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Estimation of energy requirements in a controlled feeding trial[1–3]

Pao-Hwa Lin, Michael A Proschan, George A Bray, Claudia P Fernandez, Kimberly Hoben, Marlene Most-Windhauser, Njeri Karanja, and Eva Obarzanek for the DASH Collaborative Research Group

ABSTRACT

Background: Estimating energy requirements is a frequent task in clinical studies.

Objective: We examined weight patterns of participants enrolled in a clinical trial and evaluated factors that may affect weight stabilization. The Harris-Benedict equation and the FAO/WHO equation, used in conjunction with physical activity levels estimated with the 7-d Physical Activity Recall, were compared for estimating energy expenditure.

Design: This was a multicenter, randomized controlled feeding trial with participants of the Dietary Approaches to Stop Hypertension Trial. For 11 wk, the amount of food participants received was adjusted to maintain their body weights as close to their initial weights as possible. Change-point regression techniques were used to identify weight-stable periods. Factors related to achieving weight stabilization were examined with logistic regression.

Results: A stable weight was achieved by 86% of the 448 participants during the run-in period and by 78% during the intervention period. Energy intake averaged 11 ± 2.4 MJ/d (2628 ± 578 kcal/d), with most participants ($n = 270$) requiring 9–13 MJ/d (2100–3100 kcal/d). The difference between predicted and observed intakes was highest at high estimated energy intakes, mainly because of high and probably incorrect estimates of the activity factor. Participants with lower energy intakes tended to need less adjustment of their energy intakes to maintain a stable weight than did participants with higher energy intakes.

Conclusions: Weight stabilization is not affected by diet composition, sex, race, age, or baseline weight. Either the Harris-Benedict equation or the FAO/WHO equation can be used to estimate energy needs. Activity factors > 1.7 often lead to overestimation of energy needs. *Am J Clin Nutr* 2003;77:639–45.

KEY WORDS Harris-Benedict equation, FAO/WHO energy equation, stable weight, activity factor, controlled feeding study, clinical trial, clinical study

INTRODUCTION

In clinical trials, it is frequently necessary to estimate energy requirements, particularly when maintenance of a stable body weight is desired. Accurate methods include measuring resting metabolic rate with an indirect calorimeter, measuring total energy expenditure with a whole-room calorimeter or doubly labeled water, and measuring physical activity with heart rate or activity monitors (1–3). However, these methods are expensive and are often not available or feasible. Alternatively, several equations have been developed from these physiologic measures and the equations can be applied when direct measurement of energy expenditure is not possible (4). The most widely used equations are those of Harris-Benedict (5) and the FAO/WHO (6), both of which may either overestimate or underestimate the actual energy expenditure of individuals. It is not clear which of the 2 equations is preferable (4).

Similarly, measurement of physical activity is important for estimating total energy expenditure. Many physical activity questionnaires have been developed, and these instruments vary in terms of reliability and validity (7). These questionnaires also may have inherent bias in estimation, and the participants may over- or under-report their actual activity levels, thereby leading to inaccurate estimation of total energy expenditure (8).

The protocol for the Dietary Approaches to Stop Hypertension (DASH) trial called for maintaining stable body weight over a 3-wk run-in period and an 8-wk controlled feeding intervention to eliminate effects of changes in body weight on blood pressure. From the data collected on body weight, energy intake, and physical activity, it was possible to examine weight patterns during a controlled feeding study and to estimate energy requirements during periods of weight stabilization. In addition, we examined whether diet composition and other factors were related to energy requirements or the achievement of weight stabilization and we evaluated the usefulness of the Harris-Benedict and the FAO/WHO equations for estimating energy requirements.

SUBJECTS AND METHODS

The DASH trial was a multicenter, controlled, outpatient trial designed to compare the effects of 3 dietary patterns on blood pressure (9–11). The 3 dietary patterns included a control diet that

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[1] From the Sarah W Stedman Center for Nutritional Studies, Duke University Medical Center, Durham, NC (P-HL and KH); the Division of Epidemiology and Clinical Applications, the National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, MD (MAP and EO); the Pennington Biomedical Research Center, Baton Rouge, LA (GAB and MM-W); the North Carolina Institute for Public Health, University of North Carolina at Chapel Hill (CPF); and the Kaiser Permanente Center for Health Research, Portland, OR (NK).

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[3] Reprints not available. Address correspondence to P-H Lin, Box 3487, Duke University Medical Center, Sarah W Stedman Center for Nutritional Studies, Durham, NC 27710. E-mail: lin00004@mc.duke.edu.

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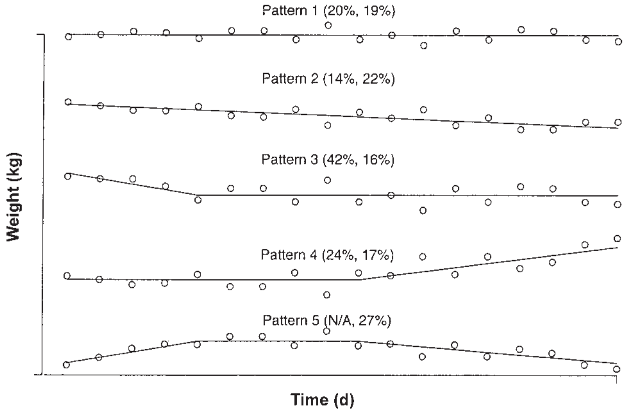

FIGURE 1. Patterns of weight fluctuation during the run-in and intervention periods; the percentage values represent the percentages of participants who fit the pattern during the run-in and intervention, respectively. N/A, not applicable.

was typical of the diets of many Americans; it was moderately high in total fat, saturated fat, and cholesterol and low in fruit, vegetables, and dairy products. A second diet (fruit and vegetables diet) was rich in fruit and vegetables but otherwise similar to the control diet. The combination diet (DASH diet) emphasized fruit, vegetables, and low-fat dairy foods, included whole grains, poultry, fish, and nuts, and was reduced in fats, red meat, sweets, and sugar-containing beverages. Compared with the control diet, the DASH diet had reduced amounts of total and saturated fat and cholesterol and increased amounts of potassium, calcium, magnesium, dietary fiber, and protein (12). All participants consumed the control diet during a 3-wk run-in period and then were randomly assigned to continue on the control diet or to receive 1 of the other 2 diets for an additional 8-wk intervention period.

A 7-d cycle of menus was used for the intervention period (13). Menus were designed to provide 6.7, 8.9, 10.9, and 13.0 MJ (1600, 2100, 2600, and 3100 kcal) by using commonly available foods. All foods were weighed to the accuracy of ± 0.5 g, except for oils and salt, which were weighed to the accuracy of ± 0.1 g. Unit foods, in the form of cookies that contained 418 kJ (100 kcal) each and had a nutrient profile similar to the main diet, were used to provide diets with total energy levels between the 4 core-menu energy levels. For example, a participant with an energy requirement of 9.6 MJ (2300 kcal) was assigned the 8.9 MJ (2100 kcal) menu plus 2 unit foods/d. Participants were asked to eat only foods provided by the study, and they could consume up to 3 servings of designated nonalcoholic beverages (coffee, tea, and diet soft drinks) and up to 2 servings of alcoholic beverages (beer, white wine, and spirits) per day.

A total of 459 adults participated in the study from 1994 to 1996 at 4 clinical sites (10). Each clinical site conducted the study in 4–5 cohorts, with each cohort including ≈30 participants. Throughout the 11-wk intervention, participants consumed a main meal at the clinical site on Monday through Friday and took home the other meals and snacks for the remaining 24 h. Meals and snacks for weekends were given to participants on Fridays. Participants were not given the opportunity to select the types or amounts of foods consumed. Body weight was measured each weekday, and total energy intake was adjusted in increments of 418 kJ (100 kcal) when necessary to keep body weight within 2% of baseline weight. Each day during the intervention, participants completed diaries indicating the amount of allowed beverages consumed, whether they ate any nonstudy foods, and whether they ate all of the study foods. Energy intake was calculated by adding the total intakes from the study meals as served, the unit foods, and the estimated alcohol consumption, which was reported in the daily food diaries. Deviation in food consumption was usually small; missing a bite of bread or consumption of a trivial amount of nonstudy foods (eg, a piece of candy) was not estimated, even if it was recorded in the food diary (14). Energy intake data were calculated for each participant on each intervention day.

Participants were asked to maintain their habitual level of daily activity throughout the study. Before the study and again at the end of the intervention, participants were asked to complete an interviewer-administered 7-d Physical Activity Recall (PAR). This instrument was validated and tested for reliability previously (15–17). The PAR provides an estimate of kJ expended per kg per day; we divided the total $kJ \cdot kg^{-1} \cdot d^{-1}$ by 24 h to obtain an activity factor in $kJ \cdot kg^{-1} \cdot h^{-1}$. The activity level assessed before the intervention was used in conjunction with FAO/WHO equations to estimate energy requirements during the intervention.

All participants gave their written informed consent before the study began, and the study protocol was approved by the Institutional Review Board of each collaborating institution.

Statistical analyses

The statistical analyses were performed with SAS for PC, version 6.10 (SAS Institute Inc, Cary, NC). For each participant, we determined whether body weight stabilized, and if so, when this occurred during the run-in and intervention periods separately. This was done by developing change-point regression models to relate daily weight to the amount of time (in d) that had elapsed since the beginning of the run-in or intervention period. We used the method of least squares to determine which of the following patterns fit best for each participant throughout either the run-in or the intervention: *1*) a flat, weight-stable period; *2*) a linear increase or decrease in weight; *3*) a linear increase or decrease for a period of time, followed by a flat, weight-stable period; *4*) a flat, weight-stable period followed by a linear increase or decrease; or *5*) a linear increase or decrease for a period of time, followed by a flat, weight-stable period, followed by another linear increase or decrease in weight until the end of the intervention (**Figure 1**). Pattern 5 could be detected only during the intervention, when there were many more days of measurement than during the run-in (56 compared with 21 d). A flat period had to last for ≥ 5 d to be considered a weight-stable period. A hierarchical procedure was used to select the simplest pattern that reasonably fit a participant's data. Thus, the simplest model, pattern 1, was the default unless pattern 2 substantially improved the fit, in which case pattern 2 became the default until it was proven inferior to pattern 3, and so on.

To determine whether the percentage of participants who eventually reached a stable weight differed by diet assignment, sex, race, age, baseline weight, cohort, or site (henceforth referred to as the baseline covariates), each covariate was considered separately by using chi-square methods. Multiple logistic regression was then used to determine the independent effects of the covariates on the probability of eventually stabilizing. Baseline age and weight were treated as continuous variables in the logistic regression but were presented as dichotomized variables (ie, either below or above the median) for ease of interpretation. Separate analyses were done for the run-in and intervention periods.

TABLE 1
Characteristics of participants by categories of energy intake during the intervention

	Energy intake				
	6.7–8.8 MJ (1600–2099 kcal)	8.9–10.8 MJ (2100–2599 kcal)	10.9–12.9 MJ (2600–3099 kcal)	13.0–15.0 MJ (3100–3599 kcal)	≥15.1 MJ (≥3600 kcal)
n	37	143	127	83	26
Age (y)	47.7 ± 9.1[1]	46.3 ± 10.0	45.4 ± 11.8	41.5 ± 10.6	40.1 ± 7.6
Weight (kg)	68.3 ± 12.3	75.7 ± 11.3	83.0 ± 10.5	93.5 ± 13.1	98.8 ± 12.7
Height (cm)	160.4 ± 6.6	165.0 ± 6.5	172.5 ± 7.9	179.1 ± 6.2	181.0 ± 5.1
BMI (kg/m^2)	26.5 ± 3.9	27.9 ± 4.2	28.0 ± 3.5	29.2 ± 3.7	30.1 ± 3.5
Subscapular skinfold thickness (mm)	23.6 ± 8.8	24.4 ± 8.8	22.2 ± 8.6	22.0 ± 7.8	21.8 ± 6.5
Activity factor	1.5 ± 0.15	1.5 ± 0.16	1.5 ± 0.16	1.7 ± 0.32	1.9 ± 0.39
Hypertensive at baseline (%)	37.8 ± 49.2	31.5 ± 46.6	29.9 ± 46.0	16.9 ± 37.7	7.7 ± 27.2
Female (%)	97.3 ± 16.4	83.2 ± 37.5	33.1 ± 47.2	6.0 ± 23.9	0.0 ± 0.0
African American (%)	64.9 ± 48.4	63.6 ± 48.3	52.0 ± 50.2	49.4 ± 50.3	65.4 ± 48.5

[1] $\bar{x}$ ± SD.

The distribution of the number of days required to achieve weight stabilization, and whether that distribution differed depending on the baseline covariates, was examined. However, time to weight stabilization was expected to have a skewed distribution, with some participants stabilizing from the beginning and others never stabilizing. Also, there were artificial troughs because body weight was not measured on weekends. For these reasons, time to stabilization was dichotomized for 3 separate variables: stable by the first week or not, stable by the first 2 wk or not, and ever stable or not. This allowed the inclusion into the statistical models of participants whose weights never stabilized. Chi-square methods were used to assess separately the association between each of the baseline covariates and whether the participant stabilized during the first week, first 2 wk, or ever, and multiple logistic regression was used to assess their independent effects. Separate analyses were done for the run-in and intervention periods.

Analysis of covariance was used to determine whether energy intake and weight during the weight-stable periods differed depending on the values of the baseline covariates. Differences between baseline and intervention for stable weight and energy intakes were assessed by using paired *t* tests.

Energy intakes were estimated by multiplying the activity factor by resting energy expenditure (REE) calculated by using the FAO/WHO and Harris-Benedict equations (shown below). Estimated energy intakes were compared with the observed intakes during weight-stabilization periods. Stepwise regression was used to determine whether a better equation could be derived from the data by using height, weight, squares of height and weight, sex, race, age, and site.

Harris-Benedict equation:

For women:

$$\text{REE (kcal/d)} = 655 + 9.5\ (\text{weight in kg}) + 1.9\ (\text{height in cm}) - 4.7\ (\text{age in y}) \tag{1}$$

For men:

$$\text{REE (kcal/d)} = 66 + 13.8\ (\text{weight in kg}) + 5.0\ (\text{height in cm}) - 6.8\ (\text{age in y}) \tag{2}$$

FAO/WHO equation:

For men:

$$\text{Age 18–30 y: REE (kcal/d)} = (15.3 \times \text{weight in kg}) + 679 \tag{3}$$

$$\text{Age} > \text{30–60 y: REE (kcal/d)} = (11.6 \times \text{weight in kg}) + 879 \tag{4}$$

$$\text{Age} > \text{60 y: REE (kcal/d)} = (13.6 \times \text{weight in kg}) + 487 \tag{5}$$

For women:

$$\text{Age 18–30 y: REE (kcal/d)} = (14.7 \times \text{weight in kg}) + 496 \tag{6}$$

$$\text{Age} > \text{30–60 y: REE (kcal/d)} = (8.7 \times \text{weight in kg}) + 829 \tag{7}$$

$$\text{Age} > \text{60 y: REE (kcal/d)} = (10.5 \times \text{weight in kg}) + 596 \tag{8}$$

RESULTS

Of the 459 participants who were randomized in the DASH study, 448 had sufficient body weight data to determine whether their weights had stabilized; 86% of them (*n* = 386) were weight-stable during the run-in period and 78% (*n* = 350) were weight-stable during the intervention. Self-reports of perfect adherence (no nonstudy foods consumed and all study foods eaten) occurred in 96%, 96%, and 94% of person-days for participants assigned to the control diet, the fruit and vegetables diet, and the DASH diet, respectively (14). As previously reported, there was little change in self-reported physical activity between run-in and the end of the intervention (10). During run-in, the most frequent pattern (seen in 42% of participants) was a linear increase or decrease in weight for a period of time followed by a flat, weight-stable period (pattern 3). During the intervention, the most frequent pattern (seen in 27% of participants) was a linear increase or decrease for a period of time, followed by a flat, weight-stable period, followed by another linear increase or decrease of weight until the end of the intervention (pattern 5).

Note that even though no numerical weight was defined in determining weight stability, body weight generally fluctuated up to ± 1 kg from day to day for most participants. However, in some participants, body weight fluctuated up to 3–5 kg from the lowest to the highest point during the study. The mean changes in body weight did not differ significantly from end of run-in to end of intervention between the 3 diet groups. Regardless of whether the participants' weights stabilized or not, the mean changes were −0.1, −0.3 and −0.4 kg for the control, fruit and vegetables, and DASH diet groups, respectively.

In **Table 1**, the characteristics of the participants are shown by categories of energy intake during the intervention period.

TABLE 2
Stable weight and energy intake for participants whose weight eventually stabilized[1]

	Control diet	F and V diet	DASH diet
Stable weight (kg)			
Run-in	81.9 ± 14.0 [127]	83.0 ± 14.0 [127]	82.6 ± 13.8 [131]
Intervention	82.2 ± 14.4 [114]	82.4 ± 13.9 [120]	82.5 ± 14.1 [116]
Change from run-in to intervention[2]	0.1 ± 1.0	−0.1 ± 1.3	−0.1 ± 1.1
Energy intake [MJ/d (kcal/d)]			
Run-in	11.2 ± 2.5 (2672 ± 601)	11.1 ± 2.2 (2650 ± 535)	10.9 ± 2.3 (2601 ± 549)
Intervention	11.0 ± 2.4 (2634 ± 579)	11.1 ± 2.5 (2654 ± 593)	10.9 ± 2.4 (2596 ± 565)
Change from run-in to intervention[2]	0.13 ± 0.69 (−30 ± 164)	0.05 ± 0.77 (−13 ± 185)	0.04 ± 0.46 (9 ± 111)

[1] $\bar{x}$ ± SD; *n* in brackets. F, fruit; V, vegetables; DASH, Dietary Approaches to Stop Hypertension. There were no significant differences among the 3 diet groups for any of the data shown.

[2] Changes reflect those participants whose weights stabilized during both the run-in and the intervention.

Because 32 of the 448 participants had missing data from their daily diaries, Table 1 shows unadjusted baseline data for 416 participants. BMI was greater for participants in the higher categories of energy intake. More women than men were in the lower categories of energy intake, and no women were in the highest energy-intake category. The subscapular skinfold, an index of central fat, was lower in participants in higher energy-intake categories. The activity factor was higher as energy-intake categories increased. The percentage of participants who were hypertensive was lower in the higher energy-intake categories. Except for the small group of participants in the highest energy-intake category, the prevalence of hypertension and percentage of African Americans showed the expected parallel trends that hypertension is more prevalent among African Americans. Employment status, income, and educational attainment did not show any patterns in relation to energy intake (data not shown).

The percentage of participants whose weight stabilized did not differ by diet assignment, sex, age, or weight during both the run-in and intervention periods. For those participants whose weight eventually stabilized, their weight during the weight-stable period of run-in differed significantly by sex ($P < 0.0001$) and race ($P = 0.004$) (data not shown). After adjustment for diet assignment, sex, age, height, cohort, and site, African Americans weighed ≈4.6 kg more than non-African Americans. Men weighed ≈11.5 kg more than women after adjustment for diet assignment, race, age, height, cohort, and site. Stable weight did not differ significantly by diet assignment. The change between stable weight during run-in and stable weight during the intervention did not differ among the 3 diet groups ($P = 0.36$) and was not significantly different from 0 ($P = 0.24$) (**Table 2**).

Energy intake during the weight-stable periods of the run-in and intervention periods, for those participants who eventually stabilized, differed by sex, age, baseline weight, cohort and site at $P < 0.0001$ for all variables except site ($P = 0.004$) during the intervention period but did not differ by race (data not shown). After adjustment for age, baseline weight, cohort, and site, men required 2.5 MJ/d (600 kcal/d) more than women. The energy required to maintain a stable weight was lower by 377 kJ/d (90 kcal/d) for each additional 10 y of age when the other covariates were held constant. There was no difference in energy intake by diet assignment in the run-in ($P = 0.66$) or intervention ($P = 0.93$) periods. The average change in energy intake between the run-in and intervention periods during weight-stable periods did not differ by diet assignment ($P = 0.24$) and was not significantly different from 0 ($P = 0.24$) (Table 2).

Overall, nearly 37% of the participants consumed the same amount of energy throughout the intervention period, and no adjustment in energy intake was required to maintain their weight. However, adjustments were made from 1 to 25 times during the 56-d intervention for the rest of the participants. Approximately 29% of participants needed adjustments of ≤400 kcal, whereas the other 34% needed adjustments >500 kcal. The number of adjustments in energy intake was greater as energy intake increased ($P < 0.05$) (**Table 3**). Participants who needed more adjustment were more likely to be male and non-African American ($P < 0.05$ for both).

TABLE 3
Characteristics of participants by number of adjustments made in energy intake during intervention

No. of adjustments in energy intake	Age	Percentage female[1]	Percentage African American[1]	Energy intake[1]	Weight
	y	*%*	*%*	*MJ (kcal)*	*kg*
0 (*n* = 119)	43.5 ± 10.9[2]	53.8	63.0	10.4 ± 2.2 (2485 ± 517)	81.2 ± 14.7
1 (*n* = 50)	43.8 ± 9.3	56.0	74.0	10.5 ± 2.3 (2495 ± 538)	80.7 ± 12.4
2–3 (*n* = 36)	44.3 ± 10.3	47.2	63.9	11.1 ± 1.9 (2656 ± 454)	82.6 ± 11.6
4–5 (*n* = 30)	45.8 ± 9.8	60.0	53.3	11.6 ± 2.5 (2771 ± 593)	85 ± 14.1
6–8 (*n* = 34)	45.2 ± 11.4	41.2	50.0	12.1 ± 2.4 (2896 ± 581)	86 ± 13.1
9–12 (*n* = 33)	42.8 ± 11.6	30.4	47.8	11.3 ± 2.7 (2693 ± 645)	79.3 ± 16.7
13–25 (*n* = 23)	46.2 ± 10.1	36.4	48.5	12.3 ± 3.1 (2938 ± 737)	86 ± 16.9

[1] Significantly related to number of adjustments, $P < 0.05$.

[2] $\bar{x}$ ± SD.

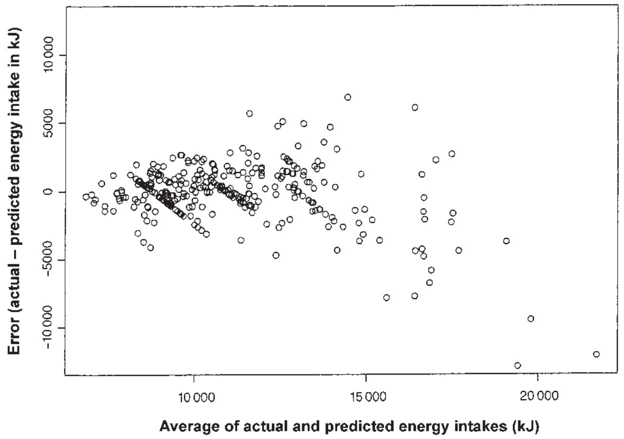

FIGURE 2. Scatter plot of the differences between actual and predicted energy intakes during the intervention. Predicted energy intake was determined with the FAO/WHO formula by using the untruncated activity factor. Actual intake was the average intake during the weight-stable period.

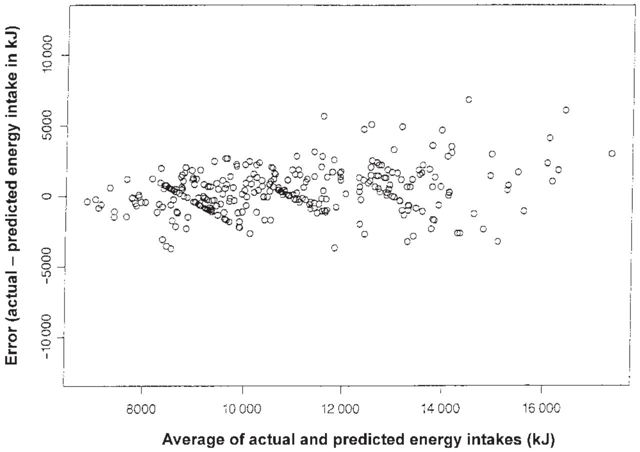

FIGURE 4. Scatter plot of the differences between actual and predicted energy intakes during the intervention. Predicted energy intake was determined with the FAO/WHO formula by using the truncated activity factor, which was truncated at 1.70. Actual intake was the average intake during the weight-stable period.

Figure 2 is a scatter plot of the differences between actual and predicted energy intakes during the intervention. Predicted energy intake was determined with the FAO/WHO formula, and actual intake was the average intake during the weight-stable period. The extended right tail of the plot indicates overprediction, and this mainly occurred in participants who consumed the highest amounts of energy. A similar pattern was seen during run-in and when using the Harris-Benedict formula (graphs not shown).

Because the measurement of the activity factor was less precise than were the measurements of other variables needed to estimate energy intake (age, height, and weight), we speculated that the extended tail might have been caused by the very skewed distribution of the activity factor (**Figure 3**). Unrealistically large activity factors may have resulted in overestimation of the amount of energy needed to maintain a stable weight. To confirm this speculation, we truncated the activity factors beyond a cutoff. We determined that the optimal cutoff (the one that minimized the average squared difference between the actual and predicted energy intakes) was 1.70 for both the FAO/WHO and Harris-Benedict equations. Truncating the activity factor at 1.70 eliminated the extended tail (**Figure 4**). Nevertheless, the discrepancy between actual and predicted energy intakes was still more variable at higher energy intakes than at lower intakes.

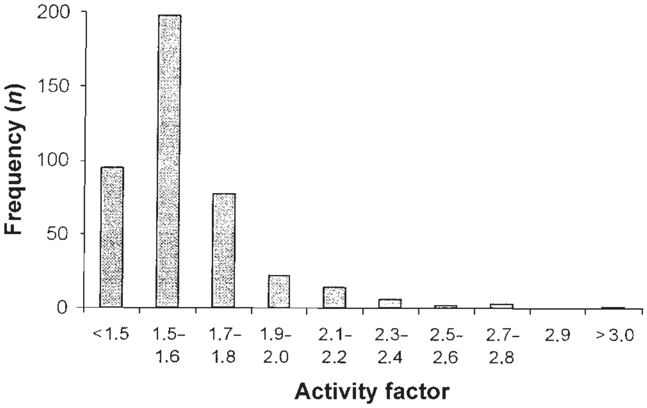

FIGURE 3. Distribution of the activity factor.

Although this simple technique improved the prediction markedly, we still attempted to determine whether a better equation could be found to predict energy requirements on the basis of participant characteristics. Forward and backward regression to relate energy intake during the weight-stable period to height, weight, age, activity factor (truncated and untruncated), the square of height, and the square of weight showed that the most important variables were the activity factor, age, square of height, and weight. This was true during both the run-in and the intervention. This equation was not better than the FAO/WHO or Harris-Benedict equations that used the truncated activity factor.

DISCUSSION

This report used data collected from participants in the DASH trial on the effects of dietary patterns on blood pressure. In the present analysis, we examined factors related to energy requirements and body weight when an effort was made to maintain a stable body weight. On the basis of regression models, body weight was defined as stable for 86% of the 448 participants during the 3-wk run-in period and for 78% of participants during the 8-wk intervention period. From the data, we identified 4 patterns of weight fluctuations in participants during run-in and 5 patterns during the intervention (Figure 1). Most participants had a pattern of a linear increase or decrease up to some time point, followed by a flat, weight-stable period (pattern 3) during run-in and a linear increase or decrease up to some time point, followed by a flat, weight-stable period, followed by another linear increase or decrease until the end of the intervention (pattern 5). Even though most participants' weights stabilized eventually, about one-third of the participants' weights did not stabilize during the first week of run-in, and 3 wk were necessary for an additional 20% of the participants to stabilize their weights. Research studies requiring stable weights should allow adequate time initially (≥2–3 wk) for stabilization so that weight changes do not interfere with the study outcome. In the DASH study, the mean weight change from the end of run-in to the end of the intervention was very small and was not significant. However, some participants' weights did fluctuate by 3–5 kg at one point during the study, although overall weight fluctuation was < 2% of baseline weight.

The percentage of participants with hypertension decreased from > 30% in the lowest energy-intake category to < 10% in the highest energy-intake category. The highest energy-intake category were associated with higher activity factors and younger age. One may speculate that in addition to younger age, a higher physical activity level at baseline was associated with a lower percentage of participants having hypertension (18–20).

Several equations have been proposed for estimating energy requirements (4). Two of these, the Harris-Benedict equation (5) and the FAO/WHO equation (6), are among the most widely used. Each equation estimates resting metabolic rate by using height and weight, which can be measured with high precision (21). The equations also use an activity factor, which is multiplied by the resting metabolic rate to obtain the estimated energy requirements. From the data presented in this report, it is clear that the estimation of the activity factor is the most problematic element in the use of either equation.

The activity factor, like resting metabolic rate, can be estimated by using one of several methods. In the present study, we derived the activity factor from a structured interview (PAR), and this resulted in a clustering of observed versus predicted requirements. At high values of the activity factor, the difference between observed and predicted energy requirements widened substantially, as can be seen from the increased scatter in Figure 2. These results suggest that an activity factor > 1.7 is unlikely, or that adjustment needs to be made when using the FAO/WHO or Harris-Benedict equations in conjunction with a very high activity factor. Although the scatter points are clustered around zero, suggesting good estimation of the group mean intake, the difference between observed and predicted energy requirements for any individual could be large.

A previous report also showed that the PAR overestimated energy expenditure (22). Although the energy expenditure estimated from the PAR correlated significantly with that estimated with the doubly labeled water method, the PAR overestimated energy expenditure by an average of 1154 kJ/d (276 kcal/d), or 10.8%. Another potential explanation for the overestimation of energy expenditure is over-reporting of physical activity by the participants. In a study examining why obese participants failed to lose weight despite the low energy intakes reported (8), the authors found that these participants under-reported actual food intake by an average of 47% and over-reported their physical activity by 51%. It is not clear whether participants with higher energy requirements in the current study over-reported their physical activity levels or not. However, it is possible that inherent bias in the PAR questionnaire may have contributed to the overestimation of physical activity in the current study.

Thus, energy-requirement formulas such as the FAO/WHO or Harris-Benedict equations, in conjunction with an activity adjustment factor, are useful as a first estimate. However, to maintain stable weight in controlled diet studies it is necessary to monitor weight frequently and adjust energy intake when body weight deviates from baseline. In addition, when using the PAR in estimating the activity factor, one may need to reevaluate factors > 1.7.

The greater number of energy-intake adjustments needed to maintain stable weights in participants with higher energy intakes may be explained in part by the fact that overestimation of the predicted energy requirement was highest in these participants. However, it is possible that other unidentified factors may also have contributed to the differences among the participants in the number of adjustments made. Overall, ≈two-thirds of the participants had actual energy intakes that were within 400 kcal of the predicted amounts, and such differences were compensated for by changing the number of unit foods. However, energy adjustments for one-third of the participants were made by switching to a higher- or lower-energy menu, which had a greater impact on menu production in the research kitchen.

In summary, the results of this study show that body weight can be stabilized in most participants within 1–3 wk and that such weight stabilization is not affected by diet composition, sex, race, age, or weight. Both the FAO/WHO and Harris-Benedict equations are suitable for estimating the energy needs of participants in a controlled feeding trial when used in conjunction with an activity factor and when body weight is monitored. The 7-d PAR may overestimate activity levels, particularly for individuals with estimated energy requirements > 15 MJ/d (3600 kcal/d).

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