Energy intake: reduced as prescribed?1,2

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A classic clinical observation is an overweight or obese patient’s failure to lose weight despite reporting a severely restricted caloric intake (1). Similarly, very modest weight loss is observed in numerous long-term calorie restriction studies (2). Although in both cases we suspect that the participants are eating more than reported or prescribed, confirming this hypothesis is remarkably difficult in an outpatient clinical setting. The article by Hall and Chow (3) in this issue of the Journal addresses this topic by providing a novel approach to estimating the free-living rate of energy intake (EI) within specified CIs.

Because self-reported diet histories are inaccurate and often biased (1), investigators measure EI by other approaches that are all formulated around a simplified version of the first law of thermodynamics: the sum of EI and energy output (EO) rates is equal to change in body energy storage (ES) rate. When inpatient resources are available, the EI required for weight maintenance can be estimated by ‘‘titrating’’ the amount eaten until changes in weight (a measure of ES) from day-to-day average zero. Another inpatient approach for estimating maintenance EI in weight-stable subjects is to measure 24-h energy expenditure (ie, EO) with a respiratory chamber indirect calorimeter (4). Both approaches are limited because they do not provide the subject’s EI under free-living conditions, the main question posed when the observed magnitude of weight loss is less than expected based on a prescribed hypocaloric diet.

The unreliability of outpatient diet histories is inaccurate (1, 5) requires investigators to apply other approaches when estimating ‘‘actual’’ EI. The rate of energy storage change averages zero in outpatients who are weight stable, and therefore EI is approximately equal to EO. The reference for estimating EO in outpatients is the doubly labeled water (DLW) method that quantifies carbon dioxide production over several weeks through calculation of deuterium and oxygen-18–labeled water disappearance rates (4, 5). The rate of carbon dioxide production can be converted to EO by making several indirect calorimetry assumptions. The DLW method revolutionized clinical nutrition research by providing a reliable (relative accuracy: ±1%; within-subject precision: within 5–8%) measure of EO, and thus EI, in weight-stable outpatients (1, 5). Two other approaches alone, or in combination, can be used to estimate EO in nutritional research studies. The first relies on measured 24-h heart rate and the second on motion derived by accelerometry (6). These body signals correlate with 24-h energy expenditure and can be calibrated to provide a measure of EO. The simplest, and perhaps least accurate, approach is to calculate energy expenditure, and thus EO, from empirical equations that rely on predictors such as sex, age, height, weight, race, and estimated activity level.

Estimating EI in outpatients is more complex when body energy stores are changing during calorie restriction, which is the focus of Hall and Chow’s report (3). Under these conditions estimation of actual EI requires measures of both EO and ES. Dual-energy X-ray absorptiometry (DXA), quantitative magnetic resonance (QMR), bioimpedance analysis (BIA), hydrometry, and multicomponent methods can all be used to estimate ES (7). However, under short-term non–steady state conditions when weight changes are relatively small, the accuracy of these methods can be influenced by fluctuations in fluid balance in addition to changes in body energy stores that consist of glycogen, protein, and fat. Only inpatient metabolic balance methods can discern the proportion of weight change as fluid and ES with a high degree of reliability on a day-to-day basis (7). Although this is a relatively unstudied area, we can thus assume that ES is measured with reasonably large random or systematic error with methods such as DXA, QMR, and BIA when weight changes are relatively small over short time periods of days or weeks.

Have obese patients or groups reduced their EI as prescribed? The traditional research approach to estimating EI is to combine a measure of EO with a measure of ES first at weight-stable baseline and then during outpatient calorie restriction. For example, outpatient EI in calorie restriction studies can be measured at baseline and then again at a later time by combining EO derived by DLW and ES with DXA (4). These approaches, however, are impractical and costly when used in the clinical setting and highlight the importance of new potential methods for evaluating patient adherence to a prescribed level of ES.

Hall and Chow’s approach focuses on estimating changes in EI and 95% CI for modest weight loss by summing a mathematically derived rate of ES change with calculated EO. The Hall-Chow method requires easily obtained baseline subject measurements (eg, weight and height) and weight data collected over a specified evaluation period, ideally daily weights. Unlike complex differential energy balance models (8), Hall and Chow simplify calculations of ES by ‘‘linearizing’’ Forbes’ fat-free mass

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(FFM)-fat model around baseline fat mass. Forbes’ “law” describes the curvilinear association between changes in FFM and changes in total body fat mass (9). The value for baseline fat mass is obtained from an empirical prediction formula including known measures such as weight, height, and body mass index. Energy output estimates in the algebraic model are provided by use of several simplifying assumptions and an empirical energy expenditure prediction formula. Hall and Chow validated their novel model through comparison with prescribed $E_I$ data from 3 obese inpatients placed on calorie restriction. Although $E_I$ predictions were not very accurate during the early phase of weight loss (first 1–2 wk), generally good results within the 95% CI were observed thereafter. The authors also showed the robustness of their model by invoking artificial perturbations in fluid balance (eg, with changes in dietary sodium intake) and physical activity level, body weight, and $E_O$ influencing factors and showed that the predicted $\Delta E_I$ agreed with the moving average of noise-induced simulations.

Hall and Chow’s $E_I$ model (3) along with the differential equation $E_I$ model recently reported in the Journal by Thomas et al (10) provide major new tools for monitoring outpatient adherence to dietary weight-loss interventions. The models advance current practice by moving beyond simple constant rules, which can lead to predictions with a high magnitude of error (8). Many assumptions are nested within the Hall-Chow $\Delta E_I$ prediction model, and the validity and implications of these simplifications need to be critically examined through future studies.

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REFERENCES