EDITORIAL

Challenges in measuring energy balance and body composition

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Body weight and body composition of adults is the result of the regulation of energy balance, and remains fairly stable over an extended period of time. Regulation of energy balance calls for fine tuning of energy intake to energy expenditure. Under normal living conditions, an individual has a daily energy turnover of 8 to 12 MJ, which at a mean energy turnover of 10 MJ per day amounts to 3650 MJ per year [1]. Body weight fluctuations generally are within 5–10 kg in, say, 5–10 years. A weight change of 1 kg per year represents 30 MJ, based on the quarter fat-free mass and three-quarter fat mass rule [2]. Thus, the annual weight change is less than 1 per cent of the annual energy turnover. In other words, there is a perfect regulation of energy balance.

Despite this perfect regulation of energy balance, in real life, most adults seem to be heavier than their ideal weight for height. So where do the discrepancies sit? Newer insights from energy balance studies require accurate measurements of energy intake, energy expenditure and body composition. Energy intake measurements commonly rely on reported food intake. The gold standard for measurement of energy expenditure is the doubly labelled water method. In vivo body composition can only be measured with indirect techniques, based on assumptions derived from carcass analysis. Consequently, objective measures to explain real life fluctuations in energy balance are still in their infancy [3].

Established methods cannot detect components of energy balance that explain why adults develop overweight, or explain the general failure of weight loss programs. At present, overweight and obesity remains best prevented by preventing overeating. Energy expenditure, more specifically physical activity energy expenditure, has not declined over the same period that overweight and obesity have increased dramatically [4]. New tools to measure food intake require validation before allowing transformation of lifestyle interventions into precise and personalized interventions [5]. The resulting evidence potentially may be used to prevent overweight and obesity, and increase effectiveness of weight loss programs [6].

Evaluation of the effectiveness of programs to prevent overweight and obesity, or to induce weight loss, ideally covers at least one or more years, similar to development of overweight and obesity in real life. However, accurate measurements of energy intake and energy expenditure can only be accomplished over relatively short intervals covering one or more weeks. Already over weekly intervals, assessment of energy balance is challenging, especially when energy balance is derived from changes in body weight and body composition [7]. Moreover, there are indications that proportions of the chemical components of the fat-free mass before and after short-term weight changes are not identical, thus affecting the inevitable assumptions in the calculation of body composition measured with indirect techniques [8]. Thus, energy balance over weekly intervals is preferably derived from measurements of energy intake and energy expenditure. A typical example of a recent energy balance study over four-week intervals under free-living conditions, measuring intake by providing all food and sequential measurement of energy expenditure with doubly labelled water, resulted in a 400 kJ/day discrepancy between intake and expenditure, as well as a change in calculated body energy content over the four-week interval [9]. The discrepancy was explained by participants not reporting all food consumed or by the error of modelling small changes in energy balance with the available techniques.

In many settings, energy balance cannot be derived from sophisticated techniques for measurements of energy intake, energy expenditure and body composition. Papers in this special issue show examples of limitations of indirect approaches. Physical activity is often recommended as an important component for the prevention of a positive energy balance. In a cross-sectional study, higher levels of accelerometer-assessed physical activity were inversely associated with obesity in children [10]. Based on this association, the authors concluded that children should be provided with opportunities to perform physical activities in order to prevent excess body fat. They also state the limitations of a cross-sectional study to draw causal conclusions. Indeed, accelerometer assessed physical activity was reduced in adolescents with obesity but doubly labelled water assessed activity energy expenditure was not [11]. Less body movement does not necessarily imply a lower activity energy expenditure as previously suggested [10]. In one of the papers, body composition was derived from predictive equations based on anthropometric variables instead of multi-component models based on measurements including body mass, body volume, total body water and bone mass, the basis of the gold standard 4-component model. In a cross-sectional study in nearly 400 participants, age ≥ 60 y and excess adiposity, anthropometric variables explained 80 to 90 per cent of the variation in fat mass [12]. The predictive equation thus derived was concluded to be interchangeable with the 4-component model in the population of study. Despite the predictive model showing promising results at group level, discrepancies at the individual level ranged from +6 kg to − 6 kg fat mass. Clearly, such differences would not allow energy balance to be determined with any degree of precision. Finally, in a cross-sectional study, total energy expenditure from DLW was compared between young Indian children with and without stunting [13]. Higher energy expenditure (kcal/kg body weight) was positively related to stunting. Here, the reader should realize that the relation between energy expenditure and bodyweight has a significant positive intercept, resulting in higher energy expenditure values for participants with a lower body weight when energy expenditure is expressed per unit body weight [14].

In conclusion, measurements of energy balance and body composition remain challenging. Data analysis and data reporting should comply with published standards. Current methods cannot yet explain annual weight changes as observed in many adults in daily life.

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AUTHOR CONTRIBUTIONS

KW and MJS co-wrote the manuscript.

COMPETING INTERESTS

KW is an Editorial Board Member and MJS is the Editor in Chief of EJCN.

ADDITIONAL INFORMATION

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