Measured versus predicted resting metabolic rate in overweight men and women following weight loss.

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Abstract

The multiplicity of resting metabolic rate (RMR) prediction equations indicates that many variables affect RMR, making it difficult to adopt a single equation for all individuals who wish to lose, gain or maintain weight.

PURPOSE:

To improve the accuracy of RMR prediction equations for obese individuals and to construct a new formula to evaluate RMR after weight loss (WL).

METHODS:

This study examined the RMR gap in 21 men (M) and 18 women (W), 25-60 yrs, with $27 < BMI < 40$ kg/m^2 and 10-20% WL after at least three months in a structured weight reduction program with a customized diet and professionally tailored exercise prescription. At entry and at follow-up visits participants' RMR, weight, height, fat-free mass (FFM), fat mass (FM), were measured with reliable instruments to ascertain the RMR change relative to FFM and FM. Pre and post RMR measurements were compared to calculated RMR using existing Harris and Benedict (HB), Ravussin and Bogardus (RB) and Johannsen et al. (J) prediction equations with and without regulating for FFM. T-test, ANOVA and χ^2 test comparisons were analyzed using SPSS 19.0, significance level P>0.05. To improve accuracy new prediction equations were constructed through stepwise linear regression based on before (RMR_b) and after (RMR_a) RMR measurements:

M: $RMR_b = 132.82 + 28.37(W) - 250.595(H) + 9.464(FFM) - 2.871(A) - 25.932(FM)$

M: $RMR_a = 1862.68 - 7.779(W) + 1716.697(H) + 18.091(FFM) + 1.964(A) + 14.972(FM)$

W: $RMR_b = 553.971 + 16.601(W) + 1033.839(H) - 13.734(FFM) - 10.930(A) - 19.668(FM)$

W: $RMR_a = 552.850 + 7.288(W) + 340.730(H) + 8.932(FFM) - 5.064(A) - 5.015(FM)$.

RESULTS:

In M and W there was a significant difference in WL (M: 104±13 vs. 87±11; W: 88±10 vs.75±8, P≤0.01), BMI (M: 33±3 vs. 28±3; W: 32±4 vs. 27±3, P≤0.01) and FM in kg (M: 37±7 vs. 26±9; W: 40±9 vs. 27±8, P≤0.01); M only in FFM (65±9 vs. 63±9, P=0.02); W only in RMR (1802±176 vs. 1684±176, P=0.04). Calculated RMR before and after WL using the J equation was closest to measured RMR in M and W before and in W after WL (M: -337±223; W: -57±256, vs. -69±128); the only difference was in W before WL (P=0.351 vs. P<0.001). RMR calculations with the new equations were more accurate and closest to measured RMR before and after WL in M (-0.05±154 vs. 0.03±197) but only after WL in W (-30±116).

CONCLUSION:

The study illuminates the need to adopt different equations for assessment of individuals' RMR before and after weight loss.

Introduction

Measuring resting metabolic rate (RMR in kilocalories/day) is a difficult procedure. Due to the this difficulty , over one hundred equations have been developed to predict the energy expenditure of individuals, based on easily determined characteristics such as weight, height, gender, age, body temperature, body composition, and more. The multiplicity of equations testifies to the existence of biological, physical, ethnic, and environmental variabilities that affect RMR, making it difficult to adopt a single equation for all individuals. Weight loss decreases total calorie expenditure and RMR due to a decrease in both fat mass (FM) and fat free mass (FFM). The existing RMR prediction equations (RMRe) were calculated based on heterogeneous samples, making it difficult to differentiate between various subgroups with conditions that may affect RMR besides the basic parameters.

Existing RMR/REE prediction equations (RMRe)

Harris and Benedict (HB): based on 239 subjects, including trained athletes, men at an average weight of 64 ± 10 kg, and women average 56 ± 1 kg; the variables used to construct the equation were weight, height, age and gender.

The HB equation, does not take into consideration the distribution of fat in the body, and therefore, it is less accurate for overweight and obese individuals.

Ravussin and Bogardus (RB): examined 129 men and 120 women with a weight range of 50.3-188.1 kg and fat percentage from 9-51%. They added FFM to their equation.

Johannsen et al. (J) : subjects were 7 men and 6 women, BMI = 49.4 ±9.4 kg/m2 ; developed an equation for RMR based on FFM,FM, age and gender.

Purpose: To improve the accuracy of the most appropriate RMRe in men and women with obesity and to construct new formulas, based on the current data, to evaluate metabolism after weight loss.

Methods

Subjects:

This is prospective follow-up study using a comfort sample of thirty-nine overweight and obese participants, 21 men and 18 women aged 25-60, with 27< BMI< 40 kg/m2, and a weight loss of 10% to 20% after completion of at least three months of a structured weight reduction program at a center for nutrition and physical activity in Israel, during the years 2015-2018.

Exclusion criteria:

individuals with type 1 diabetes mellitus, kidney or liver disease (not including fatty liver), proven coronary heart disease, and a <10% or >20% weight loss within the last 3-24 months.

A personally and professionally tailored diet and exercise program was prescribed for each participant.

Data collection:

Demographic and physical activity data and detailed nutritional habits were collected using a structured questionnaire administered by a trained interviewer at enrollment and at the end of the study period.

Participants underwent followed-up every 1-2 weeks.

RMR was measured using Quark Cardiopulmonary Exercise Testing (Cosmed, Rome, Italy); weight and height were measured using the Seca 703 instrument (Chino, California, USA). FFM, FM, were measured, using the Dual-Energy X-ray Absorptiometry, GE Lunar DPX-IQ DEXA Pencil Beam instrument (GE Healthcare, Chicago, Illinois, USA).

Measured RMR was compared with calculated RMR using the three existing equations, HB, RB, and J, at pre and post diet times.

Results

Based on multiple linear regression analysis using SPSS 25.0, the highest correlation with measured RMR resulted using the J equation in men before and after weight loss. In women the result was similar to that using the J equation only after weight loss. In both genders RB equation results were the closest to measured RMR (Table1)

Table 1 RMRm and RMRe using the different existing equations before and after weight loss, by gender

	Men			Women		
	Before	After	P	Before	After	P
RMR_m (kcal/day)	2240±340	2077±296	0.70	1802±176	1684±176	0.04*
RMR_e						
HB	1756±197	1534±172	<0.01*	1289±121	1157±110	<0.01*
RB	1801±206	1766±185	0.26	1421±211	1425±512	0.75
J	2578±189	2523±167	<0.01*	1860±217	1754±172	<0.01*

Continuous data are presented as average ±SD. RMRe resting metabolic rate calculated using the existing equations; RMRm, measured resting metabolic rate; HB, Harris and Benedict equation; RB, Ravussin and Bogardus equation; J, Johannsen equation.
*Represents statistical significance after versus before weight loss ($p < 0.05$).

A paired t-test was used to assess the difference between measured and calculated results using HB, RB, J and the new equations. A non-significant result indicates a good estimate compared to measured RMR. The gap was not significant only using the new equation in women after weight loss and in men before and after weight loss (Table 2)

Table 2: Comparison of RMRe versus RMRm and RMRs versus RMRm (mean±SD) and their correlations, before and after weight loss, by gender.

	RMR_e	Difference from RMR_m	P	Correlation	RMR_e	Difference from RMR_m	P	Correlation
		Before				After		
Men								
HB	1756±197	484±252	<0.01*	0.82	1534±172	542±251	<0.01*	0.71
J	2578±189	-337±223	<0.01*	0.75	2523±167	-445±252	<0.01*	0.75
RB	1801±206	474±248	<0.01*	0.82	1766±185	311±242	<0.01*	0.57
RMR_s	2241±303	-0.05±154	0.99	0.89	2078±220	0.03±197	0.99	0.74
Women								
HB	1289±121	514±197	<0.01*	0.67	1157±110	526±148	<0.01*	0.67
J	1860±217	-57±256	0.35	0.67	1754±172	-69±128	<0.01*	0.75
RB	1421±211	378±196	<0.01*	0.37	1425±512	259±139	<0.01*	0.62
RMR_s	1574±168	228±154	<0.01*	0.69	1714±132	-30±116	0.29	0.75

Harris and Benedict equation; RB, Ravussin and Bogardus equation; J, Johannsen. equation; RMRe, resting metabolic rate calculated with existing equations; RMRm, measured resting metabolic rate; RMRs, resting metabolic rate using new suggested equations.
* Represents statistically significant difference ($p < 0.05$). A non-significant difference indicates a better match between RMRm and RMRe or that RMRs represents a more accurate equation

Results continued

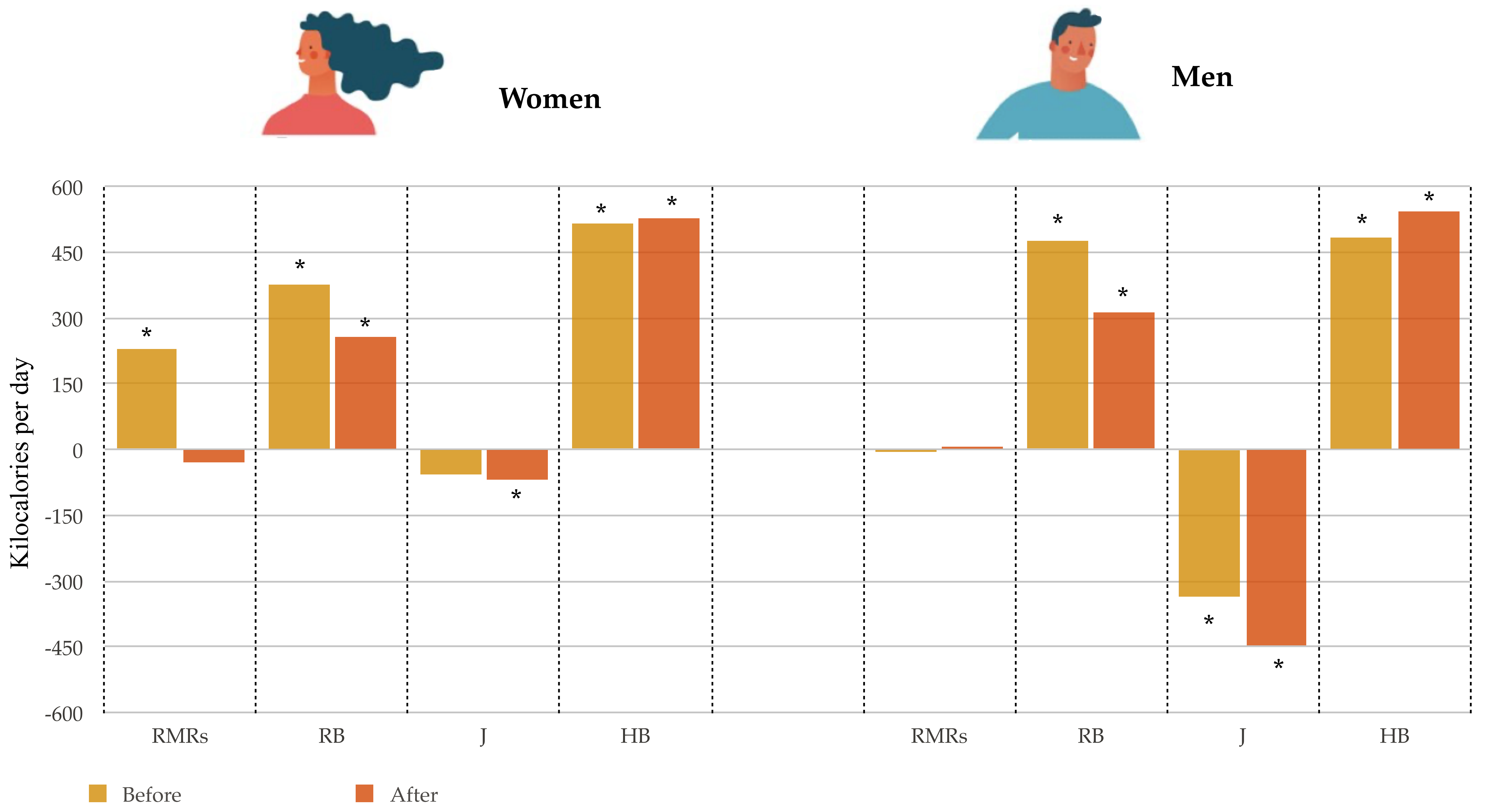

Fig. 1: Difference between RMRe and RMRm before and after weight loss, by gender.
Figure 1 shows the differences between calculated RMR (using HB, Harris and Benedict equation; RB, Ravussin and Bogradus equation; J, Johannsen equation and RMRs) and measured RMR before and after weight loss, by gender. RMRe, resting metabolic rate calculated with existing equations; RMRm, measured resting metabolic rate; RMRs, resting metabolic rate using new suggested equations. * Represents statistically significant difference ($p < 0.05$). **A non-significant difference indicates a better match between RMRm and RMRe or that RMRs represents a more accurate equation.**

Conclusions

The study illuminates the need to adopt different equations for assessment of individuals' RMR before and after weight loss.

The new equations may improve the accuracy of assessments, decrease their cost, and help overcome inaccessibility of RMR measuring equipment.

Further validation is needed in additional studies on various socio-economic populations and for different levels of weight loss.

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