EQUILIBRIUM ENERGY INTAKE ESTIMATED BY DIETARY ENERGY INTAKE AND BODY WEIGHT CHANGE IN JAPANESE YOUNG MALES

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Ⅰ. Introduction

Estimated energy requirement (EER) for the Japanese is defined as energy intake required to maintain their body weight1). However, EER is actually determined by measuring energy expenditure. Although the units of energy intake and energy expenditure are the same (kcal), the method of determination is different for two types of energies. Energy intake is calculated based on the weight of consumed foods and their energy content written in the Food Composition Tables2). On the other hand, energy expenditure is determined mainly by the measurements of oxygen intake.

There has not been confirmed that these two energies are identical to each other. However, the current guideline for energy intakes is based on an assumption that these energies are identical1). It is necessary to compare these two energies and to find a relation between them.

It would be possible to establish EER for an adult group using the energy intake if the relationship between energy intake and body weight change is significantly correlated. Therefore, in order to get a relation between them, we analyzed existing data of human metabolic studies where the subjects consumed diets that contain controlled energy and their daily body weights are recorded.

Before starting this study, we searched literatures dealing with the relation between human body weight changes and dietary energy intakes, using key words (diet, weight change, energy, adult and health) on Medical online and PubMed. However, we could not find any such article. So, we believe that this report is the first study that compared actually the energy intakes and human bodyweight changes.

Ⅱ. Subjects and Methods

In this analysis, we used two existing data that concern to human mineral balance studies, conducted by the National Institute of Health and Nutrition (Tokyo) and has been published previously3-8). The first study was a 17-day metabolic study (an 8-day balance study with 5-day pre-adaptation and 4-day post-reserve periods) conducted in the spring of 1994. The subjects were 10 young Japanese males [20.8±1.9 (19-26) year old, 172.7±8.0 (159.1-178.5) cm in height, 63.09±5.18 (59.07-73.48) kg in the initial body weight, and 21.2±1.5

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(18.0-23.1) in the body mass index (BMI) (mean ± SD ; range), who did not belong to any athletic team. They ate all the supplied diets (energy: 2,100 kcal/day and protein: 71g/day; calculated by the Food Composition Tables2) (Experiment 1; Exp 1)6).

The second study was an 11-day metabolic study (a 5-day balance study with both 3-day pre-adaptation and post-reserve periods) conducted in the spring of 1990. The subjects were 13 young Japanese males [19.5±1.2 (18-21) year old, 171.4±6.0 (162.2-183.9) cm in height, 57.90±6.27 (47.30-74.75) kg in initial body weight, and 19.7±1.3 (17.3-22.1) in BMI, who belonged to a long distance running team. During the study they exercised not a little but lighter compared to their routine schedule. They ate all the supplied diets (energy: 3,000 kcal/day and protein: 135g/day calculated by the Food Composition Tables2)) (Experiments 2; Exp 2)7, 8).

During these metabolic studies, the subjects stayed in the metabolic ward at the National Institute of Health and Nutrition, and took no other food than the experimental diets that are carefully provided under a control of a registered dietitian (NK).

Both studies were carried out after obtaining the informed consent from the subjects. The former study has been conducted with an authorization of the Ethics Committee of the Institute, but the latter had been conducted prior to the establishment of such Committee.

Body Weight Measurements

In both experiments, the subjects had measured their naked body weight (sensitivity of 10g), after having emptied the bladder in every morning immediately after getting up and at every night just before going to bed.

Lean Body Mass (LBM)

During the experiments, skin-fold thickness (upper arm back + sub-scapula) of their less skillful hand was measured by the EIKEN skin-fold calipers9). Their body density was determined by Nagamine method11) using skin-fold thickness. And their LBM was calculated from the body fat by the method proposed by Keys and Brozek10) using the body density. The body density was determined in advance using the Nagamine formula11) based on skin-fold thickness. Body weight used for LBM calculation was the initial body weight described below.

Determination of Initial Body Weight (i-BW) and Final Body Weight (f-BW)

Initial body weight (i-BW) was defined as the body weight of the morning on the first day of the balance study, and the final body weight (f-BW) was defined as the corresponding weight at the day following the termination of the balance study. The initial and the final body weight error that can be caused by body water shifts and intestinal contents are eliminated.

Data Analysis and Statistics

Data are shown in a form of mean value ± SD. Relationship between the dietary energy intake and the body weight change was analyzed newly by simple linear regression analysis after dividing those values by i-BW or LBM.

III. Results

Body weight decreases during night were 0.59±0.28 kg for Exp 1 and 0.82±0.20 kg for Exp 2. Body weight changes between the initial and the final measurements in the morning were 0.69±0.38 kg/8days for Exp. 1 and 0.28±0.60 kg/5days for Exp. 2.

1. Experiment 1

Subjects of Exp. 1, consisting of 10 young healthy men, do not belong to any athletic club. During the experimental period of 8 days, they lived in the same facility. Their average LBM ± SD (range) was 54.56±5.90 (43.20-62.11) kg. Their activity level during that period was “Lower” that is equivalent to the definition in the Dietary Reference Intake for Japanese.1)

Dietary energy intake was 2,100 kcal/day. The relationship between energy intake and body weight change was not significant ($r^2=0.295$, $p=0.105$) when measured values are divided by
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i-BW as shown in Fig. 1. (upper left), but was significant ($r^2=0.568$, $p=0.012$) when measured values are divided by LBM as shown in Fig. 1. (upper right). The mean value and the upper and lower limits of the 95% confidence interval of equilibrium energy intake that brings the body weight changes to zero, namely the mean and 95% confidence interval of equilibrium energy intake, are 46.2, 41.0 and 51.4 kcal/kg LBM/d, respectively, as shown in Fig. 1. (upper right).

2. Experiment 2

Subjects of the Exp. 2, consisting of 13 young healthy men, were long-distance runners. They stayed in the same facility during the experiment period. Their average LBM±SD (range) was 52.39 ± 5.89 (43.30-68.04) kg. We requested them to abstain from any physical exercises other than those integrated in that study during the experiment period. They, however, did not accept our request, and we had to compromise. We allowed them to exercise but demanded them to record their daily exercise. They exercised every day excepting one day that we prohibited it. We classified their amount of physical exertion into the physical activity Level III (high) defined in the “Schulz et al reported PAL of long-distance runner”.

Dietary energy intake was 3,000 kcal/day. The relationship between energy intake and body weight change was significant ($r^2=0.508$, $p=0.006$) when measured values are divided by the initial body weight. The mean and the 95% confidence interval of equilibrium energy intake are 54.6, 51.6 and 57.6 kcal/kg i-BW/day respectively as shown in Fig. 1. (lower left). When measured values are divided by LBM, the corresponding values were 60.5, 56.9 and 64.2 kcal/kg LBM/day respectively ($r^2=0.425$, $p=0.016$) as shown in Fig. 1. (lower right).

Fig. 1 Relationship between dietary energy intake and body weight change during human metabolic studies, indicated divided by initial body weight (i-BW) (left) and by lean body mass (LBM) (right) in sedentary male subjects (n=10, 8 days, energy: 2,100 kcal/d, protein: 71g/d) (upper) and in running athletes (n=13, 5 days, energy: 3,000 kcal/d, protein: 135g/d) (lower).

In the human metabolic studies, energy intakes were strictly controlled. Body weight is that obtained early in the morning at the initial day of the metabolic balance period (i-BW). Lean body mass (LBM) was calculated by body density (Keys and Brozek) after determined by measuring skin-fold thickness using EIKEN calipers (upper arm back + sub-scapula) (Nagamine). Estimated average equilibrium energy intake (E AEEI) and 95% confidential interval of the average maintaining body weight (95% CI) was determined by simple regression equation.
IV. Discussion

In this analysis, we confirmed that energy intakes and body weight changes are significantly correlated in both sedentary and athletes males, and that the correlation between energy intakes and body weight changes respectively divided by the initial body weight in the sedentary group is not significant. Because of the smallness of sample sizes and the fluctuation of the subjects, absolute values characterizing the relation between them were not confirmed precisely in this study.

Equilibrium energy intake for long distance runner obtained in this analysis is 54.6 kcal/kg BW. This value is 2.3 times of the standard value of basal metabolic ratio (24.0 kcal/kg BW/d, male, 18–29 years old)\(^2\), and is rather greater than that appearing in the dietary reference intakes (DRI)\(^1\). Difference between two energies of the same unit (energy intake and expenditure) could be shown in future to find a conversion factor between the two energies.

Stronger correlations between energy intakes and weight change divided by LBM are found than those between energy intakes and weight change divided by body weight. This result may be caused by low additional energy expenditure to the basal metabolism, which is well correlated to LBM\(^1\), in the sedentary group (Exp 1). Wide variety of adipose tissue quantity in the sedentary group made unclear the relation between energy intakes and body weight changes.

This report demonstrates firstly a positive relationship between dietary energy intakes and body weight changes, under a condition of strictly controlled dietary energy intakes. Further studies using a large sample size are necessary to confirm a standard value of equilibrium energy intake that can be calculated both from the dietary energy intakes and from the body weight changes.

We are aware that a time span of the observation period also shall be considered in the future studies.

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References