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A Comparison of Predictive Equations of Energy Expenditure and Measured Energy Expenditure in Critically Ill Patients

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Abstract

PURPOSE—Multiple equations exist for predicting resting energy expenditure (REE). The accuracy of these for estimating caloric requirements of critically ill patients is not clear, especially for obese patients. We sought to compare REE, calculated with published formulas, with measured REE in a cohort of mechanically-ventilated subjects.

MATERIALS AND METHODS—We retrospectively identified all mechanically-ventilated patients with measured body mass index (BMI) who underwent indirect calorimetry (IC) in the ICU. Limits of agreement and Pitman's test of difference in variance were performed to compare REE by equations with REE measured by IC.

RESULTS—927 patients were identified, including 401 obese patients. There was bias and poor agreement between measured REE and REE predicted by the Harris-Benedict, Owen, ACCP, and Mifflin equations ($p > 0.05$). There was poor agreement between measured and predicted REE by the Ireton-Jones equation, stratifying by gender. Ireton-Jones was the only equation which was

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CONFLICT OF INTEREST

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All authors have contributed to the conception and design of the study. Dr. Sena and Ms. Schmidt were responsible for the study conception, design and acquisition of data. Drs. Kross and Stapleton are responsible for the design of the study, analysis and interpretation of data. Dr. Kross drafted the manuscript, and all authors have critically reviewed the manuscript and contributed to the final manuscript. Dr. Kross takes responsibility for the integrity of this work as a whole, from inception to publication.

unbiased, for men and those in weight categories I and II. In all cases except Ireton-Jones, predictive equations underestimated measured REE.

CONCLUSION—None of these equations accurately estimated measured REE in this group of mechanically-ventilated patients, most underestimating caloric needs. Development of improved predictive equations for adequate assessment of energy needs is needed.

Keywords

Nutrition; Calorimetry; Critical Illness; Obesity

INTRODUCTION

Many multiparameter predictive equations exist for predicting resting energy expenditure (REE), but the accuracy of these for estimating caloric requirements for critically ill patients is not clear¹⁻⁶. Most of the predictive equations were typically derived from studies of healthy, non-hospitalized individuals⁷, while only a few have been validated in mechanically ventilated patients^{1,8}. Estimating REE becomes even more complicated in the setting of obesity, which is increasingly prevalent in the United States^{9,10}. Several previous studies have assessed the agreement of measured and calculated REE, but none has included a large number of obese, mechanically ventilated subjects^{1,5,7,8,11-17}. The limited data that is available for mechanically ventilated, obese patients suggest that predictive equations perform poorly in this cohort. Accurate determination of the energy needs is obviously important in both obese and normal weight patients as both over and underfeeding may be associated with complications and undesired consequences¹⁸⁻²¹.

The Society for Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) guidelines recommend that the target goal of enteral nutrition should be determined and clearly identified at the time of initiation of nutrition support therapy²². Enteral requirements may be calculated either by using predictive equations or indirect calorimetry. The “gold standard” method for determining REE in hospitalized patients is indirect calorimetry (IC), a method where measurements of oxygen consumption (VO₂) and carbon dioxide production (VCO₂) are used to calculate whole body energy utilization over 24 hours^{2,23-25}. Indirect calorimetry is often employed in the ICU for a brief period (e.g. 30 minutes) and extrapolated to 24 hour predictions. Standard use of indirect calorimetry in the intensive care unit is impractical and may be limited due to equipment availability, staffing and cost²⁴. Therefore, predictive equations are an appealing method to estimate patients’ energy needs. Several predictive equations are commonly used in the inpatient setting to estimate energy needs. These include the Harris-Benedict²⁶, Mifflin²⁷, Ireton-Jones²⁸, Penn State⁷ and Swinamer equations²⁹, among others.

Due to the practical limitations of routine indirect calorimetry as well as the absence of data to support existing predictive equations in obese and pre-obese patients, we set out to determine if standard predictive equations for energy expenditure accurately reflect the caloric requirements of critically ill, mechanically ventilated patients. Second, we asked whether these predictive equations differed in their ability to accurately reflect caloric requirements based on body mass index (BMI) of patients, particularly those with pre-obesity or obesity.

MATERIALS AND METHODS

All mechanically ventilated ICU patients who had indirect calorimetry performed at Harborview Medical Center in Seattle, Washington between September 1998 and December 2005 were retrospectively evaluated for inclusion in the study. Study approval was granted

by the University of Washington Institutional Review Board. Inclusion criteria were the presence of a recorded height and weight in the medical record and being at least 15 years of age. Patients were excluded if their BMI was < 18.5 because predictive equations have been shown to be inaccurate in underweight patients³⁰ and the focus of our study was pre-obese and obese patients. Patients with a BMI < 18 are generally considered malnourished and determining their precise energy needs with IC is generally unnecessary³⁰. If indirect calorimetry was performed multiple times on a given patient, only the first measure was included.

Indirect calorimetry was performed using MedGraphics CCM Express. A standard protocol was in place at Harborview Medical Center for all respiratory therapists to use when performing the metabolic carts. The protocol required that patients: 1) be inactive and undisturbed for 30 minutes prior to testing, and for the 30 minute duration of the data collection; 2) have waited at least two hours after the administration of general anesthetic agents or hemodialysis; and 3) have an administered fraction of inspired oxygen (FiO₂) of 0.6 or less. It is recommended that patients achieve steady-state prior to the initiation of testing. A respiratory quotient (RQ) of less than 0.65 or greater than 1.25 is suggestive to the therapist that the patient is not in steady-state, and is a relative contraindication. Parenteral and/or enteral nutrition was continued during the data collection period. The metabolic cart was calibrated daily by one therapist, and also had gas calibration by the performing therapist prior to each exam.

The following variables for each patient were obtained by standardized chart abstraction: admission height, admission weight, calculated body mass index (BMI), age and gender. Given the difficulty of accurately obtaining information about admission diagnoses or severity of illness scores (e.g. APACHE III [31]) from both paper and electronic medical records, this information was not abstracted beyond the measurements listed above.

Body mass index (BMI, in kg/m²) was calculated for all participants using their admission height and weight. Patients were stratified into weight categories according to World Health Organization criteria³²: normal weight (BMI 18.5 – 24.9), pre-obese (BMI 25 – 29.9), obese class I (BMI 30 – 34.9), obese class II (BMI 35 – 39.9) and obese class III (BMI 40). The predictive equations used and details of their use are summarized in Table 1. For all equations, the patient's admission body weight was used for "actual body weight".

Descriptive statistics included means $\pm$ standard deviations for normally distributed data and medians with interquartile ranges for nonparametric data. Limits of agreement analysis using Bland-Altman plots and Pitman's test of difference in variance was performed to compare REE estimated by each predictive equation and REE measured by indirect calorimetry. Bland-Altman analysis is a process used to assess agreement between two methods of measurement that measure the same characteristic on the same scale^{33, 34}. We chose to use Bland-Altman analyses over correlation coefficients because high correlation does not necessarily mean that the 2 methods agree but rather that the relationship between two variables is strong. In other words, when using correlation coefficients, either one or both of the variables may be incorrect and the correlation may still be very high, while Bland-Altman analyses measure true agreement. Limits of agreement analyses were performed for each predictive equation, stratifying both by BMI and gender due to concern for different degrees of agreement among these individual groups. Pitman's test of difference in variance gives an *r* value and a *p*-value, testing that the two measurements are in agreement with one another. This *p*-value describes the statistical probability that the two measurements agree; therefore low *p*-values (*p* < 0.05) indicate that the two measurements do not show good agreement. In addition to Bland-Altman analyses with limits of agreement analysis, we also calculated the bias of the predictive equations (REE as predicted by

equations minus REE measured by IC). We report the mean difference, or bias, along with 95% confidence intervals. The equation is considered unbiased if the 95% confidence interval includes zero. We also report the percentage of cases where the REE predicted by equations is within 10% of the REE measured by IC (% precise).

RESULTS

A total of 1519 indirect calorimetry measurements were made on 971 patients during the reviewed period of time. All of these patients were mechanically ventilated in the intensive care unit (ICU). If any patient had more than one indirect calorimetry performed during their ICU stay, only the first measurement was included in the analysis, resulting in 971 potential participants for inclusion. Body mass index data was missing in 19 of these, and another 25 patients were excluded due to a BMI < 18.5. Therefore, there were a total of 927 patients with complete data for analysis that were included, and demographic characteristics are shown in Table 2. Patients were 49.9 ± 17.6 years old and 66.6% were male. Normal weight patients (BMI 18.5–24.9) accounted for 27.4%, while 29.3% were pre-obese, 19.0% were obese class I, 9.1% were obese class II, and 15.2% were obese class III.

Mean REE measured by IC was 2456 ± 807 kcal/day. Bland-Altman plots were performed for each predictive equation (Table 1) and the resting energy expenditure measured by indirect calorimetry. Table 3 summarizes the limits of agreement, Pitman's test of difference in variance, bias, and the precision of the equations in the stratified population. The limits of agreement show the range of differences between the indirect calorimetry measurement and the REE predicted by the equations. For all equations, and in all weight categories, the limits of agreement range was large. For example, when evaluating all patients with the Harris-Benedict equation, limits of agreement ranged from -1200 kcal/day (IC less than predicted equation) to 1480 kcal/day (IC more than predicted equation).

The Harris-Benedict, Owen, ACCP guidelines, and Mifflin equations did not have good agreement with measured REE by indirect calorimetry, regardless of weight category. When examining patients either as the whole cohort or within individual weight categories, and when stratified by gender, the predictive equations underestimated the measured REE with poor agreement between the two. Of these three equations, the Harris-Benedict underestimated measured REE by the least, but this mean difference in all patients was still 150 kcal/day.

There was good agreement between the Ireton-Jones equation and measured energy expenditure when evaluating all patients together regardless of BMI, as well as among those in the subgroups of obese class I and II. However, this agreement did not remain after stratifying for gender. The Ireton-Jones equation tended to overestimate REE for men but underestimate the REE for women. A sample Bland-Altman plot comparing REE predicted by the Ireton-Jones equation and measured by IC in all patients is shown in Figure 1.

The Harris-Benedict and Ireton-Jones equation were the only equations that were found to be unbiased. For the Harris-Benedict, this was only among those with normal weight (regardless of sex), among women who were pre-obese or obese category II, and among men who were obese category III. For the Ireton-Jones equation, this was only among men and specifically in weight categories I and II. For men in other weight categories, the Ireton-Jones equation overestimated the measured REE by indirect calorimetry. The other equations, for all weight categories and for both sexes, were biased with the equations tending to underestimate the measured REE.

Precision was also poor for all equations, in all weight categories and for both sexes. We report the percentage of cases where the predicted value is within 10% of the measured

value. For all patients, the Harris-Benedict has the best precision, though only 31.3% of cases had a predicted REE within 10% of their measured REE. Overall, the ACCP guidelines equation and the Owen equation were the least precise, with only about 12% of cases having a predicted value within 10% of the measured REE. The ACCP guidelines equation was the least precise among the obese subgroups (Table 3).

DISCUSSION

Using this large dataset, we have demonstrated that for the most part, none of the equations used to predict REE agree well with actual energy expenditure measured by indirect calorimetry. The Harris-Benedict equation, which is most commonly used in clinical practice, had poor agreement with indirect calorimetry measurements, regardless of BMI category. In all cases, the Harris-Benedict equation underestimated the REE by a mean of close to 150 kcal/day, and underestimated by larger amounts for those who were overweight and obese. The Mifflin, ACCP guidelines, and Owen equations performed similarly with consistently poor agreement and underestimation of REE in all BMI groups, and the amount of underestimation was even higher than with the Harris-Benedict equation.

The Ireton-Jones equation for obesity initially appeared to have good agreement with measured REE among all patients as a whole cohort and among patients in the obese class I and II groups. However, after stratifying by gender, this was no longer true. Again, the Ireton-Jones equation substantially underestimated the REE in women but slightly overestimated the REE in men. Ireton-Jones was the only equation that was unbiased, but only among men in obese categories I and II. None of the equations showed very much precision in their ability to predict REE within 10% of the measured value.

Our results are consistent with prior findings that equations often do not accurately predict REE of patients when compared to IC^{11, 12, 14, 35}, however our study is unique in the large number of mechanically ventilated, critically ill patients. Like prior studies¹², our data show that the Harris-Benedict equation tends to underestimate by the least, as compared with Owen, Mifflin and ACCP guidelines. We also found that the Ireton-Jones equation predicts differently by gender, overestimating REE for men but underestimating for women.

There are several limitations to our study. First, we were not able to examine all the predictive equations currently used in practice because we were unable to obtain some pieces of clinical information needed to do so. For example, we were unable to fully calculate the Swinamer equation or the Penn State equation, both of which are commonly used to predict the caloric needs for ventilated patients^{7, 29}, because we could not obtain information on tidal volume (Swinamer) and minute ventilation (Penn State). However, the equations that we were able to use contain clinical information readily available to practitioners, making them clinically useful equations for critical care clinicians to use. Second, we do not have clinical information about the patients' admission diagnoses or severity of illness, and it may have been helpful to know whether these patients had sepsis, trauma, burns, or other diagnoses leading to their critical illness as well as to know their degree of illness. Similarly, we do not have information about treatments that might influence energy expenditure and carbon dioxide production, including type of nutrition and caloric intake, catecholamines, neuromuscular blocking agents, and opioids. Third, this retrospective study included a cohort of mechanically ventilated patients who had all had IC ordered for clinical reasons by treating clinicians. We do not have information on why IC was ordered, but the reasons may have included failure to wean from the ventilator or concern for overfeeding. Therefore, because we studied a select population of patients, our findings may not be generalizable to all ICU patients. Fourth, it is important to note that because the indirect calorimetry was performed for clinical indications, we do not have

information about how well the procedure was performed to the standards of the institutional protocol. Finally, it is important to note that the current guidelines from the SCCM and A.S.P.E.N. advocate for underfeeding or hypocaloric feeding in the critically ill obese patient, with BMI > 30²². Therefore, it is possible that underestimating caloric needs might be the desired result for these patients.

Despite these limitations, this is the largest study to date and supports prior reports that predictive equations do not accurately estimate resting energy expenditure for mechanically ventilated patients, especially in the setting of obesity. Our results confirm the need for development of improved predictive equations to assess energy needs, especially among obese, mechanically ventilated patients. Alternatively, due to the limitations of the predictive formula, indirect calorimetry may be required to assess the energy needs in select patients groups including those with obesity.

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ABBREVIATION LIST

ActBW	Actual body weight
AdjBW	Adjusted body weight
ACCP	American College of Chest Physicians
APACHE III	Acute Physiology and Chronic Health Evaluation III
A.S.P.E.N	American Society for Parenteral and Enteral Nutrition
BMI	Body mass index
FiO₂	Fraction of inspired oxygen
Ht	Height
IBW	Ideal body weight
IC	Indirect calorimetry
ICU	Intensive care unit
REE	Resting energy expenditure
RQ	Respiratory quotient
SCCM	Society of Critical Care Medicine
VCO₂	Carbon dioxide production
VO₂	Oxygen consumption

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Figure 1.

Bland-Altman plot for all patients using Ireton-Jones equation compared to measured energy expenditure by indirect calorimetry. The x-axis shows the average REE by the two methods (kcal/day). The y-axis shows the difference in REE between the two methods (kcal/day). If the two methods of measurement had good agreement, the points should be centered on the “0” y-axis, regardless of the average REE. In this example, the lower the average REE, the more likely the predictive equation is to overestimate REE (negative difference), and the higher the average REE, the more likely the predictive equation is to underestimate the REE (positive difference on y-axis). The appearance of two distinct cohorts displays differences for men and women.

Table 1

Description of predictive equations.

Equation name	Calculation of resting energy expenditure
Harris-Benedict equation ²⁵	Males: $[66.5 + (13.8 \times \text{AdjBW}) + (5 \times \text{Ht}) - (6.8 \times \text{Age})] \times 1.5$ Females: $[655 + (9.6 \times \text{AdjBW}) + (1.8 \times \text{Ht}) - 4.7 \times \text{Age}] \times 1.5$
Owen equation ³⁵	Males: $879 + (10.2 \times \text{ActBW})$ Females: $795 + (7.2 \times \text{ActBW})$
Mifflin equation ²⁶	Males: $5 + (10 \times \text{ActBW}) + (6.25 \times \text{Ht}) - (5 \times \text{Age})$ Females: $161 + (10 \times \text{ActBW}) + (6.25 \times \text{Ht}) - (5 \times \text{Age})$
Ireton-Jones equation for obesity ^{27, 36, 37}	Males: $606 + (9 \times \text{ActBW}) - (12 \times \text{Age}) + 400$ (if ventilated) + 1400 Females: $\text{ActBW} - (12 \times \text{Age}) + 400$ (if ventilated) + 1444
American College of Chest Physicians (ACCP) guidelines ¹⁷	BMI < 25: $\text{ActBW} \times 25$ BMI ≥ 25: $\text{IBW} \times 25$

AdjBW = Adjusted body weight = Ideal body weight + 0.25 (Actual body weight – Ideal body weight)

IBW = Ideal body weight = 50 + 2.3 per inch > 60 inches (men); 45.5 + 2.3 per inch > 60 inches (women)

ActBW = Actual body weight = weight on admission (kg)

Ht = Height (cm)

Table 2

Characteristics of cohort

	n=927
Age, mean in years (SD)	49.9 (17.6)
Male, % (n)	66.6 (617)
Admission weight (kg), med (IQR)	88.5 (72.6, 107.3)
Body Mass Index, median (IQR)	28.8 (24.4, 34.7)
WHO categories, % (n)	
Normal (BMI 18.5–24.9)	27.4 (254)
Pre-obese (BMI 25–29.9)	29.3 (272)
Obese class I (BMI 30–34.9)	19.0 (176)
Obese class II (BMI 35.0–39.9)	9.1 (84)
Obese class III (BMI 40)	15.2 (141)
Oxygen consumption (VO ₂) mL/min, med (IQR)	348 (278, 436)
Carbon dioxide production (VCO ₂) mL/min, med (IQR)	299 (239, 366)
Respiratory quotient, med (IQR)	0.85 (0.80, 0.91)
Length of stay (days), med (IQR)	33 (22, 49)
Disposition, % (n) *	
Deceased	19.8 (128)
Transferred to other unit or hospital	23.5 (152)
Transferred to skilled nursing facility	37.9 (245)
Discharged home (self-care)	18.9 (122)

*
280 missing

Table 3

Summary of limits of agreement, Pitman's test of difference, bias and precision for predicted energy expenditure (by equations listed) and measured energy expenditure (by indirect calorimetry), stratified by weight category and gender.

Equation	Weight category	Limits of agreement* (kcal/day)	Pitman's test of difference in variance (r)	Bias** (kcal/day), (95% CI)	%Precise***
Harris-Benedict	All patients	-1200.0 to 1480.7	r = 0.585 ^a	-150.6 (-193.6 to -107.7)	31.3
	Men	-1200.0 to 1449.8	r = 0.660 ^a	-119.1 (-171.7 to -66.5)	30.5
	Women	-1100.0 to 1535.6	r = 0.860 ^a	-213.7 (-287.8 to -139.6)	32.8
	Normal (all)	-1200.0 to 1116.1	r = 0.557 ^a	37.8 (-33.7 to 109.2)	28.1
	Men	-1300.0 to 1210.3	r = 0.678 ^a	44.4 (-49.5 to 138.2)	24.7
	Women	-922.5 to 876.2	r = 0.752 ^a	23.2 (-77.5 to 123.9)	35.4
	Pre-obese (all)	-1100.0 to 1443.0	r = 0.643 ^a	-185.6 (-260.9 to -110.2)	35.2
	Men	-1100.0 to 1532.0	r = 0.732 ^a	-219.7 (-260.9 to -110.2)	33.8
	Women	-981.9 to 1153.9	r = 0.811 ^a	-86.0 (-214.3 to 42.3)	39.1
	Obese class I (all)	-1200.0 to 1644.9	r = 0.624 ^a	-223.4 (-329.1, -117.7)	34.1
	Men	-1100.0 to 1388.9	r = 0.727 ^a	-127.8 (-244.8 to -10.8)	32.5
	Women	-1200.0 to 2029.3	r = 0.935 ^a	-399.1 (-606.1 to -192.1)	37.1
	Obese class II (all)	-1200.0 to 1778.8	r = 0.678 ^a	-277.0 (-440.0 to -114.1)	27.4
	Men	-1200.0 to 1833.4	r = 0.763 ^a	-324.7 (-536.9 to -112.6)	33.3
	Women	-1300.0 to 1705.4	r = 0.913 ^a	-203.3 (-469.6 to 63.0)	18.2
	Obese class III (all)	-1200.0 to 1665.4	r = 0.338 ^a	-255.7 (-373.1 to -138.4)	28.4
	Men	-1300.0 to 1455.9	r = 0.486 ^a	-76.1 (-233.7 to 81.5)	30.3
	Women	-869.9 to 1801.4	r = 0.823 ^a	-465.7 (-631.2 to -300.3)	26.5
Owen	All patients	-630.5 to 2218.7	r = 0.639 ^a	-794.1 (-839.1 to -749.1)	11.7
	Men	-623.5 to 2297.9	r = 0.621 ^a	-837.2 (-895.0 to -779.4)	13.5

Equation	Weight category	Limits of agreement* (kcal/day)	Pitman's test of difference in variance (r)	Bias** (kcal/day), (95% CI)	%Precise***
	Women	-620.1 to 2107.5	$r = 0.848^a$	-743.7 (-830.2 to -667.2)	8.1
	Normal	-544.0 to 2029.6	$r = 0.874^a$	-742.8 (-822.5 to -663.2)	10.7
	Men	-590.3 to 2205.2	$r = 0.970^a$	-807.5 (-912.1 to -702.9)	10.9
	Women	-346.6 to 1547.5	$r = 0.979^a$	-600.4 (-706.5 to -494.4)	10.1
	Pre-obese	-443.4 to 2292.7	$r = 0.880^a$	-924.6 (-1006.6 to -842.7)	8.5
	Men	-374.3 to 2400.6	$r = 0.968^a$	-1013.2 (-1109.7 to -916.7)	9.5
	Women	-507.6 to 1841.0	$r = 0.983^a$	-666.7 (-807.7 to -525.7)	5.8
	Obese class I	-685.4 to 2407.2	$r = 0.820^a$	-860.9 (-975.9 to -745.9)	9.7
	Men	-605.2 to 2230.9	$r = 0.964^a$	-812.9 (-944.4 to -681.3)	14.0
	Women	-807.4 to 2705.8	$r = 0.991^a$	-949.2 (-1172.2 to -726.1)	1.6
	Obese class II	-762.5 to 2427.6	$r = 0.832^a$	-832.6 (-1005.6 to -659.5)	14.3
	Men	-636.5 to 2515.0	$r = 0.945^a$	-939.3 (-1160.9 to -717.7)	11.8
	Women	-924.3 to 2259.6	$r = 0.990^a$	-667.7 (-949.9 to -385.4)	18.2
	Obese class III	-846.8 to 2062.8	$r = 0.265^b$	-608.0 (-729.1 to -486.9)	20.6
	Men	-1000.0 to 1839.7	$r = 0.385^b$	-407.7 (-571.3 to -244.1)	30.3
	Women	-504.6 to 2188.9	$r = 0.837^a$	-842.2 (-1009.0 to -675.3)	9.2
Mifflin	All patients	-740.1 to 2127.1	$r = 0.652^a$	-693.5 (-739.8 to -647.2)	17.8
	Men	-536.2 to 2245.7	$r = 0.594^a$	-854.7 (-909.8 to -799.7)	12.5
	Women	-924.3 to 1666.3	$r = 0.669^a$	-371.0 (-443.6 to -298.4)	28.3
	Normal	-613.4 to 1942.9	$r = 0.900^a$	-664.8 (-743.9 to -585.6)	13.0
	Men	-482.2 to 2123.4	$r = 0.896^a$	-820.6 (-918.1 to -723.1)	8.6
	Women	-583.7 to 1226.7	$r = 0.828^a$	-321.5 (-422.9 to -220.1)	22.8
	Pre-obese	-551.4 to 2246.8	$r = 0.915^a$	-847.6 (-931.5 to -763.8)	15.2

Equation	Weight category	Limits of agreement* (kcal/day)	Pitman's test of difference in variance (r)	Bias** (kcal/day), (95% CI)	%Precise***
	Men	-309.1 to 2350.4	r = 0.906 ^a	-1020.6 (-1113.1 to -928.1)	8.0
	Women	-732.5 to 1420.1	r = 0.860 ^a	-343.8 (-473.1 to -214.5)	36.2
	Obese class I	-724.5 to 2213.1	r = 0.918 ^a	-744.2 (-853.5 to -634.9)	18.8
	Men	-488.3 to 2166.7	r = 0.897 ^a	-839.2 (-962.3 to -716.0)	12.3
	Women	-1000.0 to 2223.2	r = 0.944 ^a	-569.6 (-779.5 to -359.6)	30.7
	Obese class II	-954.7 to 2349.4	r = 0.917 ^a	-697.3 (-876.6 to -518.1)	11.9
	Men	-564.7 to 2493.8	r = 0.888 ^a	-964.5 (-1180.0 to -749.5)	9.8
	Women	-1200.0 to 1789.9	r = 0.925 ^a	-284.4 (-551.3 to -17.5)	15.2
	Obese class III	-1000.0 to 1779.3	r = 0.437 ^a	-384.3 (-500.4 to -268.1)	33.3
	Men	-968.8 to 1856.2	r = 0.330 ^b	-443.7 (-605.1 to -282.3)	35.5
	Women	-1000.0 to 1686.8	r = 0.624 ^a	-314.7 (-484.7 to -144.8)	30.8
Iretton-Jones	All patients	-1300.0 to 1881.2	r = 0.041^c	-270.0 (-322.0 to -218.0)	22.2
	Men	-1400.0 to 1320.7	r = 0.608 ^a	32.0 (-21.5 to 85.6)	30.5
	Women	-519.9 to 2268.0	r = 0.875 ^a	-784.1 (-952.2 to -795.9)	5.5
	Normal	-1200.0 to 1404.0	r = 0.127 ^d	-97.8 (-178.7 to -16.9)	22.9
	Men	-1400.0 to 1156.8	r = 0.789 ^a	101.9 (7.7 to 196.0)	27.0
	Women	-389.3 to 1464.4	r = 0.622 ^a	-537.5 (-641.3 to -493.7)	13.9
	Pre-obese	-1100.0 to 1614.9	r = 0.198 ^b	-264.1 (-345.1 to -183.2)	24.4
	Men	-1200.0 to 1417.1	r = 0.832 ^a	-115.2 (-205.7 to -24.7)	31.3
	Women	-400.5 to 1796.5	r = 0.797 ^a	-698.0 (-829.9 to -566.0)	4.4
	Obese class I	-1400.0 to 2119.1	r = 0.107^e	-361.7 (-492.4 to -231.0)	20.5
	Men	-1300.0 to 1278.0	r = 0.841 ^a	18.3 (-101.9 to 138.6)	30.7
	Women	-577.3 to 2698.3	r = 0.928 ^a	-1060.5 (-1268.5 to -852.5)	1.6

Equation	Weight category	Limits of agreement* (kcal/day)	Pitman's test of difference in variance (r)	Bias** (kcal/day), (95% CI)	%Precise***
	Obese class II	-1300.0 to 2127.5	$r = 0.090^f$	-426.8 (-611.4 to -242.3)	29.8
	Men	-1400.0 to 1607.7	$r = 0.881^a$	-110.8 (-321.3 to 99.7)	47.1
	Women	-627.5 to 2458.0	$r = 0.910^a$	-915.3 (-1188.8 to -641.7)	3.0
	Obese class III	-1800.0 to 2526.2	$r = -0.379^a$	-382.2 (-560.7 to -203.7)	14.2
	Men	-1800.0 to 1030.8	$r = 0.413^a$	378.1 (217.1 to 539.0)	25.0
	Women	-60.2 to 2602.5	$r = 0.907^a$	-1271.2 (-1436.1 to -1106.2)	1.5
25 kcal/kg	All patients	-624.8 to 2322.0	$r = 0.797^a$	-848.6 (-896.1 to -801.0)	12.0
	Men	-574.2 to 2364.1	$r = 0.855^a$	-895.0 (-953.1 to -836.8)	12.0
	Women	-699.9 to 2221.2	$r = 0.889^a$	-760.6 (-842.5 to -678.7)	12.0
	Normal	-763.7 to 1843.1	$r = 0.790^a$	-539.7 (-620.2 to -459.2)	22.1
	Men	-765.4 to 2020.4	$r = 0.831^a$	-627.5 (-731.7 to -523.3)	21.3
	Women	-607.5 to 1329.9	$r = 0.771^a$	-361.2 (-469.7 to -252.7)	24.0
	Pre-obese	-503.7 to 2205.3	$r = 0.799^a$	-850.8 (-931.9 to -769.6)	11.1
	Men	-449.8 to 2319.9	$r = 0.876^a$	-935.0 (-1031.3 to -838.7)	9.5
	Women	-529.9 to 1329.9	$r = 0.804^a$	-605.3 (-741.7 to -469.0)	15.9
	Obese class I	-574.3 to 2405.2	$r = 0.803^a$	-915.5 (-1026.3 to -804.6)	9.7
	Men	-477.4 to 2251.7	$r = 0.892^a$	-887.1 (-1013.7 to -760.5)	12.3
	Women	-735.7 to 2670.7	$r = 0.937^a$	-967.5 (-1183.8 to -751.2)	4.8
	Obese class II	-584.4 to 2625.1	$r = 0.833^a$	-1020.4 (-1194.5 to -846.2)	7.1
	Men	-406.5 to 2757.0	$r = 0.860^a$	-1175.2 (-1397.7 to -952.8)	5.9
	Women	-762.1 to 2324.1	$r = 0.923^a$	-781.0 (-1054.6 to -507.4)	9.1
	Obese class III	-235.8 to 2665.8	$r = 0.713^a$	-1215.0 (-1335.8 to -1094.2)	1.4
	Men	-219.2 to 2741.2	$r = 0.745^a$	-1225.0 (-1398.2 to -1051.8)	1.3

Equation	Weight category	Limits of agreement* (kcal/day)	Pitman's test of difference in variance (r)	Bias** (kcal/day), (95% CI)	%Precise***
	Women	-178.6 to 2585.1	$r = 0.863^a$	-1204.3 (-1374.4 to -1032.0)	1.5

* Limits of agreement = range of differences between predicted value (by equation) and measured value (by IC)

** Bias = predicted value (by equation) minus measured value (by IC)

*** % Precise = Percentage of cases where the predicted value (by equation) is within 10% of measured value (by IC)

Significant findings are highlighted in bold. Legend for p-values:

- ^a

p < 0.001,
- ^b

p = 0.005,
- ^c

p = 0.213,
- ^d

p < 0.05,
- ^e

p = 0.159,
- ^f

p = 0.415