

# Validity of Resting Energy Expenditure Predictive Equations before and after an Energy-Restricted Diet Intervention in Obese Women

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## Abstract

### Background

We investigated the validity of REE predictive equations before and after 12-week energy-restricted diet intervention in Spanish obese ( $30 \text{ kg/m}^2 > \text{BMI} < 40 \text{ kg/m}^2$ ) women.

### Methods

We measured REE (indirect calorimetry), body weight, height, and fat mass (FM) and fat free mass (FFM, dual X-ray absorptiometry) in 86 obese Caucasian premenopausal women aged  $36.7 \pm 7.2$  y, before and after ( $n = 78$  women) the intervention. We investigated the accuracy of ten REE predictive equations using weight, height, age, FFM and FM.

### Results

At baseline, the most accurate equation was the Mifflin *et al.* (Am J Clin Nutr 1990; 51: 241–247) when using weight (bias:  $-0.2\%$ ,  $P = 0.982$ ), 74% of accurate predictions. This level of accuracy was not reached after the diet intervention (24% accurate prediction). After the intervention, the lowest bias was found with the Owen *et al.* (Am J Clin Nutr 1986; 44: 1–19) equation when using weight (bias:  $-1.7\%$ ,  $P = 0.044$ ), 81% accurate prediction, yet it provided 53% accurate predictions at baseline.

### Conclusions

There is a wide variation in the accuracy of REE predictive equations before and after weight loss in non-morbid obese women. The results acquire especial relevance in the context of the challenging weight regain phenomenon for the overweight/obese population.

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## Introduction

The largest component of daily energy expenditure, especially in people with sedentary lifestyle, is resting energy expenditure (REE). To determine reliable REE measurements in obese individuals is important in order to establish reachable goals for dietary intervention and weight loss [1]. REE can be objectively and accurately measured through indirect calorimetry; however, their use is limited in most dietetic settings due to their high cost, the need of qualified and trained technicians and time constraints [2]. Hence, REE estimation by mathematical equations developed from direct or indirect calorimetry was frequently adopted as the major alternative method.

The validity of REE predictive equations is under debate, especially in obese individuals [3]. Indeed, it is likely that the inaccuracy of REE predictive equations in obese subjects might be one of the reasons explaining the low efficacy of low caloric diet treatments [4], [5]. REE highly depends on body size and body composition, but considerable variability exists among individuals after taking into account several key variables such as age, sex, weight, height, fat free mass (FFM), fat mass (FM), sex-hormonal status or ethnicity [6], [7], [8], [9], [10]. Differences in the level of overweight/obesity, as well as the participants' age range are also potential factors explaining the accuracy/inaccuracy of the REE predictive equations and the differences observed in the few available studies [11], [12], [13], [14].

Several studies have assessed the validity of REE predictive equations in overweight and obese subjects (body mass index (BMI)  $> 25 \text{ kg/m}^2$ ) [3], [15], [16], and in morbid obese people (BMI  $> 40 \text{ kg/m}^2$ ) [17], [18]. Less studies have however examined the validity of REE predictive equations specifically in non-morbid obese women ( $30 \text{ kg/m}^2 > \text{BMI} < 40 \text{ kg/m}^2$ ) [3], [15], [19]. All these studies included women with a wide age range and examined pre- and post-menopausal women together despite previous reports showed that REE decreases with aging and may also decrease in women as a result of the menopause [20].

Evidence exists that weight loss leads to a reduction in REE beyond that explained by the decrease in FFM and FM. This phenomenon has been described as “*adaptive thermogenesis*” or “*metabolic adaptation*” [21], [22]. Metabolic adaptation occurs when the body counteracts energy restriction by decreasing REE [23]. This decrease is beyond the expected decrease in REE due to changes in body weight, which could account in part for the common cessation of weight loss observed after 12–20 weeks of energy restriction [24]. Our understanding of the molecular mechanisms that regulate energy homeostasis has increased remarkably over the past decade, however, little is known about the effect of energy restriction on adaptive changes in energy homeostasis. Moreover, the accuracy of REE predictive equations after a weight loss program and the consequent “*metabolic adaptation*” has not been thoroughly examined [12] despite its implication in the weight regulation after a dietary intervention and the challenging weight regain phenomenon in the overweight/obese population. Indeed, a variety of factors are known to



# Statistical analysis

We conducted paired t-tests to analyze differences in changes on body weight, BMI, FM and FFM after a 12-week energy-restricted diet intervention, and so we did to analyze the bias (mean percentage error differences between REE estimations by predictive equations and measured REE values by calorimetry). We calculated the root mean sum of squared errors (RMSE). We considered an accurate estimation when the equation predicted between 90% and 110% of the measured REE, such as in previous studies [3], [15], [19], whereas we classified as under-prediction and over-prediction when the estimation was <90% and >110% of the measured REE, respectively. The percentage of women that had a predicted REE within  $\pm 10\%$  of the measured REE was considered as an index of accuracy at individual level. Nevertheless, as this range could be considered too wide in the clinical practice [4], we included also the percentage of accurate predictions within  $\pm 5\%$  of the measured REE.

The agreement between REE predicted equations and measured REE was graphically examined [39] by plotting the difference between the predicted and the measured REE against the measured REE [40]. We calculated the mean difference, 95% confidence intervals of the difference, and the 95% limits of agreement (mean difference  $\pm 1.96SD$  of the difference). The heteroscedasticity, that is, the association between the magnitude of the measurement (i.e. measured REE) and the difference between the predicted and measured REE, was examined by regression analysis, entering the absolute difference between the predicted and measured REE as dependent variable and the measured value as independent variable. Data were analyzed by using PASW (Predictive Analytics SoftWare, v. 18.0 SPSS Inc., Chicago, IL, USA).

## Results

The characteristics of the study sample at baseline and after a 12-week energy-restricted diet intervention are shown in **Table 2**. Women had lower BMI, FM and FFM after the intervention (all  $P < 0.001$ ).

	Baseline (n = 86)		Post 12-week diet intervention (n = 78)	
	mean	sd	mean	sd
Age (y)	36.6	7.2		
Weight (kg)	89.5	10.2	81.2	10.0
BMI (kg/m <sup>2</sup> ) <sup>a</sup>	33.9	2.8	30.7	2.8
Fat mass (kg)	37.8	6.3	32.6	6.2
Fat free mass (kg)	50.6	5.4	47.8	5.3

<sup>a</sup>BMI, body mass index; sd, standard deviation.  
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**Table 2. Descriptive characteristics of the study participants before (baseline) and after a 12-week energy-restricted diet intervention.**  
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**Table 3** shows (before and after 12-week diet intervention) the means and SD values of measured REE and estimated REE with the selected predictive equations, the percentage bias, the maximum values observed for negative errors (under-prediction) and positive errors (over-prediction), the RMSE (in kcal/d), and the percentage of under and over predictions. At baseline, we observed a significant bias in all the REE predictive equations (all  $P < 0.05$ ) except in the equation reported by Mifflin et al. [36] when using weight (bias:  $-0.2\%$ ,  $P = 0.982$ ), RMSE of 136 kcal/d, 74% of accurate predictions, 14% under-predictions and 12% over-predictions. The highest bias observed corresponded to the equation reported by Bernstein et al. [38] when including FFM and FM ( $-25\%$ ,  $P < 0.001$ ), RMSE of 341 kcal/d, 5% accurate predictions and 95% under predictions.

REE predictive equation	REE	sd	Bias <sup>a</sup>	Maximum negative error <sup>b</sup>		Maximum positive error <sup>b</sup>		RMSE	Accurate predictions <sup>c</sup>		Under predictions <sup>d</sup>		Over predictions <sup>e</sup>	
				kcal/d	%	%	%		kcal/d	%	%	%	%	%
REE measured	1869	173												
Mifflin et al. [36]	1840	118	-0.8	-20	22	185	41	98	6	14	12			
Owen et al. [35] Weight	1839	79	-1.7	-12	9	108	23	81	12	7	12			
Owen et al. [35] Fat free mass	1781	142	-10.7	-41	9	259	8	74	12	14	12			
Mifflin et al. [36] Weight	1850	141	-0.2	-11	18	156	56	74	14	12				
Mifflin et al. [36] Fat free mass	1410	187	-10.7	-51	19	180	34	40	14	12				
PADONGKARNA [37] Weight	1861	154	0.2	-19	26	162	37	76	6	14				
PADONGKARNA [37] Weight and Fat mass	1766	267	-14.7	-53	24	306	8	18	11	12				
Deep & Newman [38] Weight and Height	1726	140	0.1	-19	36	215	29	73	1	12				
Bernstein et al. [38] Weight and Height	1339	79	-17.7	-41	4	269	12	24	79	0				
Bernstein et al. [38] Fat free mass	1264	116	-19.9	-52	1	302	9	9	100	0				
Post 12-week diet intervention														
REE measured	1800	141												
Mifflin et al. [36]	1748	114	-1.7	-16	26	189	31	74	6	12				
Owen et al. [35] Weight	1702	72	-1.2	-19	17	111	44	81	12	7				
Owen et al. [35] Fat free mass	1276	187	-10.9	-51	18	190	35	49	14	12				
Mifflin et al. [36] Weight	1841	141	-1.4	-6	23	201	4	74	0	12				
Mifflin et al. [36] Fat free mass	1305	189	-13.2	-57	15	162	26	50	14	12				
PADONGKARNA [37] Weight	1760	127	-1.3	-6	25	204	23	74	6	12				
PADONGKARNA [37] Weight and Fat mass	1526	116	0.9	-6	25	164	30	74	6	12				
Deep & Newman [38] Weight and Height	1610	140	0.8	-11	37	204	16	73	1	12				
Bernstein et al. [38] Weight and Height	1176	72	-20.1	-41	2	269	24	18	107	0				
Bernstein et al. [38] Fat free mass	1211	114	-16	-45	1	212	8	24	79	0				

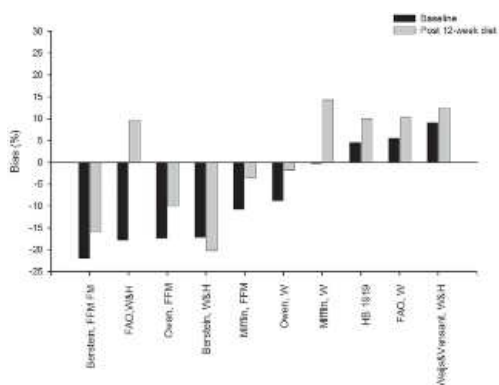
<sup>a</sup>Bias, percentage error.  
<sup>b</sup>Mean and range error between predictive equations and measured values.  
<sup>c</sup>The largest under-prediction observed with the predictive equation as a percentage of the measured value.  
<sup>d</sup>The largest over-prediction observed with the predictive equation as a percentage of the measured value.  
<sup>e</sup>Percentage of women predicted by the predictive equation within 10% of the measured value.  
<sup>f</sup>Percentage of women predicted by the predictive equation within 5% of the measured value.  
<sup>g</sup>Percentage of women predicted by the predictive equation < 10% of the measured value.  
<sup>h</sup>Percentage of women predicted by the predictive equation < 5% of the measured value.  
doi:10.1371/journal.pone.0023759.t003

**Table 3. Evaluation of resting energy expenditure (REE) predictive equations in Spanish obese women before (n = 86) and after a 12-week energy-restricted diet intervention (n = 78) based on bias, root mean squared error (RMSE), and percentage accurate prediction.**  
doi:10.1371/journal.pone.0023759.t003

After 12-week energy-restricted diet intervention, the equation reported by Owen et al. [35] when using weight was the one with the lowest bias ( $-1.7\%$ ,  $P = 0.044$ ), RMSE of 106 kcal/d, 81% accurate prediction, 12% under-predictions and 7% over-predictions. The equation reported by Mifflin et al. [36] when using weight had a bias of  $14.4\%$  ( $P < 0.001$ ), RMSE of 249 kcal/d, 24% accurate predictions and 76% over-predictions. Moreover, the equation reported by Mifflin et al. [36] when using FFM had a bias of  $-3.5\%$ , RMSE of 103 kcal/d, 82% accurate predictions, 14% under-predictions and 4% over-predictions. The highest bias observed corresponded to the equation reported by Bernstein et al. [38] when including weight and height ( $-20.1\%$ ,  $P < 0.001$ ), RMSE of 238 kcal/d, 13% accurate predictions and 87% under-predictions.

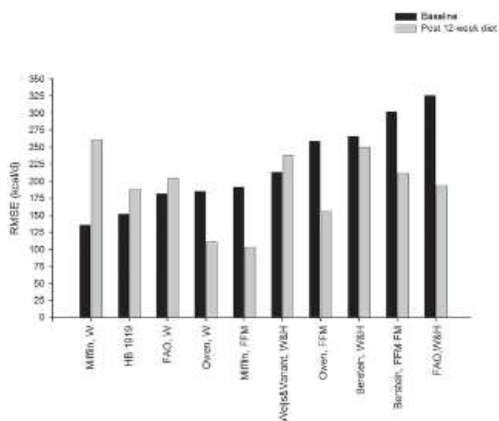
Percentage bias and RMSE at baseline and after the 12-week energy-restricted diet intervention of those women who completed the intervention (n = 78) is depicted in

**Figure 1 and 2**, respectively. Both percentage bias and RMSE are significantly different compared to that observed after the 12-week diet intervention in all the studied REE predictive equations (all  $P < 0.001$ ). The bias observed with the equation reported by Mifflin et al. [36] changed from  $-0.35\%$  at baseline to  $14.4\%$  after 12-week diet intervention (RMSE: 136 and 249 kcal/d, at baseline and after 12-week diet intervention, respectively). Similarly, the bias observed with the equation reported by Owen et al. [35] changed from  $-8.7\%$  at baseline to  $-1.7\%$  after 12-week diet intervention (RMSE: 185 and 106 kcal/d, at baseline and after 12-week diet intervention, respectively). The HB1919 equation [34] had a predicted REE within  $\pm 10\%$  of the measured REE at both baseline (bias  $4.6\%$ , RMSE of 152 kcal/d, 66% accurate predictions, 6% under-predictions and 28% over-predictions) and post 12-week diet intervention (bias  $10.0\%$ , RMSE of 180 kcal/d, 56% accurate predictions and 44% over-predictions).



**Figure 1. Percentage bias for 10 resting energy predictive equations in Spanish obese women before (baseline,  $n = 78$ ) and after a 12-week energy-restricted diet intervention (post 12-week diet intervention,  $n = 78$ ).**

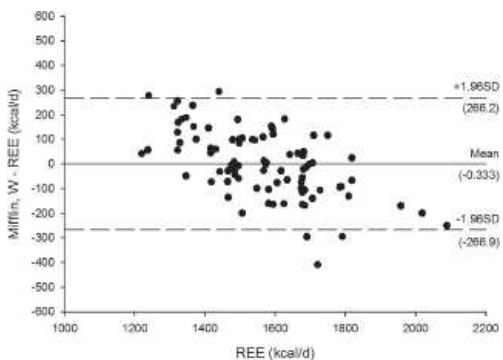
Data are sorted by mean values at baseline. FFM indicates fat free mass; FM, fat mass; W, weight; W&H, weight and height. doi:10.1371/journal.pone.0023759.g001



**Figure 2. Root mean squared error for 10 resting energy predictive equations in Spanish obese women before (baseline,  $n = 78$ ) and after a 12-week energy-restricted diet intervention (post 12-week diet intervention,  $n = 78$ ).**

Data are sorted by mean values at baseline. FFM indicates fat free mass; FM, fat mass; W, weight; W&H, weight and height. doi:10.1371/journal.pone.0023759.g002

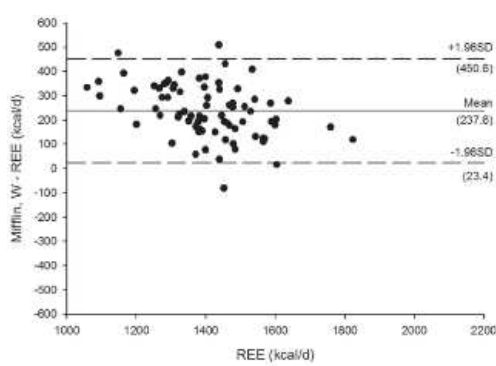
**Figure 3 and 4** shows the Bland Altman plots for the Mifflin et al. [36] REE predictive equations, **Figure 5 and 6** shows the Bland Altman plots for the Owen et al. [35] REE predictive equations, and **Figure 7 and 8** shows the Bland Altman plots for the HB1919 [34] REE predictive equations. We observed heteroscedasticity in all equations (all  $P < 0.001$ ). There was an inverse association between the magnitude of the measurement (i.e. measured REE) and the difference of the predicted and measured REE.



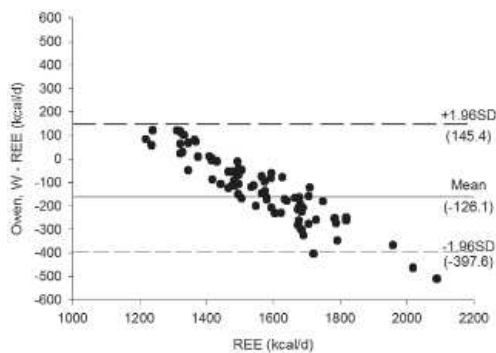
**Figure 3. Bland Altman plots for the Mifflin et al. (34) for resting energy expenditure predictive equations in Spanish obese women before a 12-week energy-restricted diet intervention (baseline,  $n = 78$ ).**

Solid line represents the mean difference (bias) between predicted and measured resting energy expenditure (REE). Upper and lower dashed lines represent the 95% limits of agreement (mean difference  $\pm 1.96$  SD of the difference).

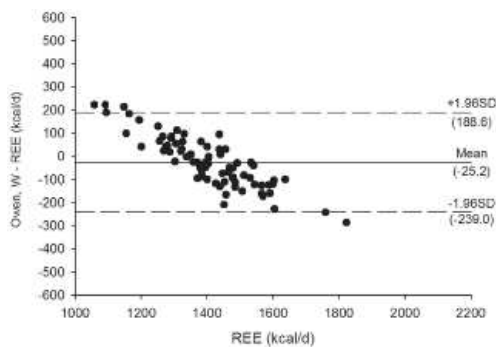
doi:10.1371/journal.pone.0023759.g003



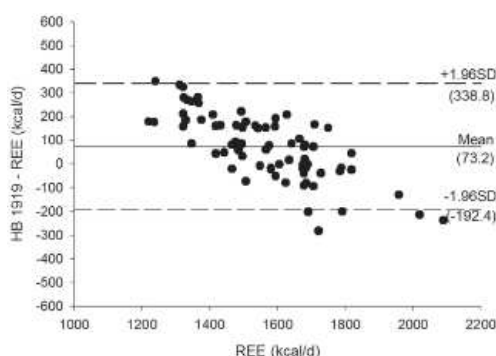
**Figure 4. Bland Altman plots for the Mifflin et al. (34) (weight) for resting energy expenditure predictive equations in Spanish obese women after a 12-week energy-restricted diet intervention (post 12-week diet intervention, n = 78).** Solid line represents the mean difference (bias) between predicted and measured resting energy expenditure (REE). Upper and lower dashed lines represent the 95% limits of agreement (mean difference  $\pm 1.96$  SD of the difference).  
doi:10.1371/journal.pone.0023759.g004



**Figure 5. Bland Altman plots for the Owen et al. (33) (weight) for resting energy expenditure predictive equations in Spanish obese women before a 12-week energy-restricted diet intervention (baseline, n = 78).** Solid line represents the mean difference (bias) between predicted and measured resting energy expenditure (REE). Upper and lower dashed lines represent the 95% limits of agreement (mean difference  $\pm 1.96$  SD of the difference).  
doi:10.1371/journal.pone.0023759.g005



**Figure 6. Bland Altman plots for the Owen et al. (33) (weight) for resting energy expenditure predictive equations in Spanish obese women after a 12-week energy-restricted diet intervention (post 12-week diet intervention, n = 78).** Solid line represents the mean difference (bias) between predicted and measured resting energy expenditure (REE). Upper and lower dashed lines represent the 95% limits of agreement (mean difference  $\pm 1.96$  SD of the difference).  
doi:10.1371/journal.pone.0023759.g006

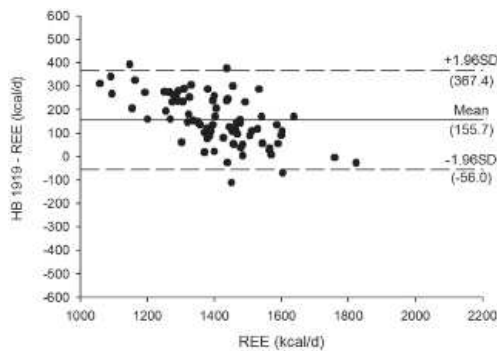


**Figure 7. Bland Altman plots for the HB 1919 (32) for resting energy expenditure predictive equations in Spanish obese women before a 12-week**

### energy-restricted diet intervention (baseline, n = 78).

Solid line represents the mean difference (bias) between predicted and measured resting energy expenditure (REE). Upper and lower dashed lines represent the 95% limits of agreement (mean difference  $\pm 1.96$  SD of the difference).

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**Figure 8. Bland Altman plots for the HB 1919 (32) for resting energy expenditure predictive equations in Spanish obese women after a 12-week energy-restricted diet intervention (post 12-week diet intervention, n = 78).**

Solid line represents the mean difference (bias) between predicted and measured resting energy expenditure (REE). Upper and lower dashed lines represent the 95% limits of agreement (mean difference  $\pm 1.96$  SD of the difference).

doi:10.1371/journal.pone.0023759.g008

## Discussion

The results of this study indicate that the best equation to estimate REE before a weight loss program in obese (BMI: 30–39.9 kg/m<sup>2</sup>) pre-menopausal Caucasian women is the equation reported by Mifflin *et al.* [36] when using weight, whereas the Owen *et al.* [35] equation (when using weight) is the best to estimate REE after a 12-week energy-restricted diet intervention in the same women. The Mifflin equation provides 74% accurate predictions before the diet intervention, yet, this level of accuracy cannot be reached after the 12-week diet intervention (24% accurate prediction). The Owen equation provides 81% accurate predictions after a 12-week energy-restricted diet intervention, although it only provides 53% accurate predictions at baseline. The average weight loss percentage in this study was close to 10%, which matches well the current clinical recommendations for overweight or obese persons [41], [42]. These findings are clinically relevant and suggest that the best equation to estimate REE in Caucasian obese women greatly depends on whether the patient has recently participated or not on an energy-restricted diet intervention.

The Mifflin equation was derived from a sample of 498 men and women, which included non-overweight, overweight and obese subjects and whose age ranged between 19 and 78 years. Several studies proposed this equation as the most valid to estimate REE in non-obese subjects aged 18 to 78 years (82% accurate predictions) [3], and in overweight and obese subjects aged 19 to 69 years (78% accurate predictions). There is some support also for using the Mifflin equation in European American females [43] and extremely obese females [17]. Likewise, Frankenfield *et al.* [14] in a validation study conducted in a cohort of 20 adults (12 women) aged 18 to 69 years, observed that 70% were within the range of agreement ( $\pm 10\%$  of measured REE). Weijs [15] tested the accuracy of 27 REE predictive equations in Dutch and U.S. overweight (BMI between 25 and 40 kg/m<sup>2</sup>) adults (18–65 years) and reported that the Mifflin equation provided almost 80% accurate predictions for U.S. adults and performed well across sex and BMI groups; but, for the whole sample of Dutch adults, none of the equations reached this level of accuracy. Nevertheless, the Mifflin equation provided 68% of accurate predictions for obese Dutch women (n = 74 women aged <65 years) from this same sample. More recently, Weijs *et al.* [19] examined the validity of REE predictive equations in 536 normal weight to morbid obese Belgian women and showed that either the original Harris–Benedict (69% of accurate predictions) or the Mifflin equation (68% of accurate predictions) can be used with accuracy to predict REE across a wide range of body weight (BMI, 18.5–50 kg/m<sup>2</sup>). However, they noticed that the accuracy of both Harris–Benedict and the Mifflin equations was fairly low when considering the BMI range of 30–40 kg/m<sup>2</sup>. Our results confirm and extend these findings, and provide more evidence for the use of the Mifflin equation in pre-menopausal, non-morbid obese women with weight stability of at least 3 months.

The observed variability in the accuracy of the Mifflin equation for predicting REE in obese women in the above mentioned studies could be explained by (i) the inclusion of both pre-menopausal and post-menopausal women; and (ii) the lack of control about weight stability during the previous months. REE decreases beyond values expected from body weight and body composition losses as result of energy restriction [24]. Thus, this metabolic adaptation could affect the validity of the equations which are derived from data of individuals with a stable energy balance. Interestingly, we observed that the error of all equations changed after losing ~9% of body weight and that we cannot use with accuracy the same equation before and after a weight loss program. Indeed, both percentage bias and RMSE at baseline were significantly different compared to those observed after the 12-week diet intervention in all the studied REE predictive equations. Moreover, the percentage of over-predictions increased after weight loss in all the predictive equations. Siervo *et al.* [12] explored the influence of losing at least 5% of body weight in the accuracy of REE predictive equations in 31 subjects, and reported that the Owen equation was the most accurate, which is in agreement with our own findings. However, no information regarding the energy restriction treatment (diet composition, duration of intervention, etc.) or study sample characteristics (i.e. sex, age and BMI range) was provided, which hamper further between study comparisons. Interestingly, the Mifflin equation using FFM after the 12-week diet intervention had similar accuracy than the Owen equation. As far as we are aware, ours is the first study examining the influence of an energy restriction treatment on the validity of REE predictive equations in a well characterized sample of obese pre-menopausal Caucasian women. Whether the best equation to estimate REE after an energy-restricted diet intervention varies depending on the length of the intervention is not known. Moreover, the possible variation in the validity of REE equations when weight loss is achieved through programs combining hypocaloric diet and exercise remains to be elucidated. Future studies should address these issues. Furthermore, future studies should also investigate which is the best REE predictive equation after a follow up period of, for instance, 3–6 months in women that followed an energy-restricted diet intervention.

The Harris-Benedict equation is one of the most commonly used in clinical practice and, as it is the oldest, has undergone the most extensive validation. An expert panel evaluated 25 of validation studies and showed that accurate REE predictions occurred in 45% to 80% of individuals and that REE overestimates occurred more frequently than underestimates [3]. We observed that the Harris-Benedict equation had 66% of accurate prediction (6% under-predictions and 28% over-predictions) with a bias of 4.6% at baseline, and 56% of accurate prediction (0% under-predictions and 44% over-predictions) with a bias of 10.0% after 12-week of energy-restricted diet intervention. It has been reported that this equation systematically overestimates REE by approximately 5% [12], [14], [36], [44], which is in agreement with our results at baseline. In the current study, we extend these observations to the over-estimation of REE by the Harris-Benedict equation after 12-week of energy-restricted diet that reached the 10% of bias in obese women (RMSE of 180 kcal/d and 44% over-predictions).

Previous studies noted that the error in the prediction of REE was more likely in obese than in non-obese individuals [14], [19]. In our study, we observed that there was an inverse association between the magnitude of the measurement (i.e. measured REE) and the difference between the predicted and the measured REE. Indeed, the error in the REE estimation increased when increasing the magnitude of REE, which is closely associated with body size. In consequence, the use of adjusted body weight in the prediction of REE for the calculation of energy content in the prescription of low caloric diets does not seem a reasonable maneuver in clinical

practice.

In agreement with other studies [14], [15], [19], we noted that the inclusion of body composition (FFM and/or FM) did not improve the accuracy of REE prediction while women were within a stable weight period. Likewise, the most accurate predictive equation after the 12-week diet intervention program, the Owen equation, does not consider body composition. This is a relevant finding because weight derived equations are more feasible in clinical practice. Only the Mifflin et al. equation that includes FFM was enough accurate in predicting REE after weight loss in obese pre-menopausal women.

Although this study has strengths, we acknowledge several limitations. We did not measure sex hormones level to ensure that women were at the same phase of the menstrual cycle at baseline and after the dietary treatment. However, it is reasonable to think that they were at almost the same phase; indeed we designed the length of the treatment to be multiple of 4 weeks. Second, we did not exclude participants if they smoked, yet, smoking was not allowed before performing the indirect calorimetry measurement [29]. In our study conditions of measurement were strictly controlled and standardized, which is certainly a strength. Moreover, it is worth mentioning that our sample was more homogeneous than other previously reported due to the strict inclusion criteria and to the highly controlled intervention. Women were Spanish Caucasian, non-diabetic and non-morbid obese pre-menopausal women and followed an energy-restricted diet with similar macronutrient composition based on Mediterranean dietary habits, and whose energy content was estimated from measured REE. The use of DXA to measure body composition before and after weight loss should also be acknowledged.

In conclusion, this study shows that there is a wide variation in the accuracy of REE predictive equations before and after weight loss in non-morbid obese women. These findings are clinically relevant and suggest that the best equation to estimate REE greatly depends on whether the patient has recently participated or not on an energy-restricted diet intervention. The results acquire also especial relevance in the context of the challenging weight regain phenomenon for the overweight/obese population. Our findings confirm that the best equation to estimate REE in non-morbid obese, pre-menopausal women is the equation reported by Mifflin et al. [36]. However, the equation that best estimates REE in obese women after a 12-week energy-restricted diet intervention is the equation reported by Owen et al. [35]. There is a need to develop best practices with focus on weight regain [45], and understanding the accuracy of REE predictive equations in obese individuals after an energy intervention program may be such an example. Future studies in post-menopausal women, in morbid obese women, in men, and in other ethnicities are needed to further investigate the validity of REE predictive equations before and after and energy-restricted diet intervention so that the efficacy of weight loss programs can be improved.

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## Author Contributions

Conceived and designed the experiments: IL JRR. Performed the experiments: PA. Analyzed the data: JRR. Wrote the paper: IL JRR. Critically discussed and revised the manuscript: JRR FOB GR PA IL.

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