Validation of the Novel Basal Metabolic Rate Prediction Equation Among Adult Overweight and Obese Filipino Patients

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ABSTRACT

Background: Various methods and equations are available to predict the basal metabolic rate (BMR). A published study comparing the Harris-Benedict Equation, Bioelectrical Impedance Analysis, and Indirect Calorimetry (IC), was done among Filipinos, and was able to obtain a novel formula for BMR. The purpose of this study is to validate this novel formula.

Methods: This is a multi-center, cross-sectional, validation study of the novel BMR equation, done among adult overweight and obese Filipinos, who were seen at St. Luke's Medical Center and Providence Hospital in Quezon City, Outpatient Clinics from August 2019 to March 2020. Purposive sampling was done, and upon giving consent, subjects had undergone interview, anthropometrics measurement, and IC.

Results: 174 samples were enrolled. Mean age is 43 years old, majority are females. 27% have no co-morbidities; of those with co-morbidities, half have diabetes mellitus (DM). Mean weight is 74.30 kg; mean BMI is 29.78 kg/m^2. The mean computed BMR is 1174.70 kcal/day, which is 145.83 significantly lower than the BMR derived with calorimetry: 1320.53 kcal/day (P-value 0.000). However, the scatterplot reveals the linearity of positive direction for both values. 31% of the computed BMR fell within the +/-10% estimate of the actual BMR. Stratification of the results between those with DM and without, lowered the difference between the calculated and actual BMR to 46 kcal/day (from 145.83) among the DM subgroup, and increased the estimated accuracy to 38% falling within the +/- 10% estimate of the actual values.

Conclusion: The novel BMR formula is linearly reflective of the basal metabolism of adult overweight and obese Filipinos, but the numerical values are lower compared to actual calorimetry results, yielding more accuracy when applied among patients with diabetes.

Keywords: *Basal metabolic rate; Indirect calorimetry; Obesity management*

INTRODUCTION

Since 1975, according to the World Health Organization, the prevalence of obesity has increased nearly three-fold. More than 1.9 billion adults, which is 39% of adults 18 years and above, were overweight as of 2016; and 650 million of them (13%) were obese.[1] The fundamental cause of this is a mismatch between energy intake and energy expenditure. Energy intake can be computed by knowing the number of calories in food and counting them. Daily energy expenditure (DEE), on the other hand, can be divided into the basal metabolic rate (BMR) (65% of DEE), energy expenditure associated with activity (25%), and the thermic effect of food (10%). The BMR refers to the energy expenditure of the body (tissues and organs) at rest, to sustain body functions. The energy expenditure associated with activity is also referred to as the thermic effect of activity, which is the energy usage with physical movements. The thermic effect of food is the energy used in digestion, absorption, and metabolism of nutrients.[2]

Because the BMR is the main contributor to the DEE, it has been frequently a main focus in the treatment of obesity.[2] It can be utilized to determine target intake in weight loss programs and to devise prediction models of weight gain and loss.[3] It can be considered as the total energy expenditure of all the tissues and organs in the resting state, and is dependent on the body composition, gender, age, physical activity, and nutritional status. Body composition is further divided into fat-free mass and fat

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mass, wherein fat-free mass is the main determinant of BMR, but fat mass is more significant in obese patients. Gender is also a significant factor in determining the BMR, with men having a greater BMR due to greater fat-free mass. In addition, BMR decreases with age, probably due to the impaired ability to regulate energy balance, and also with decreasing fat-free mass that occurs with aging.[2]

In line with these significant factors, various methods and equations are available to predict the BMR. The most common of which include the Harris-Benedict Equation (HBE), the Bioelectrical Impedance Analysis (BIA), and Indirect Calorimetry (IC). Among these, the HBE is the simplest, most easy to use, and universally available.[4] It is computed by utilizing a person's weight, height, and age in the following formula: kilocalories/day in men = 66 + 13.75 x (weight in kg) + 5.0 x (height in cm) – 6.76 x (age in years); and kilocalories/day in women = 655 + 9.56 x (weight in kg) + 1.85 x (height in cm) – 4.68 x (age in years). However, it was shown in a study by Frankenfield et al., that this equation failed to predict the BMR in 67% of men with BMI (body mass index) more than 50, and underestimated it when adjusted body weight is used in obesity.[5] In addition, various studies have shown that "predicted BMR equations derived from Caucasian subjects overestimated the BMR of Asian subjects."[6] This is especially more so because according to a BMR database, BMR is higher among Caucasians than non-Caucasians; and there are few available equations to estimate energy expenditure among the Asian population, particularly Filipinos.[7] BIA, on the other hand, because it uses electrical impedance to determine fat-free mass to estimate BMR, may be affected by hydration, prandial/fasting state, activity, diuresis, race, age, or body shape. IC, which is based on the measurement of oxygen consumption and carbon dioxide production, is the gold standard in measuring BMR in the clinics. However, this is "not feasible for frequent and timely individual use," mainly because of the tedious and step-by-step preparation and process by which it should be done, and the availability of the machine itself.[3] The cost of the test is another issue. A previously published study done by Luy and Dampil compared these three measures in predicting the BMR of adult obese Filipino patients with prediabetes or type 2 diabetes mellitus, and found that the "HBE and BIA significantly overestimated the mean BMR measured using IC by 329 and 336 kcal/day, respectively."[4] The said study was then able to derive a new BMR prediction equation, using a multiple stepwise regression analysis: BMR (kcal/day) = -780.806 + (11.108 x weight in kg) + (7.164 x height in cm), taking into consideration the various factors that significantly correlated to BMR (namely, weight and height).[4]

The purpose of this study is then to validate this newly-derived equation in comparison with the gold standard in predicting BMR among adult overweight and obese Filipino patients in general.

METHODS

This is a multi-center, validation study of the BMR prediction equation, derived from the previously published study comparing the Harris-Benedict Equation, Bioelectrical Impedance Analysis, and Indirect Calorimetry as a measure of BMR, among adult overweight and obese Filipino patients who were seen at the Outpatient Clinics (both private and social service) of St. Luke's Medical Center Quezon City and Providence Hospital Quezon City from August 2019 to March 2020.

Study Subjects. Subjects included were aged 18 to 65 years old, Filipino, with a BMI of 23 kg/m^2 and above (overweight and obese criteria in Asians), and must have signed the informed consent. Those with current or chronic (>/= 1 week duration) recent (within the past 3 months) steroid use, current state of hyper- or hypothyroidism (subject must be clinically and biochemically euthyroid during the time of examination), chronic kidney disease stage 3 and above, chronic obstructive pulmonary disease or bronchial asthma in exacerbation/ with poor control, any illicit drug use at present or within the past 5 years, who cannot follow instructions and cannot undergo fasting, were pregnant or breastfeeding, and who already underwent clinical weight loss intervention for the past 3 months with a significant weight loss of >5% of baseline, were excluded from the study, as these may affect the calorimetry results.

Operational definitions are as follows:

Basal metabolic rate – energy expenditure at rest; will be derived using the novel formula and using indirect calorimetry as gold standard

BMR (kcal/day) * = -780.806 + (11.108 x weight in kg) + (7.164 x height in cm)

* Novel formula for BMR

Filipino – individual of Philippine ethnic descent, born of Filipino parents

Indirect calorimetry – gold standard in measuring BMR; utilizes measurement of oxygen consumption and carbon dioxide production

Obese – body mass index of 25 kg/m^2 (cut-off used in Asians)

Overweight – body mass index of 23 kg/m^2 (cut-off used in Asians)

Study Procedure. The study was a cross-sectional study and utilized purposive sampling. All overweight and obese patients who were seen in the Outpatient Clinics (both private and social service) of St. Luke's Medical Center Quezon City, Providence Hospital Quezon City, and in the Diabetes, Thyroid, and Endocrine Center of both hospitals, who met the inclusion and exclusion criteria were included as samples. Consent was secured from each subject, and the following information was collected: (1) Demographics: Age, sex, co-morbid conditions, including maintenance medications, previous operations, social history; and, (2) Weight and height, in kilograms and centimeters (both rounded off to the first decimal place).

After enrollment, the subjects were then scheduled for indirect calorimetry and were asked to go to the Out-Patient Department (OPD) and to the Diabetes, Thyroid, and Endocrine Center of their respective institution for the weight and height measurement, and for the BMR measurement using indirect calorimetry. All the measurements were done in the same day, starting with the anthropometrics, then proceeding to indirect calorimetry. All procedures were done during the day, during office hours. Weight and height were measured using the *Detecto* weighing scale and height meter, with no shoes, and with light clothing, and were done by the primary investigators. These were then used to compute for the BMR using the derived formula specified above. Indirect calorimetry was done using the *Fitmate GS* portable desktop indirect calorimeter developed by *Cosmed*. Each of the patients had the following preparations prior to calorimetry: no food intake for at least 2 hours, no exercise done for at least 4 hours, no caffeine intake for at least 4 hours, no stimulatory nutritional supplements (containing ephedra or synephrine) for at least 4 hours, and has not smoked for at least 8 hours. The procedure, lasting for approximately 30 minutes, was conducted in a darkened, quiet room, with soft music provided. The patient was positioned in a semi-reclined manner, instructed to breath comfortably inside the canopy hood placed over his head, and the expired gas was sent to the turbine and sampling line in order to get ventilation parameters and gas (oxygen and carbon dioxide) concentrations.[4] All calorimetry procedures were conducted by any of the trained personnel/staff in the centers.

Sample Size Estimation. The sample size computation was based on the results of the study done by Ikeda et. al., in which the mean BMR and standard deviation as computed using the Harris-Benedict equation was 1388 $\pm$ 309 kcal/day, and the one from indirect calorimetry was 1260 $\pm$ 219 kcal/day.[7] Targeting 95% power and a level of significance of 5%, and a two-tailed alternative hypothesis, the computed sample size was 135 patients.

Table 1. Demographic Characteristics of the Studied Overweight/Obese Subjects

Characteristics	Number (%)	Mean (SD)
Age (in years)		
18 – 25	19 (11)	
26 – 35	42 (24)	43 (13)
36 – 45	37 (21)	
46 – 55	40 (23)	
56 – 65	36 (21)	
Sex		
Male	49 (28)	
Female	125 (72)	
Social history		
Smoker	9 (5)	
Alcohol drinker	21 (12)	

Data Analysis. Descriptive statistics, frequency, mean, and median were used to summarize the baseline characteristics of the subjects. Tables were utilized to summarize the data. Mean BMR was compared between the indirect calorimetry and the estimated BMR using the novel equation; accuracy was defined as within the $\pm$10% of the actual BMR obtained using IC. The Bland-Altman method was used to cross-validate the derived equation with the gold standard.

Ethical Considerations. The protocol and all necessary documents were reviewed and approved by the SLMC Institutional Ethics Review Committee. The study abode by the Principles of the Declaration of Helsinki (2013) and was conducted along the Guidelines of the International Conference on Harmonization-Good Clinical Practice (ICH-GCP). Informed consent was obtained from each participant prior to initiation of any of the procedures, by any of the investigators. Risks and benefits were explained and each participant was given ample time to study and go through the informed consent form, making sure the participant understood the risks and benefits of the procedure. There were no anticipated risks to the subjects; discomfort may be due to the process of performing indirect calorimetry, which involved fasting, abstinence from certain substances, and the procedure itself. Benefits involved knowing the participant's basal metabolic rate, both via the formula and the gold standard, which may be utilized for a more appropriate caloric meal planning. Patient confidentiality was respected by ensuring anonymity of patient records. Each patient document was coded and did not contain any identifying information in order to ensure confidentiality. All study data were recorded and investigators were responsible for the integrity of the data, i.e., accuracy, completeness, legibility, originality, timeliness, and consistency. Access to gathered information was limited to the project leader and co-leaders, and the trained personnel conducting the measurements. Forms were compiled and stored in an envelope throughout the duration of the study and until the completeness of writing the final manuscript, up to 5 years after completion. Data was tabulated in Microsoft Excel format and saved in a CD, which was kept with the project leader. The manner of disseminating and communicating the study results guarantees the protection of the confidentiality of patient's data.

RESULTS

A total of 174 subjects were screened and enrolled. There were no drop-outs or missing data, as the data collection was a one-time assessment per subject. Majority of the population are between 26 to 35 years of age (24%), and majority are females (72%). Most are nonsmoker and non-alcohol beverage drinker (*Table I*). Twenty-seven percent of the samples do not have any co-morbidities. Of those with co-morbid illnesses, the most common is type 2 diabetes mellitus. Those with thyroid diseases are currently euthyroid at the time of calorimetry testing (*Figure 1*). Seventy-two percent do not have any previous surgeries. Of those with previous surgeries, the most

Table 2. Estimated Accuracy Test

n=172	Underestimation	Within ± 10%	Overestimation
Computed BMR	92 (53%)	53 (31%)	27 (16%)

Table 3. Results of Subgroup Analysis (DM/pre-DM vs. non-DM/pre-DM)

	(+) DM / pre-DM N = 89 (SD)	(-) DM / (-) pre-DM N = 83 (SD)
Age	49 (11)	35 (10)
Weight (kg)	74.75 (15.48)	73.82 (14.31)
Height (cm)	157.73 (7.84)	157.76 (7.13)
BMI (kg/m^2)	29.95 (5.29)	29.60 (5.06)
IBW (kg)	56.17 (5.80)	56.43 (5.15)
Computed BMR (kcal/day)	1179.55 (205.53)	1169.50 (188.38)
Actual BMR (kcal/day)	1226.21 (379.19)	1421.67 (396.88)

Table 4. Estimated Accuracy Test (Subgroup Analysis)

	Underestimation	Within ±10%	Overestimation
Computed BMR			
(+) DM (N = 89)	33 (37%)	34 (38%)	22 (25%)
(-) DM (N = 83)	58 (70%)	20 (24%)	5 (6%)

common include Cesarean Section, repair of laceration/hernia/ meniscus tear, and removal of cyst or the uterus. Thirty-five percent do not have any maintenance medications. The most common medications taken include anti-dyslipidemic, anti-hypertensives (but no diuretics), and oral hypoglycemic agents (OHAs). Of the patients with diabetes/pre-diabetes, 17% are taking sodium-glucose co-transporter-2 (SGLT-2) inhibitors, 3% are on glucagon-like peptide-1 (GLP-1) receptor agonists, and the rest are taking either dipeptidyl peptidase-4 (DPP-4) inhibitors alone or together with insulin or sulfonylurea/s. However, no patient had significant weight loss of >5% from their baseline weight within the past 3 months. Only 5 patients take levothyroxine, but had normal thyroid function tests during the time of calorimetry (*Figure 2*).

The main results are as follows: the mean weight is 74.30 kg (SD 14.89), and the mean height is 157.74 cm (SD 7.48). The mean BMI is 29.78 kg/m^2 (SD 5.17). The mean computed BMR based on the actual weights of the subjects is 1174.70 kcal/day, with a standard deviation of 196.93. This was computed from a total of 172 samples, as two of the samples were outliers and thus were removed from the sample set. On the other hand, the mean actual BMR using the Indirect Calorimetry is 1320.53 kcal/day, with a standard deviation of 398.90. The difference of their average is 145.83, with the Indirect Calorimetry results as having the higher values. The values of the calculated BMR, on the other hand, are more

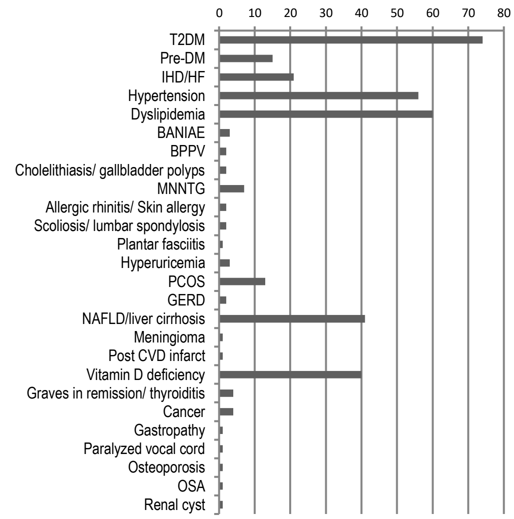

Figure 1. Co-morbidities of the Studied Overweight/ Obese Subjects.

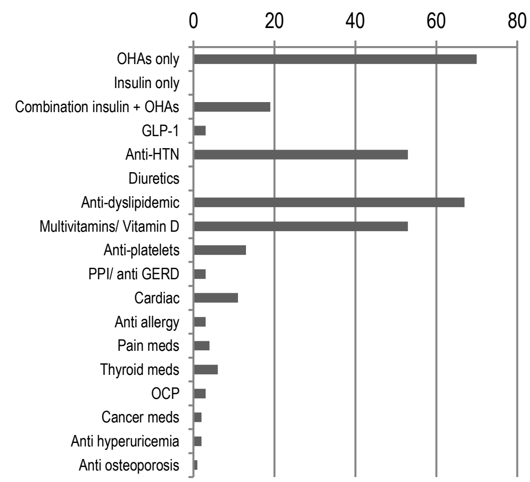

Figure 2. Maintenance Medications of the Studied Overweight/Obese Subjects.

homogeneous than those of the Calorimetry, when the standard deviations were compared.

Their correlation coefficient shows 0.506 with a high statistical significance ($p < 0.000$). This means that there is an excellent direct correlation between the difference and the mean measurements. Correlation coefficient using Pearson's R also signifies a moderate direct relationship between the two measurements, with R = 0.470 at a high significance ($p < 0.000$). The scatterplot reveals the linearity of positive direction for the values of each sample of the two measurements. The Bland-Altman Plot shows that the SE = 0.078, with the value closer to 0, indicating more reliability on the calculated BMR. Those who have a low score value in the indirect calorimetry will also have a low score value with the formula, and it is the same if a high score value is obtained. However, the significance

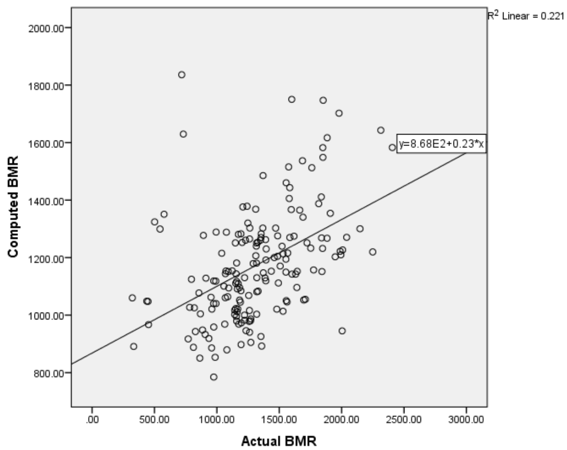

Figure 3A. Correlation between Calculated BMR and IC (Actual BMR)

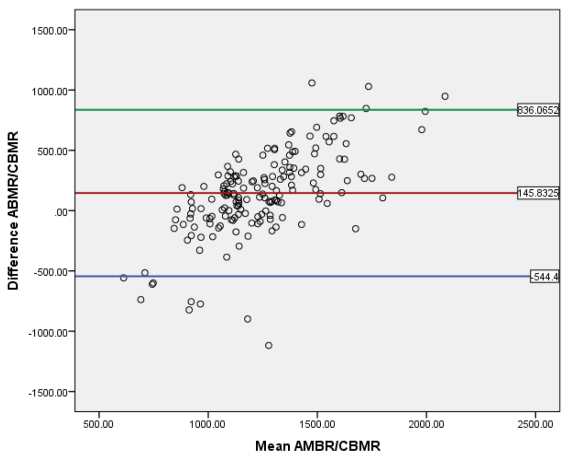

Figure 3B. Bland Altman Scatterplot

value shows that there is a high significant difference between the two measurements (*p < 0.000*), which means that the average measurement of the calculated BMR is statistically lower by an average of 145.83 than the value of the calorimetry (*Figure 3*). On the estimated accuracy test, 31% of the subjects' actual values fell within the $\pm$10% of the actual BMR values (*Table 2*).

Calibration to the novel formula was done, arriving to new factors for the weight and height: 11.361 and 4.597, with the constant being -248.842, revising the formula to: Y (BMR in kcal/day) = -248.842 + (11.361 x weight in kg) + (4.597 x height in cm).

As the base formula was derived from a study among persons with diabetes (DM) and pre-diabetes (pre-DM), stratification of the results between those with DM and pre-DM, and those without, was done. The only major difference between the subgroups was the age, in which the DM population was ~15 years older than those without (*Table 3*). Correlation coefficient using Pearson's R still noted linearity of positive direction for the values of each sample of the two measurements, with R = 0.452 and R = 0.538 for the DM(+) and DM(-) subgroups respectively, with high significance (*p < 0.000*). The Bland-Altman plot shows that the standard error is 0.116 for the DM (+) and 0.102 for the DM (-) patients. For the DM group, the Bland-Altman shows a significant difference of 46 kcal/day between the computed and actual BMR; while the difference between the two is greater among the non-DM group, with a difference of 252 kcal/day (*Figure 4*). Using an independent samples *t-test*, the mean differences of the two groups are highly significantly different (*p <0.01*) by 206 kcal/day. Comparing the BMR values, there is no significant difference noted between the computed mean BMR of the two groups; however, using the actual IC values, there is significant difference (p < 0.000) of 196 kcal/day between the BMR of DM and non-DM, with the non-DM population having a higher BMR.

The estimated accuracy test in the subgroup analysis showed that among the DM population, majority of the subjects' results was evenly distributed between correct estimation (38% fell within the $\pm$10% of the actual calorimetry values) and underestimation (37%). When used among non-DM subjects, the novel formula underestimated the BMR (70% of subjects) (*Table 4*).

DISCUSSION

Targeting the BMR, being a major component of a person's energy expenditure, can be utilized to determine the appropriate caloric intake per day, either for weight loss or weight gain.[2,3] There are various methods of measuring the BMR: through indirect calorimetry (IC; which is the gold standard; measures oxygen consumption and carbon dioxide production), bioelectrical impedance analysis (BIA), and numerous formulas, utilizing different variables.[3,5] Among these formulas is the newly-derived formula, specifically made for Filipinos, from the published study of Luy and Dampil done last 2018. This study compared the BMR of obese patients with type 2 diabetes mellitus or pre-diabetes, derived using the Harris-Benedict Equation (HBE), BIA, and IC. Their results showed that "HBE and BIA significantly overestimated the mean BMR measured by IC by 329 and 336 kcal/day, respectively," and derived a new formula, which was validated in this current study. [4]

In this study, the sample population is similar to the previous study that derived the new formula, in terms of age, sex, and BMI: the mean age of samples in both studies is 42-43 years old, with more females than males (70/30% previously, vs. 72/28% presently). The mean BMI is 29-32 kg/m^2 in both studies; albeit the previous study enrolled a heavier population (78-93 kg with an average BMI of 32-32.6 kg/m^2, vs. 74.30 kg with an average BMI of 29.8 kg/m^2 in the present study). However, the previous study only enrolled subjects with either type 2 diabetes mellitus, or pre-diabetes, while this study enrolled overweight and obese patients in general (BMI $\geq$ 23kg/m^2), even without any co-morbidities. The presence of diabetes and the BMI cut-off ($\geq$ 25 kg/cm^2 vs 23 kg/m^2) are the two main differences between the 2 studies.[4]

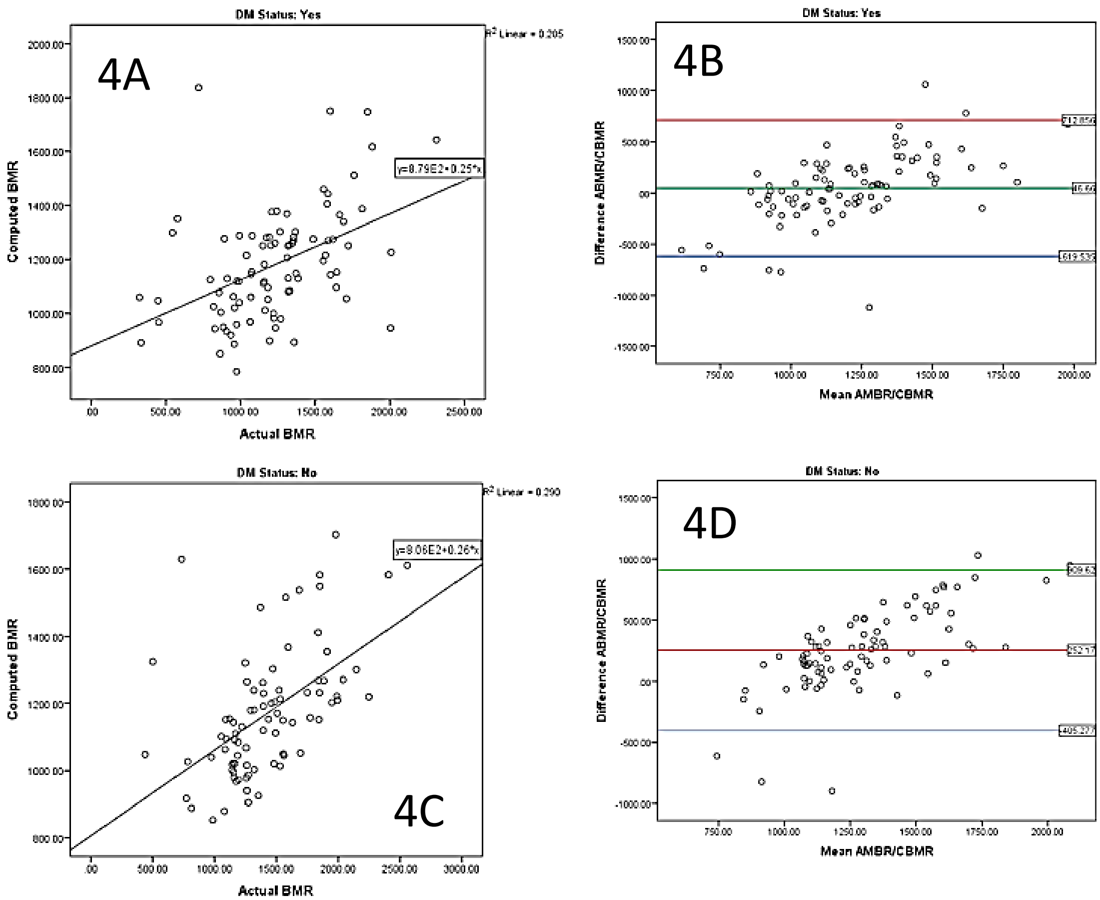

Figure 4. Calculated BMR using Actual Weight and Calorimetry Correlation and Bland-Altman Scatterplot, Stratified Between (+) DM and (-) DM. (4A – Correlation Scatterplot for (+) DM; 4B – Bland-Altman Scatterplot for (+) DM; 4C – Correlation Scatterplot for (-) DM; 4D – Bland-Altman Scatterplot for (-) DM)

In line with this, the computation of the BMR using the newly derived formula resulted to a mean value of 1174.70 (±196.93) kcal/day, which is 145.83 lower than the actual mean BMR result of 1320.53 (± 398.90) kcal/day using indirect calorimetry. This difference is statistically significant in the Bland-Altman Plot. In addition, utilizing the estimated accuracy test, only 31% of the computed BMR fell within the ± 10% of the indirect calorimetry values. This can be explained by the differences in the sample population studied, in terms of the presence or absence of diabetes mellitus or pre-diabetes, and the lower BMI cut-offs of the current sample population. Previous studies show that the BMR and the 24-hour energy expenditure are significantly higher among patients with diabetes.[8-12] Studies done by Alawad et al., Bitz et al., and Morino et al., all enrolled diabetic cases and non-diabetic controls, and their results showed a significantly higher BMR among the cases than the controls.[8,9,11] This can also be seen in this study, in which the calculated BMR is higher among the DM and pre-DM subgroup (1179.55 vs. 1169.50 kcal/day). Abnormal metabolic reactions in the skeletal muscle, liver, and adipose tissue, associated with insulin resistance among those with diabetes, can result to a higher rate of oxygen consumption and carbon dioxide production, leading to a higher BMR.[8] Other mechanisms are poorly understood, but may include, increased gluconeogenesis, increased protein turnover, increased sympathetic nervous system activity, and hyperglucagonemia, all resulting to higher energy release among DM patients.[8,9,12] The inclusion of patients without diabetes may have contributed to the significant difference between the results of the IC and the applied formula. This hypothesis was further exemplified when the subgroup analysis was done, resulting to a lower difference of 46 kcal/day (from an initial difference of 145.83) and an increase to 38% (from an initial 31% falling within ± 10% of the IC values on the estimated accuracy test, when the formula was applied among the DM and pre-DM samples only. In contrast, a higher difference of 252 kcal/day between the calculated and actual values and a decrease to 24% on the estimated accuracy test resulted when the formula was applied among non-DM samples only. The independent samples *t-test* showed that this difference between the two groups (46 kcal/day vs. 252 kcal/day) was highly significantly different; denoting a more accurate result when the formula is applied to the population with diabetes/pre-diabetes. It can also be noted in this subgroup analysis that the formula underestimated the actual BMR in majority of the non-DM population, which can account for the underestimation of the formula among the general overweight and obese population. These are all consistent with the finding of Martin et al., in which diabetes status independently contributes to the variability for resting energy expenditure. [13]

In addition, as this study utilized a lower cut-off BMI for its sample population, the previous study had a slightly heavier population. This may also have contributed to the significant difference between the IC and the formula results. Fat-free mass, being the metabolically active component of the body, remains to be the main significant determinant of BMR, while fat mass is more significant in obese patients, but only contributes 3-4% of the BMR.[2,14] Nonetheless, the correlation coefficient using the Pearson's R and the scatterplot of both the general and subgroup analyses reveal a linearity of positive direction for both the calculated and actual BMR (using IC). If the calculated BMR (utilizing the height and weight) is high, the actual BMR may also be expected to be high. This coincides with the fact that BMR is dependent on body composition, among other factors, which is then divided into fat-free mass and fat mass, and is reflected on a patient's weight.[2]

When the actual calorimetry results were compared between the DM and the non-DM subgroups, a lower BMR was noted among those with DM and pre-DM, which is quite inconsistent with previous studies discussed above. But this may be explained by better glycemic control, which shows lower resting metabolic rates, compared to poor control.[8] Majority of the subjects with diabetes in this study are controlled on only oral hypoglycemic agents. In addition, it can be noted that the DM population is ~15 years older than the non-DM, which can also explain why their BMR is lower. A study by Lazzer et al., showed an inverse relationship between age and BMR, which was mainly attributed to reduced fat-free mass among older individuals.[2] In theory, since BMR depends on the mass and metabolic rate of tissues and organs, age-related decline in cellular fraction of organs and tissues may account for the lower BMR as an individual gets older.[2,14,15] Weyer et al., found in their study that the effect of age on BMR was marginal, but significant, causing a decrease of 2 kcal/day per year.[16] This strengthens the fact that among other variables, fat-free mass remains to be the main significant determinant of BMR, and the theory that age-related decline in cellular metabolism may be a contributory factor in the decrease in BMR occurring with age.

The novel formula is linearly reflective of the basal metabolism, but the exact numerical values are statistically lower when the formula is applied to the general population. However, among patients with diabetes and pre-diabetes, this novel formula predicts a more accurate result. Because of the numerous factors affecting the basal metabolic rate and the body's energy expenditure (body composition, gender, age, physical activity, nutritional status, co-morbidities), there may be no one-size-fits-all formula that can accurately predict the basal metabolic rate of a specific patient.[2] Including these factors (such as age, sex, fat-free mass) in consideration of the formula may result to a more accurate BMR estimation; though previous studies have shown no significant improvement to the prediction model in the addition of other variables (age and sex), especially after adjustment for fat-free mass.[2,4] It still boils down to considering all the factors present, and this is consistent with the study done by Ferreira et al., which revealed that most of the results from the estimations of their studied equations differed from the results of indirect calorimetry, as these equations "cannot estimate values with the same consistency and magnitude as the results determined by gas exchange."[10] Another review article by Gupta et al., summarized that various studies cross-validated published predictive equations for measured resting energy expenditure (REE) among obese patients and the critically ill, and the results either overestimated or underestimated (for obese and critically ill respectively) the BMR, especially since the resting metabolic rates (RMRs) of adipose tissue are low.[17] This may also be the same principle that can be applied in this newly-derived formula, rendering it linearly reflective of the basal metabolism, but the exact numerical values being statistically different (lower). The constant and the coefficients used must be modified, depending on the specific population and their characteristics that the formula is being applied to.

A major limitation of this validation study is that only patients with access to healthcare were given the chance to be recruited; they may not be representative of the whole population. Given this data set, the authors recommend that: (1) The ideal and more accurate method to obtain the REE among obese patients is still through an indirect calorimetry. The procedure may be expensive, not readily available, inconvenient, and the preparations may be tedious, but the results are the most accurate in terms of BMR. (2) Variations (with different constants and coefficients) may be devised for specific application among different populations: overweight/obese, diabetics, critically ill, children and adolescents, among others. These variations may be derived from comparison and validation studies involving the different populations. (3) A larger study, enrolling a larger, more heterogeneous sample size, may be done in order to devise a formula more applicable to the general population (ex. like Harris-Benedict Equation), but specific for Filipinos.

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