



# Validity of Energy Intake Estimated by Digital Photography Plus Recall in Overweight and Obese Young Adults



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## ABSTRACT

**Background** Recent reports have questioned the adequacy of self-report measures of dietary intake as the basis for scientific conclusions regarding the associations of dietary intake and health, and reports have recommended the development and evaluation of better methods for the assessment of dietary intake in free-living individuals. We developed a procedure that used pre- and post-meal digital photographs in combination with dietary recalls (DP+R) to assess energy intake during ad libitum eating in a cafeteria setting.

**Objective** To compare mean daily energy intake of overweight and obese young adults assessed by a DP+R method with mean total daily energy expenditure assessed by doubly labeled water (TDEE<sub>DLW</sub>).

**Methods** Energy intake was assessed using the DP+R method in 91 overweight and obese young adults (age = 22.9±3.2 years, body mass index [BMI; calculated as kg/m<sup>2</sup>]=31.2±5.6, female=49%) over 7 days of ad libitum eating in a university cafeteria. Foods consumed outside the cafeteria (ie, snacks, non-cafeteria meals) were assessed using multiple-pass recall procedures, using food models and standardized, neutral probing questions. TDEE<sub>DLW</sub> was assessed in all participants over the 14-day period.

**Results** The mean energy intakes estimated by DP+R and TDEE<sub>DLW</sub> were not significantly different (DP+R=2912±661 kcal/d; TDEE<sub>DLW</sub>=2849±748 kcal/d, *P*=0.42). The DP+R method overestimated TDEE<sub>DLW</sub> by 63±750 kcal/d (6.8±28%).

**Conclusion** Results suggest that the DP+R method provides estimates of energy intake comparable to those obtained by TDEE<sub>DLW</sub>.

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IMPROVED METHODS FOR THE ASSESSMENT OF DIETARY intake are needed to advance our understanding of the association between energy and macronutrient intake and the risk for chronic diseases, including cancer, heart disease, diabetes, and obesity.<sup>1-3</sup> Dietary intake in health-related research is typically assessed using self-report measures, including food frequency questionnaires, diet records, and recalls.<sup>4-6</sup> However, self-report measures have been shown to underestimate energy intake by approximately 20% when compared with objectively measured energy expenditure (doubly labeled water),<sup>7-9</sup> with greater underestimations in overweight and obese individuals compared with normal weight individuals.<sup>9-11</sup> Although they are both relatively inexpensive and convenient, several recent reports

have questioned the adequacy of self-report measures of dietary intake as the basis for scientific conclusions regarding the associations of dietary intake and health.<sup>3,12,13</sup> They also suggested that investigators should work to improve and apply newer methods of energy intake assessment suitable for use in free-living individuals, such as remote sensing devices<sup>14,15</sup> or digital photography,<sup>16</sup> rather than continuing to rely on self-report.

Digital food photography, in which images of food selections and any food remaining after the meal are used to estimate dietary intake, may provide a quick, unobtrusive method for the assessment of dietary intake in relatively large samples of individuals in naturalistic settings. The digital approach eliminates reliance on participant estimations of portion size, which have been shown to be a major source of error with self-report measures of energy intake.<sup>11</sup> Participant training has been shown to improve portion size estimation only moderately.<sup>17</sup>

Digital photographic assessments have been employed in studies on dietary intake in military recruits during basic

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training<sup>18</sup> and in both preschool–<sup>19</sup> and elementary school–aged children<sup>20</sup>; however, evidence for the validity of these methods is limited. With the exception of the Remote Food Photography method described by Martin and colleagues,<sup>21</sup> which uses a smartphone to capture food images and plate waste, validity for the other digital photographic approaches has been established by comparing estimates of food weight by digital photography vs measured food weight of test meals in a laboratory setting<sup>18,19</sup> or against weighed food records over 1 to 7 days<sup>22</sup> rather than against a biomarker of energy expenditure, such as doubly labeled water in free-living individuals.

Our group has an interest in studying energy balance in the context of clinical weight management trials; therefore, we have developed or evaluated methods for the assessment of energy intake in overweight and obese individuals.<sup>23,24</sup> An earlier trial assessed energy intake over 14-day periods of ad libitum eating in a university cafeteria. Research staff weighed all foods and beverages before and again after completing the meal. Any food, snacks, or beverages consumed outside the cafeteria were captured by dietary recalls conducted before each meal. Baseline data indicated that this method provided estimates of mean energy intake within approximately 3% of total energy expenditure assessed by doubly labeled water.<sup>24</sup> However, the burden for both participants and investigators of this time- and labor-intensive procedure make its use impractical for most applications. To reduce participant and investigator burden, a procedure was developed that used pre- and post-meal digital photographs in combination with dietary recalls (DP+R) to assess energy intake during ad libitum eating in a cafeteria setting for use in a recently completed 10-month Midwest Exercise Trial-2 (MET-2). In the analysis presented herein, baseline data from MET-2 was used to compare mean daily energy intake assessed by the DP+R procedure with mean total daily energy expenditure assessed by doubly labeled water (TDEE<sub>DLW</sub>).

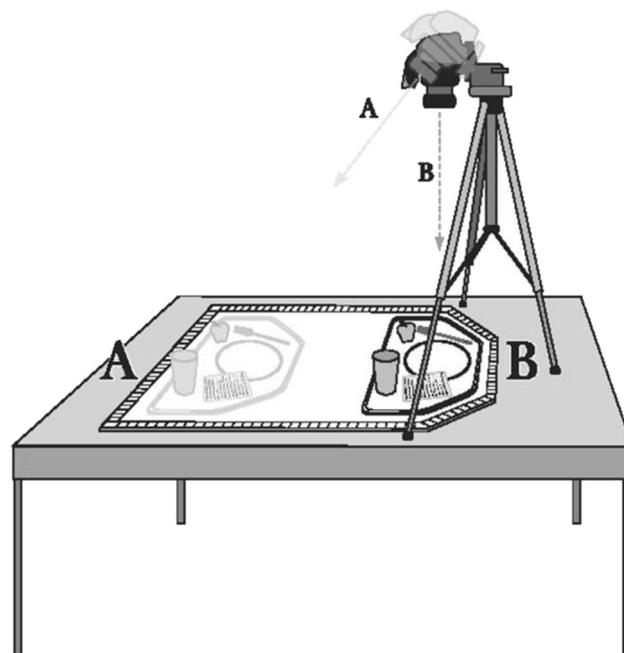
## SUBJECTS AND METHODS

### Background

The primary aim of MET-2 was to evaluate the role of aerobic exercise training without energy restriction on weight and body composition. A detailed description of the design and methods for MET-2,<sup>25</sup> results for the primary outcomes,<sup>26</sup> and changes in non-exercise energy expenditure and physical activity<sup>27</sup> and energy and macronutrient intake<sup>28</sup> have been published. Briefly, MET-2 was used to randomize young adults aged 18 to 30 years with body mass index (BMI; calculated as kg/m<sup>2</sup>) of 25 to 40 to a 10-month, 5-days/wk supervised exercise intervention at two levels of exercise energy expenditure (400 or 600 kcal/session) or non-exercise control.

### Participant Eligibility

Potential participants were excluded for the following reasons: age outside the range 18 to 30 years; BMI outside the range 25 to 40; a history of chronic disease (eg, diabetes, heart disease); elevated blood pressure (>140/90 mm Hg); high levels of fasting lipids (cholesterol >259 mg/dL [6.70 mmol/L]; triglycerides >495 mg/dL [5.59 mmol/L]); high levels of fasting glucose (>140 mg/dL [7.78 mmol/L])<sup>29</sup>; use of



**Figure 1.** Camera positioning for pictures of pre- and post-consumption meal trays used in the digital photography+diet recall protocol. (A) Photo at 45°; (B) Photo at 90°. (Reprinted with permission from Washburn and colleagues<sup>28</sup>; © 2015 American College of Sports Medicine.)

tobacco products; taking medications that would affect physical performance (eg, beta blockers) or metabolism (eg, thyroid, steroids); inability to perform laboratory tests or to participate in moderate-to-vigorous intensity exercise; and being currently engaged in planned physical activity greater than 500 kcal/wk as assessed by recall.<sup>30</sup>

### Recruitment

Potential participants were obtained from a variety of sources, including advertisements in the local and campus newspapers and radio stations, flyers in campus buildings, and postings on our laboratory website. All forms of advertisement included our dedicated study phone number as well as our laboratory website and study e-mail address. Potential participants completed a web-based initial eligibility screener regarding height and weight to determine BMI, use of medications, smoking and drinking habits, and current levels of physical activity. Those without web access completed the initial screen by hard copy or telephone interview. Participants who appeared eligible based on the initial eligibility questionnaire met with the project coordinator, who described the study, answered questions, obtained written informed consent, and assessed height and weight to determine final eligibility. A total of 2,338 individuals completed the initial eligibility questionnaire. One hundred forty-one individuals were determined to be eligible and were randomized to one of the three study groups. Of the 141 participants randomized, the 91 participants (46 men, 45 women) who completed the 9-month study and completed all assessments of energy intake by DP+R and TDEE<sub>DLW</sub> were included in this analysis.<sup>26</sup> Approval for this study was

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