Changes in resting energy expenditure among children undergoing allogeneic stem cell transplantation[1–3]

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ABSTRACT

Background: Because of the effects of chemotherapy and radiotherapy, patients undergoing stem cell transplantation (SCT) are commonly provided nutritional support with parenteral nutrition. The energy and nutrient needs of these patients have not been well studied.

Objective: The objective was to measure resting energy expenditure (REE), dietary intake, and biochemical and anthropometric changes in children before and after allogeneic SCT.

Design: This was a prospective cohort study of 37 children aged 9.1 ± 6.4 y ($\bar{x}$ ± SD) undergoing SCT who were enrolled in an open-label trial of a unique supportive care intervention that included the routine use of oral leucovorin, vitamin E, and ursodeoxycholic acid. Parenteral nutrition was provided to match 100% of measured or estimated REE. REE was measured weekly via indirect calorimetry.

Results: Baseline REE was 95% of the predicted age- and sex-matched norms and was significantly correlated with midarm muscle area ($r = 0.82$, $P < 0.001$). REE fell to a nadir of ≈80% of the predicted levels by week 3 after SCT, with a gradual increase in weeks 4 and 5. Arm anthropometric measurements showed no change in triceps skinfold thickness but significant declines in midarm muscle area after SCT. Serum vitamin E remained in the normal range.

Conclusions: Children undergoing SCT show significant declines in REE after transplantation. These changes may be due to alterations in lean body mass. Standard nutritional regimens may lead to overfeeding. *Am J Clin Nutr* 2003;78:104–9.

KEY WORDS Energy expenditure, pediatrics, stem cell transplantation, supportive care

INTRODUCTION

Both adult and pediatric cancer patients have a high prevalence of malnutrition (1, 2). Children undergoing stem cell transplantation (SCT) are at particularly high risk of poor nutritional outcomes because of their underlying diseases and the intensive medical therapy before and after transplant (3, 4). High-dose chemotherapy and total body irradiation (TBI) as conditioning for SCT often produce painful oral mucositis, abdominal pain, and diarrhea, all of which may result in reduced oral intake for days to weeks. Significant declines in lean body mass and energy intake have been reported in children undergoing chemotherapy (5, 6).

Parenteral nutrition (PN) is commonly used during SCT because it has been associated with earlier engraftment and improved survival (7–9). Although PN may be an important supportive therapy in this setting, it may also be associated with significant complications, including infections, liver disease, and metabolic disturbances. Some of these complications may be related to providing excessive amounts of PN (so-called overfeeding), although underfeeding is also associated with adverse nutritional and metabolic outcomes. Preliminary data suggest that a reduction in PN intake in the setting of SCT is associated with fewer metabolic complications and comparable nitrogen balance when compared with standard energy intake regimens (10). Provision of appropriate nutritional support while minimizing potential risks has been difficult without a clearer understanding of the energy and nutrient needs of children undergoing SCT. We therefore performed a prospective cohort study of energy needs and anthropometric outcomes among children undergoing allogeneic SCT.

SUBJECTS AND METHODS

The study was part of a prospective intervention administered to allogeneic SCT patients designed to reduce regimen-related toxicity. The interventions were intended to address both acute and chronic end-organ toxicities from preparative chemotherapy, radiation therapy, allogenicity, cytokine release, and infectious illnesses. The multimodal interventions were studied in an open-label fashion and included *1*) the prescribed use of leucovorin (folinic acid) rescue after the methotrexate portion of graft versus host disease (GVHD) prophylaxis, *2*) routine oral supplementation with vitamin E (8 IU · kg^{-1} · d^{-1} for patients who weighed ≤ 25 kg and 400 IU · kg^{-1} · d^{-1} for patients who weighed > 25 kg) during the week before and the month after transplantation, *3*) oral ursodeoxycholic acid

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($7.5\ mg \cdot kg^{-1} \cdot d^{-1}$ for < 40 kg, $300\ mg \cdot kg^{-1} \cdot d^{-1}$ for > 40 kg, given twice a day) for the month after transplantation, and *4*) reduction in the conventional practice of providing parenteral energy intake from 130% to 150% of estimated basal energy needs (11) to 100% of estimated or measured resting energy expenditure (REE). These interventions were chosen as practical and readily applicable because they were based on the use of approved available agents or modalities. The rationale also considered data supporting low risk and the suggestion of potential improvements in SCT patients, including less venoocclusive disease (12), less adverse response to immunosuppression (13), better tolerance of GVHD prophylaxis (14), and improved electrolyte balance (10). The study was designed to determine the feasibility of these interventions, particularly the oral formulations, among pediatric SCT patients; the study was not designed to examine efficacy.

Study population

Patients undergoing allogeneic SCT at Dana Farber Cancer Institute/Children's Hospital Boston were eligible for enrollment provided that "short course" methotrexate (given on days 1, 3, 6, and 11) and cyclosporine were used for GVHD prophylaxis. Patients undergoing unrelated donor SCT (n = 24) also received 1 mg methylprednisolone $\cdot kg^{-1} \cdot d^{-1}$ intravenously from day 7 to day 21, tapered as appropriate for the grade of GVHD. Patients who were on experimental protocols that conflicted with this study and patients receiving alternative approaches to prophylaxis for GVHD were not eligible. Patients with known allergy or hypersensitivity to any of the study reagents were also ineligible. Study enrollment occurred between July 1998 and June 2000.

Written informed consent was obtained from the parents or guardians of all subjects. Assent was obtained from subjects in an age-appropriate manner. The protocol was approved by the Dana-Farber Cancer Institute Scientific Review Committee and Institutional Review Board.

Oncologic management

Thirty-three patients received TBI-containing regimens, and in each case TBI was given at 175 cGy twice a day for 4 d, for a total dose of 1400 cGy. Most of the patients (n = 32) also received cyclophosphamide (1800 mg/M^2 per day for 2 d), whereas one patient received etoposide. Six patients received anti-thymocyte globulin in addition to cyclophosphamide and TBI, whereas one patient also received VP-16. Two patients with aplastic anemia received cyclophosphamide (1500 mg/M^2 per day for 4 d) and anti-thymocyte globulin, whereas 2 patients received busulfan ($4\ mg \cdot kg^{-1} \cdot d^{-1}$ for 4 d) and cyclophosphamide (1500 mg/M^2 per day for 4 d). Transplants were carried out in laminar flow rooms. All patients received oral, nonabsorbable antibiotics for gut decontamination and prophylactic antipneumocystis, antiviral, and antifungal treatment per standard guidelines. Intravenous immunoglobulin was administered at 400–500 mg/kg per dose to maintain immunoglobulin G concentrations at > 500 mg/dL. Hematopoietic growth factors were not administered. Blood and urine cultures were obtained as indicated by symptoms for any fever or evidence of infection; infections were treated with broad-spectrum antibiotics if necessary until hematopoietic recovery. Aggressive antifungal therapy was administered for persistent fever. Patients who developed > grade I GVHD were treated at the discretion of the attending physician. Initial treatment generally consisted of the initiation or increase in dose of intravenous corticosteroids.

Nutritional assessment and management

Anthropometric assessment

Body weight was measured daily from the time of admission until hospital discharge with an electronic digital scale accurate to 0.1 kg. Standing height was measured on the day of admission with a stadiometer to the nearest 0.1 cm. Triceps skinfold thickness was measured to the nearest 0.2 mm with Lange skinfold calipers at the time of admission and at discharge. Midarm circumference was measured to the nearest 0.1 cm with a flexible nonstretchable plastic tape at the time of admission and at discharge. Midarm muscle area was calculated as follows:

$$\text{Midarm muscle area} = (\text{midarm circumference} - 3.14159 \times \text{triceps skinfold thickness})^2/4 \times 3.14159 \quad (1)$$

Arm measurements were made by a single observer (LB). Arm anthropometric data were compared with published norms (15). Weight, height, and body mass index z scores were calculated with EPI INFO 2002 (Centers for Disease Control and Prevention, Atlanta).

Dietary intake assessment

All nutrient intakes during hospitalization for SCT were measured by doing calorie counts. Daily calorie counts in the stem cell transplant unit are routine. The total intake of calories, protein, carbohydrate, and fat was calculated with the use of nutrient analysis software (NUTRITIONIST IV), and the pharmacy specifications for the parenteral solutions. Food quotient (FQ) was calculated according to standard methods (16).

Resting energy expenditure

In subjects able to cooperate (n = 25; mean age: 12.3 y; age range: 1.3–19.1 y), REE was measured by indirect calorimetry with the Vmax V29 metabolic monitor (SensorMedics, Yorba Linda, CA). Some younger children were not routinely able to cooperate with testing conditions, which included the need to remain at rest for ≥ 30 min under a clear canopy. Twelve subjects (mean age: 2.4 y; age range: 0.6–9.3 y) did not undergo REE measurements. Initial (baseline) REE was measured between 6 and 8 d before transplantation. Subsequent studies were performed at weekly intervals between the hours of 0700 and 0900 until hospital discharge. The calorimeter was calibrated each morning with a gas mixture of known composition. The subjects were studied in a modified fasted state (6 h without any oral or enteral intake; intravenous fluids and nutrition as needed). While the subjects were at rest in the supine position, a transparent canopy was placed over their head. Carbon dioxide production ($\dot{V}CO_2$) and oxygen consumption ($\dot{V}O_2$) were calculated each minute and then converted to standard temperature and pressure by using dry gas equations. The minute values for the fraction of oxygen in inspired air minus the fraction in expired air, the minute values for carbon dioxide in expired air minus the fraction in inspired air, $\dot{V}O_2$, $\dot{V}CO_2$, and respiratory quotient (RQ = $\dot{V}CO_2/\dot{V}O_2$) were recorded for 20–30 min, averaged, and then printed. REE was calculated by using the Weir equation and expressed as kcal/d. The percentage predicted REE was calculated by using World Health Organization (WHO) (17) and Schofield normative (18) data.

Nutritional management

PN was begun when oral dietary intake fell below REE for 5–7 d. Parenteral energy intake was titrated so that total energy intake (oral and intravenous) provided ≈100% measured REE. For children aged < 6 y who did not undergo regular REE measurements,

TABLE 1
Demographic and nutritional characteristics at the time of hospital admission in children undergoing allogeneic stem cell transplantation

Variable	Value
Age (y)	9.1 ± 6.4[1]
Male sex [*n* (%)]	17 (46)
Diagnosis (*n*)	
Acute lymphoblastic leukemia	10
Myelodysplastic syndrome	10
Chronic myelogenous leukemia	6
Acute myelogenous leukemia	3
Other	8
Type of stem cell transplantation (*n*)	
Matched, unrelated	24
Sibling, matched	13
Weight (kg)	35.9 ± 22.4
Weight-for-age *z* score[2]	0.13 ± 1.22
Height (cm)	126.9 ± 38.9
Height-for-age *z* score[2]	−0.18 ± 1.38
BMI (kg/m^2)[3]	20.0 ± 3.3
Weight-for-height or BMI *z* score	0.52 ± 1.00
Triceps skinfold thickness (% of std)	143 ± 63
Midarm circumference (% of std)[4]	105 ± 14
Midarm muscle area (% of std)[4]	103 ± 20
Prealbumin (mg/dL)	19.6 ± 6.5
Resting energy expenditure[5]	
(kcal/d)	1295 ± 357
(% of predicted)	95.1 ± 14.8

[1] $\bar{x}$ ± SD; *n* = 37, except where otherwise noted.
[2] *n* = 34.
[3] *n* = 28.
[4] Percentage of the standard, ie, 50th percentile.
[5] *n* = 23.

TABLE 2
Univariate correlations with measured resting energy expenditure in children undergoing allogeneic stem cell transplantation[1]

Variable	Pearson's *r*	*P*
Age	0.57	0.004
Weight	0.81	<0.001
Height	0.81	<0.001
BMI	0.44	0.04
Midarm circumference	0.68	<0.001
Midarm muscle area	0.82	<0.001

[1] *n* = 23.

PN was titrated so that the total energy intake was 100% of the REE estimated on the basis of WHO standards. Throughout the study, oral intake was allowed ad libitum. PN was discontinued when oral intake met REE needs for 2 consecutive days.

Laboratory methods

Serum C-reactive protein was measured by immunoassay, and serum vitamin E was measured by HPLC.

Data analysis

Data were analyzed with SPSS (release 10.1.3; SPSS Inc, Chicago) and R (version 1.4; 19). Univariate analysis between baseline REE and select clinical and demographic predictor variables was performed by using Pearson's correlation analysis for continuous variables and *t* testing for categorical variables. Data collected before and after SCT were compared with the use of paired *t* tests. The shape of the curve for REE versus time suggested a quadratic function, so a random coefficient quadratic polynomial model was fit by using restricted maximum likelihood.

RESULTS

Admission characteristics of the 37 subjects are shown in **Table 1**. Children had normal weight and body mass index variables, well-preserved visceral protein stores (as measured by serum prealbumin), normal measures of lean body mass (on the basis of measured midarm muscle area), and moderately increased fat stores (on the basis of measured triceps skinfold thickness). At baseline, mean (± SD) measured REE was 95.1 ± 14.8% of that predicted on the basis of WHO data sets. The median duration until engraftment was 20 d, and the median length of stay was 38 d. Significant univariate correlates of baseline REE are shown in **Table 2**; the admission characteristic most strongly correlated with baseline REE was midarm muscle area.

During the course of transplantation, REE variables changed significantly (**Table 3**). Between weeks 1 and 4, there was an 18% reduction in mean $\dot{V}O_2$, a 20% reduction in mean $\dot{V}CO2$, and an 18% reduction in REE (kcal/d). Between weeks 1 and 3, there was a 14% reduction in REE expressed as kcal/kg body wt. The mean RQ was > 1.0, and the FQ was < 1.0 for the duration of the study.

Anthropometric and biochemical data before and after SCT are presented in **Table 4**. Significant decreases in weight, midarm circumference, and midarm muscle area were noted, whereas triceps skinfold thickness was unchanged. This suggests that peripheral fat mass is preserved when lean body mass decreases during SCT. Serum concentrations of prealbumin rose significantly during the course of transplantation. Serum vitamin E concentrations were not significantly different over the course of SCT.

Dietary intakes during SCT are depicted in **Table 5**. Overall dietary energy intake slightly exceeded REE throughout the study, with predictable declines in oral intakes from weeks 1 to 3 and the resumption of oral intakes thereafter.

The trend of REE over time, expressed as a percentage of WHO norms, is shown in **Figure 1**. Analysis of REE data with the use of Schofield norms produced similar results. REE decreased significantly over time, reaching a nadir by weeks 3 and 4 of close to 80% of the value predicted on the basis of WHO data. A small increase in measured REE was noted in weeks 5 and 6. Random-coefficient quadratic polynomial models were fit to the REE data by using restricted maximum likelihood. On the basis of likelihood ratio tests and other model-selection criteria, it was found that a quadratic polynomial with an intercept that was allowed to vary among subjects fit the data best. Within-subject correlations for the data were found to be small, so repeated measurements within subjects were modeled as independent. The quadratic model fit, the individual 95% CIs for this fit for each week, and the data averages are shown in Figure 1. The results from this mixed-model regression are given in **Table 6**. Significant coefficients in the model included week ($P < 0.0001$) and week^2 ($P < 0.003$), indicating that REE decreases significantly over the course of SCT and then recovers along the quadratic curve.

Several covariates, including body weight, sex, time until engraftment, diagnosis, degree of match, serum concentrations of C-reactive protein, whether the donor was a relative, presence of infection, anthropometric measures, and age were examined as predictors of changes in REE over time. Of these candidate

TABLE 3
Energy expenditure data during allogeneic stem cell transplantation[1]

Time	$\dot{V}O_2$	$\dot{V}CO_2$	RQ	REE	REE	FQ
	mL/min	*mL/min*		*kcal/d*	$kcal \cdot kg^{-1} \cdot d^{-1}$	
Week 1 (n = 23)	177 ± 48	183 ± 53	1.04 ± 0.10	1295 ± 357	31.2 ± 13.3	0.95 ± 0.04
Week 2 (n = 22)	159 ± 40	158 ± 39[2]	1.01 ± 0.12	1154 ± 281[2]	29.1 ± 10.6	0.92 ± 0.03[2]
Week 3 (n = 24)	157 ± 40[2]	163 ± 39[2]	1.04 ± 0.08	1151 ± 286[2]	26.8 ± 7.9[2]	0.90 ± 0.02[2]
Week 4 (n = 16)	145 ± 48[2]	147 ± 40[2]	1.03 ± 0.10	1057 ± 331[2]	29.2 ± 11.8[2]	0.90 ± 0.04[2]
Week 5 (n = 14)	155 ± 47[2]	159 ± 48[2]	1.03 ± 0.06	1128 ± 343[2]	26.4 ± 8.2[2]	0.92 ± 0.04

[1] $\bar{x}$ ± SD. $\dot{V}O_2$, oxygen consumption; $\dot{V}CO_2$, carbon dioxide production; RQ, respiratory quotient; REE, resting energy expenditure; FQ, food quotient.
[2] Significantly different from week 1, $P < 0.05$ (mixed-effects model with fixed effects for subject and week adjusted for multiple comparisons).

covariates, only sex was found to be of use as an explanatory variable. The boys tended to have a higher baseline REE than did the girls, but the difference was only nearly significant ($P = 0.08$) by both a likelihood ratio test and a two-sample t test.

DISCUSSION

In our cohort of 37 pediatric patients undergoing allogeneic SCT and managed with PN, we found significant changes in REE and anthropometric measures of nutritional status in the weeks immediately after transplantation. On admission, subjects had well-preserved body weight and arm anthropometrics and nearly normal REE measurements. We found strong correlations between baseline REE measurements and readily available clinical information, including bedside measures of body composition. After transplantation, significant decreases in body weight and lean body mass were noted, whereas peripheral fat mass was unchanged. In addition, we observed significant decreases in $\dot{V}O_2$, $\dot{V}CO_2$, and REE, with some recovery toward baseline values later in the hospitalization. These declines were substantial, ranging from 14% to 20% compared with baseline measures.

We also noted important changes in the biochemical profiles of our subjects. Despite supplementation with vitamin E, serum concentrations of this nutrient did not change over the course of SCT. Previous studies documented a decrease in serum vitamin E concentrations after SCT (20, 21), so the fact that our subjects were able to maintain normal serum concentrations of vitamin E may be a notable positive finding. Vitamin E and other antioxidants have been hypothesized to reduced lipid peroxidation in the setting of SCT (22).

The energy needs of patients undergoing SCT have been the subject of only a limited number of studies. A study of 7 adults undergoing allogeneic SCT reported a tendency for REE to increase in the 3 wk after transplantation. However, wide variability in REE values were noted, with values ranging from 79% to 121% of estimated basal needs during that time (23). Another study of adult SCT patients found that allogeneic SCT patients had an average reduction in REE after transplantation of 8%, whereas autologous SCT patients had an 11% increase in REE, both compared with predicted values. This study suggests that the nutritional requirements of adults undergoing autologous or allogeneic SCT may vary because of differences in treatment regimens (24).

Few studies of energy metabolism have been performed in children with cancer. Stallings et al (25) measured REE in 9 patients with acute lymphoblastic leukemia (ALL) and found that patients with a higher tumor burden (elevated white blood cell count and organomegaly) had an increased REE. A study of 26 patients with ALL or solid tumors in remission showed no evidence of an increased REE compared with age- and sex-matched healthy control subjects (26). Using a combination of indirect calorimetry and ambulatory heart rate monitoring to measure REE and total energy expenditure in 34 long-term survivors of ALL, Warner et al (27) concluded that ALL survivors have a lower total energy expenditure, largely because of a lower physical activity (27). Of 6 children undergoing autologous peripheral blood SCT, REE was higher than predicted up to 22 d after transplantation (28). To our knowledge, our study is the largest and most systematic evaluation of REE in children undergoing SCT.

Limiting PN intake to avoid overfeeding and other metabolic complications has been reported in one previous study of SCT patients (10). In that study, adult SCT patients were assigned to PN that provided either 150% of estimated basal needs or 100% of basal needs. Serum sodium and potassium concentrations were maintained in the normal range more often in patients who received lowered amounts of PN than in those who received 150% of estimated basal needs. Nitrogen balance was negative and was not significantly different between the 2 study groups. In another trial in adult SCT patients, subjects receiving micronutrients and a small amount of intravenous lipids had better preserved

TABLE 4
Changes in anthropometric and biochemical data in children before and after allogeneic stem cell transplantation (SCT)[1]

	Before SCT	After SCT
Weight (kg)	35.9 ± 22.4	33.8 ± 20.6[2]
Weight-for-age z score	0.13 ± 1.22	−0.24 ± 1.29[2]
Triceps skinfold thickness		
(mm)	16.5 ± 7.4	15.8 ± 8.7
(% of std)	143 ± 62	132 ± 61
MUAC		
(cm)	21.9 ± 5.5	21.4 ± 5.4[3]
(% of std)	105 ± 14	102 ± 15[4]
MAMA		
(cm^2)	24.6 ± 12.0	22.9 ± 9.6[3]
(% of std)	103 ± 20	98 ± 19
Serum prealbumin (mg/dL)[5]	19.6 ± 6.5	26.0 ± 7.3[2]
Serum vitamin E (mg/dL)[6]	14.7 ± 6.4	13.2 ± 6.1

[1] x ± SD; n = 37, except where noted otherwise. MUAC, midupper arm circumference; MAMA, midarm muscle area; std, standard (50th percentile).
[2–4] Significantly different from before SCT (paired t test): [2] $P < 0.001$, [3] $P = 0.03$, [4] $P = 0.02$.
[5] n = 33.
[6] n = 27.

TABLE 5
Dietary intake during stem cell transplantation in children[1]

Time	Energy	Protein	Fat	Total energy intake via oral nutrition	Measured REE
	kcal/d	*g/d*	*g/d*	*%*	*% of total energy intake*
Week 1 (n = 37)	938 ± 501	23.3 ± 21.8	19.4 ± 19.8	59 ± 32	85 ± 40[2]
Week 2 (n = 37)	1037 ± 485	29.2 ± 18.5	25.3 ± 15.9	27 ± 36	106 ± 27[2]
Week 3 (n = 37)	1053 ± 450	35.3 ± 19.0	26.7 ± 15.9	23 ± 33	114 ± 34[3]
Week 4 (n = 37)	1114 ± 572	38.2 ± 22.8	28.7 ± 20.5	48 ± 41	116 ± 36[4]
Week 5 (n = 31)	1135 ± 566	36.8 ± 23.3	25.7 ± 14.1	60 ± 40	110 ± 23[5]

[1] $\bar{x}$ ± SD.
[2] n = 23.
[3] n = 24.
[4] n = 16.
[5] n = 13.

antioxidant status than did those who received 120% of estimated energy needs from standard PN. Clinical outcomes were not reported (21).

Several limitations of our study should be noted. First, the limitation of energy intake to 100% of measured REE may itself have led to an adaptive reduction in REE. Among healthy adults fed 800 kcal/d until 10% weight loss ensued, REE decreased 15% (29). In contrast, dietary energy intake among our subjects (Table 5) averaged near 110% of measured needs, RQ was close to 1.0 throughout the study, and the FQ was less than the RQ, implying that energy intake was provided in excess of needs. Although subjects did lose weight during the study, their final body weight was only 6% lower than their admission weight. Even when body weight was taken into consideration by expressing REE in kcal · kg^{-1} · d^{-1}, decreases in energy expenditure were observed. It seems likely that the decreased lean body mass in the patients, presumably resulting from the effects of radio- and chemotherapy, was more responsible for the observed decrease in REE than was the reduction in energy intake from PN.

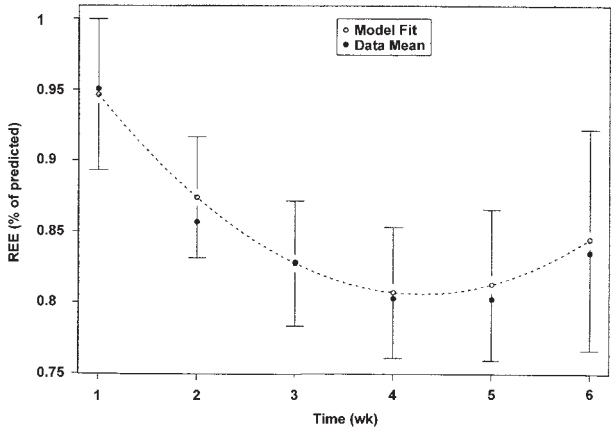

FIGURE 1. Changes in measured resting energy expenditure (REE) over time in children undergoing allogeneic stem cell transplantation (n = 25). Values are the percentage of the values predicted on the basis of World Health Organization norms (18).

Second, anthropometric measurements of body composition may be inaccurate in the setting of fluid shifts and edema, both of which are common in patients who have undergone SCT. We tried to avoid these biases by limiting our measures of peripheral fat and lean tissue to 2 points only (before and after SCT) and by having all measurements performed by one observer. More detailed measures of body composition during SCT, such as with dual-energy X-ray absorptiometry or isotope dilution, might allow evaluation of these issues. Finally, our analysis was limited to subjects undergoing allogeneic SCT, who are maintained with cyclosporine for GVHD prophylaxis. Cyclosporine itself has effects on blood glucose and lipids that might influence measured nutritional outcomes. In addition, patients undergoing unrelated donor SCT received steroids for ≥2 wk during the study, and others who developed GVHD were treated with corticosteroids. GVHD itself may place different metabolic demands on patients, in contrast with the demands on, for example, patients receiving autologous SCT, who might have a different clinical and metabolic response to transplantation. We observed no differences in patients who underwent matched-sibling or unrelated donor transplantation.

The nutritional management of pediatric patients undergoing SCT is largely based on empirical estimates of energy and nutrient needs. As survival rates have improved for these patients, it has become increasingly clear that long-term nutritional problems are common, including obesity (30), short stature (31), and insulin resistance (32). Our data suggest that standard approaches to the nutritional management of SCT patients, which commonly provide 120–150% of estimated basal energy needs (11), may provide excess energy intake. In addition, the preferential loss of lean body mass relative to fat mass may be related to this reduction in REE. We successfully used indirect calorimetry in a research setting to measure energy expenditure; the procedure was well tolerated and it may be a useful clinical tool as well. Further studies of body composition and energy needs in patients undergoing SCT are needed.

TABLE 6
Coefficients from a random intercept model for changes in resting energy expenditure over time

	Value	SE	df	t	P
Intercept	0.83	0.02	81	37.11	<0.0001
Week	−0.03	0.006	81	−4.91	<0.0001
Week[2]	0.013	0.004	81	3.10	<0.0026

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CD, LB, and EG designed the study. KD, AO, CH, and LL collected data and enrolled the subjects. EG and LL oversaw the completion of the supportive-care protocol. MV and CD performed the data analysis. All authors reviewed the final report.

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