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Energy Prediction Equations for Obese Hispanic Youth

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Abstract

Assessing energy requirements is a fundamental activity in clinical dietetic practice. A study was designed to determine if published linear regression equations were accurate for predicting resting energy expenditure (REE) in fasted, obese Hispanic children (7–15 y). REE was measured using indirect calorimetry; body composition was estimated with whole-body air displacement plethysmography. REE was predicted using four equations: Institute of Medicine for healthy-

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weight children (IOM-HW), IOM for overweight and obese children (IOM-OS), Harris-Benedict, and Schofield. Accuracy of the prediction was calculated as the absolute value of the difference between the measured and predicted REE divided by the measured REE, expressed as a percentage. Predicted values within 85%–115% of measured were defined as accurate. Participants ($n=58$; 53% male) were 11.8 ± 2.1 y (mean $\pm$ SD), had $43.5\pm5.1\%$ body fat and a body mass index (BMI) of 31.5 ± 5.8 kg/m² (98.6 ± 1.1 BMI percentile). Measured REE was 2339 ± 680 kcal/d; predicted REE was 1815 ± 401 kcal/d (IOM-HW), 1794 ± 311 kcal/d (IOM-OS), 1151 ± 300 kcal/d (Harris-Benedict), and, 1771 ± 316 kcal/d (Schofield). Measured REE adjusted for body weight averaged 32.0 ± 8.4 (95% CI: 29.8, 34.2) kcal/kg per day. Published equations predicted REE within 15% accuracy for only 36–40% of 58 participants, except for Harris-Benedict, which did not achieve accuracy for any participant. The most frequently accurate values were obtained using IOM-HW, which predicted REE within 15% accuracy for 55% (17/31) of boys. Published equations did not accurately predict REE for youth in the study sample. Further studies are warranted to formulate accurate energy prediction equations for this population.

Keywords

resting energy expenditure; Hispanic; obese; Institute of Medicine; Harris Benedict; Schofield; youth; lean body mass

INTRODUCTION

The assessment of energy requirements is a fundamental activity in clinical dietetic practice. Basal energy represents the minimal energy supporting vital organ functions, which is estimated from indirect calorimetry measures of resting energy expenditure (REE) (1). REE is used along with assessment of physical activity to plan diet therapy. REE is especially poignant in the care of those with limited tolerance or capacity to self-correct overfeeding or underfeeding (e.g., mechanically ventilated patients) (2). Since measuring REE requires specialized and expensive equipment, REE is often predicted using linear regression equations (1,3,4).

The Harris-Benedict equations (HBEE) (3) were generated from REE measures of mostly college students and faculty of unreported race and ethnicity (Table 1). Only 19 participants enrolled by Harris and Benedict (3) were overweight or obese (5). Although few young children were included in the dataset and despite lack of agreement with pediatric measures (6,7), HBEE continues to be used in pediatric practice (8). The Schofield equations (4) were generated from data published over a sixty-year period in the scientific literature of mostly European and North American children (Table 1). According to the Institute of Medicine (IOM) (1), the pediatric Schofield equations (4) were validated in British (9) and Dutch (10) children. More recently, IOM (1) generated prediction equations for healthy-weight children (IOM-HW) and for overweight and obese children (IOM-OS). These equations are intended for use with age 3–18 y, although the data sample used to derive equations was young, averaging 7–9 y. The racial composition of the volunteers was mostly Caucasian in the IOM-HW data set but predominantly American Indian in the IOM-OS data set and the ethnicity in both data sets was <7% Hispanic (1). The IOM equations have yet to be validated.

Obesity and its complications are highly prevalent among Hispanic American youth. In the 2007–2008 National Health and Nutrition Examination Survey, 23% of Hispanic American children and adolescents were reported as having body mass index (BMI) clinical growth curves at $\geq 95^{\text{th}}$ percentile, an 80% higher prevalence compared to non-Hispanic white children and adolescents (11). Obese Hispanic Americans also have a high prevalence of

obesity-associated co-morbidities, including hyperinsulinemia and impaired glucose tolerance (12,13). For these reasons, the investigative team undertook research in Hispanic children. REE equations were of interest for use in planning meal studies, but the accuracy of various equations was not known for US children. The primary hypothesis tested whether there was a significant difference between an individual's measured REE value and the REE predicted by each of four equations: IOM-HW (1), IOM-OS (1), HBEE (3), and Schofield (4).

METHODS

Participants

The data were derived from baseline measures of participants enrolled in a weight-loss trial, whose procedures were approved by the Children's National Medical Center Institutional Review Board. Participants were recruited at a hospital-affiliated clinic located in a predominantly Hispanic neighborhood in Washington, DC. Inclusion criteria included obesity, Hispanic ethnicity, age 7–15 y, and ambulatory. Children with type 2 diabetes, pervasive development delay, cerebral palsy, severe asthma, Cushing syndrome, Prader-Willi syndrome, or untreated hypothyroidism were excluded. Consent and assent were obtained from parents and children, respectively.

Procedures

Participants arrived at the Clinical Research Center at 7:00 am after a 12-hour fast. The study physician conducted a medical history, physical examination and screened participants for exclusionary conditions. Compliance with fasting procedures was confirmed from a 24-hour dietary recall. The child was asked to void and change into a hospital gown. Height and weight were measured in triplicate using a wall-mounted stadiometer (SECA 216, Hanover, MD) and digital scale (Healthometer, Bridgeview, IL), respectively. BMI was calculated, BMI percentiles for age and sex were determined (14), and obesity was defined as BMI $\geq 95^{\text{th}}$ % percentile (15). Body composition was assessed in spandex clothes and swim cap via whole-body air displacement plethysmography (BOD POD®, Life Measurement, Concord, CA) using the Siri equation (16).

Participants rested in a private room on a bed in a semi-recumbent position for 20–30 minutes prior to testing. The participant was fitted with a face mask (PreVent™, Medical Graphics Corporation, St. Paul, MN) connected to a pneumotach tube into which a sensor probe containing a pair of differential pressure transducers was secured. Measures of REE were obtained using indirect calorimetry (Ultima Cardio2™ system, Medical Graphics Corporation, St. Paul, MN). All calibration procedures were performed to manufacturer specifications prior to testing each morning, including manual flow using a 3 L syringe and calibration with gases of known concentration. The operator monitored the measuring device and the participant during the entire 30-minute test in which the child was instructed to lie as still as possible. The values collected in the initial five minutes of testing were excluded to allow the participant time to adjust to the test conditions. REE measures, converted to a 24-hour value (kcal/d), were averaged for each participant.

Four prediction equations were selected based on feasibility for clinical use (e.g., used height, weight, age, sex): IOM-HW (1), IOM-OS (1), HBEE (3) and Schofield (4). For the Schofield equation (4), 239.0 kcal/MJ was used to convert REE values from MJ to kcal.

Statistical Analyses

For purposes of comparison, children were grouped according to the “Life Stage Groups” established by IOM (1): 7–8 y, 9–13 y, 14–15 y. Bias was defined as the relative difference

between the predicted and measured REE. If the bias was 15% or less of the magnitude of the measured REE, then the prediction equation was considered accurate for that individual. The proportion of individuals for whom equations predicted REE within 10%, 15%, 20% and 30% of the measured value was determined. The measured and predicted REE were compared by paired t-tests and the bias of each prediction equation was examined using Bland-Altman plots (17) across all subjects and within each gender and age group. Significant predictors of REE were identified using multiple linear regression analysis. To satisfy the assumption of normality required for analysis, REE (kcal/d), REE (kcal)/total body weight (kg) per day and REE (kcal)/lean body mass (LBM; kg) per day were log transformed. Data were analyzed using SAS version 9.1 (Cary, NC) and reported as mean $\pm$ SD (and range or 95% CI). All statistical comparisons were made at the 0.05 significance level.

RESULTS AND DISCUSSION

During REE measurement, problems arose with non-adherence to resting conditions and occasional mechanical failure of unknown origin, which was detected primarily as episodes of abnormal respiratory rates on the equipment monitor that were not congruent with visual inspection of the child's breath pattern. These factors limited the amount of data per subject and the number of subjects who could be included. Of 84 youth whose REE was measured, 24 subjects had less than 15 minutes of usable data collected when respiratory rates were within a healthy physiological range at rest (i.e., 10–29 bpm) (18–21). Two additional subjects were excluded specifically because they did not stop talking or coughing.

Subject Characteristics

Participants (n=58; 53% male) were 11.8 ± 2.1 (7.1–15.7) y and 72% (42/58) were 9–13 y. BMI was 31.5 ± 5.8 (23.5–49.7) kg/m², at the 98.6 ± 1.1 (95.2 – 99.8)th BMI percentile, and BMI z-score was 2.30 ± 0.29 . Body fat averaged $43.5 \pm 5.1\%$ (n=57), was not significantly correlated with age and did not differ significantly by sex. Height was similar for males (153.1 ± 12.0 cm) and females (152.9 ± 8.1 cm). Characteristics of the study sample, grouped by sex, were compared to participants in studies in which REE was predicted (Table 1).

The majority of parents (58/84, 69%) identified themselves as El Salvadoran. The potential exists that these results may not reflect the overall Hispanic population and/or the general population. Demographic characteristics were similar when comparing the children included (n=58) with those excluded (n=26) from analysis.

Measured REE

The duration of the REE test period averaged 22.7 ± 3.0 minutes per child, not including the five-minute adjustment period. Limited data are available to support the customary use of a five-minute period to familiarize children with testing conditions, to achieve a steady state, or to determine the minimum duration for data collection that best represent a daily value. One pediatric study reported lack of significant difference in 24-hour REE when calculated from 10-, 15-, 20-, 25-, or 30-minute test periods (22).

The respiratory rate and respiratory quotient (RQ) averaged 16.9 ± 2.3 (11.6–22.6) bpm and 0.88 ± 0.07 (0.78–1.25), respectively. Spearman correlation to compare REE with RQ before and after controlling for LBM were -0.35 (p= 0.0064) and -0.42 (p= 0.0012), respectively. Thus, there was a statistically significant negative correlation between RQ and REE regardless of LBM, meaning that lower RQ values were observed for subjects with higher REE; a finding that deserves more investigation. There were no significant differences between sexes for respiratory rate, VO₂, VCO₂, or RQ. In contrast, one small study showed

a trend where girls (n=12) had higher RQ than boys (n=12) when data were adjusted for daily energy balance (23). The RQ was similar to that reported for overweight and obese German children (24) and for non-overweight and overweight Hispanic Texan children (25). RQ differs by height, weight, body fatness and LBM ($P=0.001$) (25) but the reason some participants had $RQ > 0.85$, which is higher than anticipated for fasting conditions, is not known. Resting RQ of 0.98 was reported for fasted obese children (24) and might be due to increased production/retention of carbon dioxide, altered regulation of carbohydrate/energy, or reflect values calculated under conditions that are not consistent with assumptions used in the metabolic cart/Weir equation (26).

The REE for all participants averaged 2339 ± 680 (1205–3959) kcal/d. Grouped by age, REE was 1612 ± 362 (1165–2081) kcal/d for 7–8 y, 2386 ± 665 (1298–3973) kcal/d for 9–13 y, and 2687 ± 569 (1750–3291) for 14–15 y. In comparison, published REE for normal-weight children (boys/girls) was 1035/1004 kcal/d, 1320/1186 kcal/d, and 1729/1361 kcal/d for age 3–8 y, 9–13 y, and 14–18 y respectively (1). Other studies also reported significantly higher 24-hour REE for obese children compared to non-obese children ($P \leq 0.01$) (24,27,28), which is thought to be due to greater-than-normal amounts of structural lean tissue—the primary determinant of REE (25,27,29–32).

Measured 24-hour REE adjusted for body weight averaged 32.0 ± 8.4 (95% CI: 29.8, 34.2) kcal/kg. Grouped by age, weight-adjusted REE was 32.7 ± 5.3 (95% CI: 27.8, 37.6), 32.8 ± 9.2 (95% CI: 29.9, 35.6) and 27.6 ± 5.5 (95% CI: 23.4, 31.9) kcal/kg per day for 7–8 y, 9–13 y, and 14–15 y, respectively. In this sample of obese youth, neither REE (kcal/kg total body weight per day) nor REE (kcal/kg LBM per day) were correlated with age and did not differ significantly between males (32.0 ± 6.3 kcal/kg per day; 55.8 ± 11.4 kcal/kg LBM per day) and females (31.9 ± 10.5 kcal/kg per day; 57.5 ± 17.7 kcal/kg LBM per day). The comparison using individual t-tests between 7–8 y (58.5 ± 10.0 kcal/kg LBM per day) vs. 14–15 y (49.0 ± 9.1 kcal/kg LBM per day) was borderline significant ($p=0.0558$). The failure to detect differences may be due to the small sample size tested. The average REE in this study, measured using breath-by-breath analysis, was higher than the 22–26 kcal/kg per day reported for studies of obese children measured using a head canopy in which exhaled air from multiple breath cycles was intermingled and sampled (30,33). The measured REE for 7–8 y youth was lower than normal-weight values (boys/girls) of 51/44 kcal/kg per day for 3–8 y (1), which was expected since the comparison group included younger children who have higher metabolic rates. Mean REE was nearly that of normal-weight values (boys/girls) of 37/33 kcal/kg per day for 9–13 y and 29/25 kcal/kg per day for 14–18 y (1). Weight-adjusted REE was expected to be lower for obese individuals than for healthy-weight children (28,30,33) because fat tissue is substantially less metabolically active than LBM, and fat mass contributes proportionately more to the total body weight in obesity. To our knowledge, only one study tested differences in REE (24-hour kcal/kg total body weight) as a factor of obesity. Among 7–16 y white Spanish children, REE averaged 25.9 ± 4.4 versus 33.3 ± 5.3 kcal/kg per day ($P < 0.001$) for obese (n=57) and non-obese (n=59) participants, respectively (30). Other studies also indicated an average 7–10 kcal/kg per day lower REE in obese than normal-weight children (6,24,28,34).

Predicted REE

Predicted REE differed from measured values in the total sample ($P < 0.001$; Table 2). The equations under-predicted (negative error) the measured REE by 524–569 kcal/d, except for HBEE (3), which estimated REE at only 13–24 kcal/kg per day and under-predicted measured values by 1173 kcal/d. The predicted REE were $\pm 15\%$ of measured REE for only 36–40% of the 58 participants, except using HBEE, which did not achieve that level of accuracy for any participant. The volunteers measured by Harris and Benedict (3) were taller, less overweight, and more advanced in age than youth in the current study (Table 1).

Others (35) reported that HBEE correctly predicted REE for only 33% of 7–18 y obese, Caucasian Italian youth, using a stringent definition of accuracy within $\pm 5\%$ of the measured value; and similar to our findings, errors were due to underestimation.

Both IOM equations achieved similar levels of accuracy (Table 2). The IOM and Schofield equations also produced similar levels of accuracy but the equations differed in the individuals for whom they were accurate (i.e., same number of people with accurate predictions by IOM-OS and Schofield but different individuals). Among children aged 7–8 y, the IOM-HW prediction equation came within 15% of the measured value for 5 of 7 (71%) participants and both IOM-OS and Schofield equations were accurate for 4 of 7 (57%) of these young participants. Among teenagers aged 14–15 y, the IOM and Schofield equations accurately predicted REE for 2 of 9 (22%) participants. These preliminary data should be interpreted cautiously given the small sample tested. Among the larger sample subsets (male, female and age 9–13 y), the most frequently accurate values were obtained using the IOM-HW equation for males, which predicted REE within 15% accuracy for 17 of 31 (55%) participants (Table 2). In our sample, the greatest underestimations (bias) were evident in females ($n=27$), for whom the predictive ability of IOM and Schofield equations were similarly poor and accurate for only 22–30% of participants (Table 2). The inclusion of more data from older youth and recalculation of the IOM equations might remedy some discrepancies in accuracy.

Similar to our results, the Schofield equation (4) accurately predicted REE for 27% of obese Caucasian children ($n=287$) (36). In that study (36), where accuracy was defined as $\pm 5\%$ of the measured value, the Schofield equation underestimated measured REE for girls and overestimated REE for boys. Elsewhere (37), use of the Schofield equation produced accurate estimates that were $\pm 10\%$ of measured values for 51% of obese Dutch youth, but underestimated REE for 15% of participants and overestimated REE for the remaining 34%, yielding a mean group percentage error of 3.7%. Schofield (4) derived his prediction equations from largely normal-weight youth. Thus, the tendency for the Schofield equation to underestimate REE in our study may be due in part to obese youth having proportionally more LBM per unit height than their leaner counterparts.

A subgroup of participants had REE values around the zero mark on the Bland-Altman plots (17) indicating that predictions can be highly accurate for some individuals using the IOM and Schofield equations, particularly for participants with REE at the low end of the range measured (Figure 1). However, two patterns of systematic bias emerged: #1) variation in the magnitude of absolute bias (predicted minus measured) of 24-hour REE; and, #2) the slope of the regression line (Figure 1). The scatter plot of the differences between predicted and measured REE (bias) appeared to widen systematically as mean 24-hour REE increased, which has been observed in other studies (32,36,38,39). The second notable bias—that of a sloped regression line—was also reported by others (32,40). Thus, both substantial overfeeding and underfeeding are possible when prediction equations are used to plan feeding for obese children, particularly at the upper end of REE. This level of inaccuracy is especially concerning if such estimates are made for feeding critically ill children. The pattern of a sloped bias suggests that limits of agreement (the values set to define measurement accuracy) may need to be related to the scale of measurement, so for example, there might be greater latitude with higher REE.

In normal-weight children, 24-hour REE (kcal/d) is higher for boys than girls (1) and this difference was also reported in studies of obese children (27,41,42). Sex was a significant predictor of 24-hour REE in 11–18 y obese US children (43) and remained a significant explanatory variable after adjusting for body weight and LBM (41). Other studies showed that both obesity and sex had independent and significant effects on 24-hour REE (28). In

obese children, the difference in REE between sexes increased with age and remained significant when adjusted for LBM (42). However, the measured REE in our study was not statistically different between sexes, perhaps because sex differences are less a factor in REE for children who, on average, are at the 99th BMI percentile. Factors other than age, sex, height and weight may need to be included to improve predictive ability, especially at the upper range of REE. In our sample, LBM, RQ, and BF% were the best (statistically significant) predictors of 24-hour REE; height, age and sex were not significant: $REE (kcal/d) = -2702.43 * LOG(RQ) + 37.05 * LBM (kg) + 431.65$, with significance of $P=0.0039$ for RQ and $P<0.0001$ for LBM. Total body weight (kg) was also a significant ($P<0.0001$) explanatory variable: $REE (kcal/d) = 1509.54 * LOG(body weight in kg) - 4122.41$.

Future research might consider testing the explanatory value of Tanner stage and circumferences that clinicians can easily measure in obese children (i.e., neck, mid-arm). The scientific community has yet to verify whether ethnicity plays a role in determining REE. One report (40) indicated that for US girls, the accuracy of the Schofield equation was significantly affected by race ($P<0.03$) after controlling for age, body weight, LBM, height, and sexual maturation, producing overestimated REE among African-American girls. Thus, the explanatory value of race and ethnicity deserves further investigation.

CONCLUSION

To our knowledge, this was the first evaluation of IOM equations (1) for use in predicting REE in children. Based on high margins of error revealed by this study, the IOM-OS equation needs to be recalculated with inclusion of more data to improve its accuracy but this will depend on the availability of additional pediatric REE data. Until then, informed and cautious judgment is needed by clinicians when using existing prediction equations at the individual level, including monitoring the client's response to the amount of energy provided. The HBEE (3) was the least accurate of the equations tested and is not recommended for use in this population. Additional tools, such as the use of accelerometers should be investigated for clinical use in assessing energy requirements (44), and these data reviewed by the American Dietetic Association's Evidence Analysis Library (45). Further studies are justified to investigate genetic influences on energy metabolism that play a role in the growing and persistent obesity problem among Hispanic children.

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1a: IOM-HW versus measured.

1b: IOM-OS versus measured.

1c: Schofield versus measured.

Figure 1. Bland-Altman plotsof predicted and measured resting energy expenditure (REE) in Hispanic youth (n=58)

1a.IOM-HW, Institute of Medicine equati on for healthy-weight children (1); 1b. IOM-OS, Institute of Medicine equation for overweight and obese children (1); 1c. Schofield equation (4).

Table 1

Characteristics of the study sample of obese Hispanic youth (n=58), grouped by sex, and comparison to participants in other studies that predicted resting energy expenditure.^a

	Males		Females	
Study Sample	(n=31)		(n=27)	
Age (y)	11.5 ± 2.2 (7.1 – 15.7)		12.0 ± 1.9 (8.6 – 15.3)	
Weight (kg)	72.2 ± 20.4 (43.7 – 119.6)		78.2 ± 21.5 (44.3 – 137.3)	
BMI (kg/m ²)	30.2 ± 4.6 (23.5 – 41.2)		33.0 ± 6.7 (24.2 – 49.7)	
Harris-Benedict Sample	(n=136)		(n=103)	
Age (y)	26.9 ± 8.8 (16.0 – 63.0)		31.1 ± 13.9 (15.0 – 74.0)	
Weight (kg)	64.1 ± 10.3 (33.2 – 108.9)		56.4 ± 11.4 (35.6 – 94.1)	
BMI (kg/m ²)	21.4 ± 2.9 (15.2 ± 32.5)		21.5 ± 4.1 (12.3 – 34.6)	
IOM-HW Sample	(n=154)		(n=397)	
Age (y)	7.8 ± 3.0 (3.0 – 18.0)		9.3 ± 3.1 (3.9 – 18.0)	
Weight (kg)	27.3 ± 11.0 (15.4 – 70.6)		31.4 ± 11.6 (14.6 – 67.3)	
BMI (kg/m ²)	16.1 ± 1.6 (13.8 – 22.2)		16.8 ± 2.1 (13.6 – 23.4)	
IOM-OS Sample	(n=157)		(n=249)	
Age (y)	7.5 ± 2.5 (4.0 – 18.8)		8.9 ± 3.2 (4.0 – 16.3)	
Weight (kg)	39.3 ± 16.1 (18.1 – 83.9)		45.0 ± 19.6 (16.7 – 128.2)	
BMI (kg/m ²)	22.1 ± 4.6 (14.9 – 38.2)		22.9 ± 4.9 (16.8 – 44.6)	
Schofield Sample	(n=1072)		(n=988)	
Age category (y)	3 – 10	11 – 18	3 – 10	11 – 18
Age (y)	7.5 ± 1.8 (3.1 – 10.6)	13.7 ± 2.4 (11.1 – 18.6)	7.6 ± 1.7 (3.4 – 10.7)	12.8 ± 2.3 (11.2 – 18.3)
Weight (kg)	21.5 ± 4.4 (15.7 – 33.9)	41.8 ± 14.6 (28.6 – 77.1)	21.4 ± 4.7 (14.2 – 34.0)	38.5 ± 11.2 (25.5 – 72.4)
BMI (kg/m ²)	15.3 ± 1.3 (11.7 – 18.8)	18.1 ± 2.7 (10.5 – 25.9)	15.3 ± 1.5 (11.3 – 19.4)	17.6 ± 2.6 (11.1 – 24.1)

^aMean±SD (range); BMI: body mass index; Harris-Benedict (3); IOM-HW: Institute of Medicine for healthy-weight children (1); IOM-OS: Institute of Medicine for overweight and obese children (1); Schofield (4).

Table 2

Bias, precision, and accuracy of linear regression equations used in predicting 24-h resting energy expenditure (REE) of Hispanic youth.

Equation	Predicted REE (kcal/d) ^a	Bias (Predicted minus Measured)	Precision (SD of Bias)	Number of Accurate Individual Predictions (% Participants)		
				Accuracy within 30% of Measured	Accuracy within 15% of Measured	Accuracy within 10% of Measured
Total (n=58) Measured REE: 2339±680 kcal/d						
IOM-HW	1815±401 ^b	-524	636	41 (71%)	23 (40%)	13 (22%)
IOM-OS	1794±311 ^b	-546	580	43 (74%)	21 (36%)	18 (31%)
Schofield	1771±316 ^b	-569	605	38 (66%)	21 (36%)	18 (31%)
Males (n=31) Measured REE: 2272±632 kcal/d						
IOM-HW	2045±398	-227	414	29 (94%)	17 (55%)	9 (29%)
IOM-OS	1880±331 ^c	-392	433	25 (81%)	13 (42%)	12 (39%)
Schofield	1909±335 ^c	-362	431	25 (81%)	13 (42%)	11 (35%)
Females (n=27) Measured REE: 2417±736 kcal/d						
IOM-HW	1551±188 ^b	-866	681	12 (44%)	6 (22%)	4 (15%)
IOM-OS	1694±256 ^b	-722	678	18 (67%)	8 (30%)	6 (22%)
Schofield	1611±201 ^b	-806	693	13 (48%)	8 (30%)	7 (26%)
Youth Ages 9-13 (n=42) Measured REE: 2386±665 kcal/d						
IOM-HW	1813±401 ^b	-573	681	27 (64%)	16 (38%)	8 (19%)
IOM-OS	1789±294 ^b	-597	617	29 (69%)	15 (36%)	12 (29%)
Schofield	1760±304 ^b	-626	641	25 (60%)	15 (36%)	12 (29%)

^a Mean±SD; Predicted REE (kcal/d) for individuals is significantly different from measured REE (

^b $P < 0.0001$;

^c $P < 0.008$).

except for IOM-HW in males. IOM-HW: Institute of Medicine for healthy-weight children (1); IOM-OS: Institute of Medicine for overweight and obese children (1); Schofield (4).