was constructed for each question along with narrative summaries of the evidence.

Literature Search and Application of Inclusion/Exclusion Criteria

The search and identification of articles for inclusion was conducted in three phases (Figure 1). In the initial phase, the search for both critically ill and non–critically ill articles was completed together. The search strategy was developed by the work group, search consultant, and analysts and the search consultant conducted the search using the Ovid database (Figure 2, available online at www.andjrnl.org). Literature published between 2003 and 2012 was reviewed in order to update the original Energy Expenditure Project published in 2006, which covered literature from 1980 to 2003. The work group also evaluated all the included studies from the previous project and applied the current inclusion/exclusion criteria to these studies for the current project. References from pertinent review articles were also hand searched. The Ovid database search identified 11,071 articles and 195 articles were identified from the original project (Figure 3). After duplicate records were removed, 4,155 articles remained. Once the 4,155 articles were identified, 3,750 articles were excluded because they were conducted on critically ill subjects, or did not involve the measurement of RMR. Of the 405 articles remaining, work group members worked in pairs to screen each article based on the criteria listed in phase 2 of Figure 1, and assigned each article to the question(s) it addressed. Phase 3 criteria were applied after the evidence was evaluated for both the resting and fasting periods. These two criteria (resting and fasting conditions) were considered major factors in achieving a resting state. Subsequently, studies that did not meet these criteria or did not describe the resting and fasting periods were excluded. Some studies that had been considered for the 2006 Evidence Analysis Project were excluded for this analysis. After phase 3 was completed, these final inclusion/exclusion criteria were applied for all questions. Based on the inclusion/exclusion criteria for fasting and rest period, more than half of the articles from the original project were excluded.

Development of Conclusion Statements and Recommendations

Each question in the Evidence Analysis Library has a conclusion and recommendation. Conclusion statements were written and are supported by one of five grades, depending on factors such as quality, consistency, sample size, clinical impact, and generalizability of studies. Full conclusion statements are found on the Evidence Analysis Library.[4] Recommendations are rated as strong, fair, weak, consensus, or insufficient, and are considered "conditional" (the statement clearly defines a specific situation) or "imperative" (the statement is broadly applicable to a target population with restraints on their pertinence) based on standardized rubrics developed by the Academy.

When the phrase "more research is needed" appears in a recommendation, it implies that future research applying all the protocol standards identified in this guideline should be followed to more clearly answer the question. It should be noted that although some observed differences in RMR might be statistically significant, they might not be of practical importance, depending on the setting (ie, clinical practice vs research). Readers need to draw their own conclusions based on their particular setting.

RESULTS

A total of 43 primary research articles were included in the final analysis for all of the non–critically ill questions, some articles were used to answer more than one question. Of the 43 studies, all but 5 had been conducted on healthy adults. The exceptions included one study on healthy children (ages 7 to 12 years),[6] one study on patients with chronic obstructive pulmonary disease,[7] one study on stable hospitalized patients (mostly fractures),[8] one study conducted on individuals undergoing an elective thoracotomy,[9] and one study that included both stable individuals with cancer patients and healthy controls.[10] Therefore, unless otherwise indicated, all recommendations were developed based on studies of healthy people. Only 10 of the 43 studies were published in 2004 or later. The Table provides a summary of each study design and quality rating, participants, interventions, and outcomes of the 43 studies.

Rest Period for Adults

The rest period before the measurement of RMR is a critical step in conducting IC because many studies are not performed in an overnight metabolic unit. Therefore, when subjects come into a laboratory or office for measurement of RMR, it is important for the metabolic rate to return to a