A HIGHER RESTING METABOLIC RATE RELATIVE TO BODY MASS IS ASSOCIATED WITH LOWER BODY FAT PERCENTAGE IN ATHLETES

MAYO CLINIC

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ABSTRACT

BACKGROUND: Resting metabolic rate (RMR) accounts for 60-70% of total daily energy expenditure, and therefore, plays a pivotal role in energy balance and weight management. Varying degrees of metabolic activity may predispose certain athletes to excess body fat or conversely, to difficulties with gaining weight. Expressing RMR relative to body mass and fat-free mass (FFM) may help identify athletes with high or low RMR values.

OBJECTIVE: The purpose of the current study was to examine relationships between resting metabolic rate (RMR) and body fat percentage (BF%) when expressed relative to body mass and FFM.

METHODS: One-hundred and ninety male (n=98; Age: 20.1 ± 1.6 yr.; Body Mass: 92.7 ± 17.5 kg; Height: 181.6 ± 6.2 cm, Body Mass Index: 28.0 ± 4.7 kg/m^2) and female (n=92; Age: 19.4 ± 1.1 yr.; Body Mass: 65.2 ± 11.0 kg; Height: 168.0 ± 6.6 cm, Body Mass Index: 23.0 ± 3.6 kg/m^2) collegiate athletes completed testing during the pre-season period (within 6 weeks of the competitive season) during the 2016-2019 competitive sport seasons. Athletes from baseball (n = 8) cross country (n = 14), football (n = 62), track and field (n = 29), wrestling (n = 17), soccer (n = 43), swimming/diving (n = 6), volleyball (n = 9), and tennis (n = 2) were represented. Body composition was assessed using air displacement plethysmography and RMR was assessed using indirect calorimetry during a single morning of testing in a climate-controlled laboratory setting (temperature range: 22-24 ° C, and relative humidity range: 37-44%). Pearson correlation coefficients were used to examine relationships between BF%, and body mass, FFM, RMR, RMR/kg, and RMR/kg of FFM. Correlation coefficients were interpreted as very weak: <0.20, weak: 0.20–0.39, moderate: 0.40–0.59, strong:0.60–0.79, or very strong: >0.80. Linear regression analysis was used to determine which predictor variables (i.e., body mass, FFM, RMR/kg, RMR/kg of FFM) best predicted BF%. Statistical significance was determined as p < 0.05.

RESULTS: Weak relationships between body weight (r = 0.16; (p = 0.026), FFM (r = -0.26; p<0.001), and BF% were observed. Moderate and strong relationships were observed between RMR/kg of FFM and BF% (r = 0.37; p<0.001) and between RMR/kg and BF% (r = -0.51; p<0.001), respectively (Figure 1). RMR/kg and RMR/kg of FFM were the strongest (p<0.001) predictors of BF%.

CONCLUSIONS: Athletes with a higher RMR relative to body mass had a lower BF%, whereas athletes with a higher RMR relative to FFM had a higher BF%.

OBJECTIVES

PURPOSE: The purpose of the current study was to examine relationships between resting metabolic rate (RMR) and body fat percentage (BF%) when expressed relative to body mass and FFM.

Baseline Characteristics: One-hundred and ninety male (n=98; Age: 20.1 ± 1.6 yr.; Body Mass: 92.7 ± 17.5 kg; Height: 181.6 ± 6.2 cm, Body Mass Index: 28.0 ± 4.7 kg/m^2) and female (n=92; Age: 19.4 ± 1.1 yr.; Body Mass: 65.2 ± 11.0 kg; Height: 168.0 ± 6.6 cm, Body Mass Index: 23.0 ± 3.6 kg/m^2) collegiate athletes completed testing during the pre-season period (within 6 weeks of the competitive season) during the 2016-2019 competitive sport seasons. Athletes from baseball (n = 8) cross country (n = 14), football (n = 62), track and field (n = 29), wrestling (n = 17), soccer (n = 43), swimming/diving (n = 6), volleyball (n = 9), and tennis (n = 2) were represented.

METHODS

Body composition was assessed using air displacement plethysmography and RMR was assessed using indirect calorimetry during a single morning of testing in a climate-controlled laboratory setting (temperature range: 22-24 ° C, and relative humidity range: 37-44%).

Pearson correlation coefficients were used to examine relationships between BF%, and body mass, FFM, RMR, RMR/kg, and RMR/kg of FFM. Correlation coefficients were interpreted as very weak: <0.20, weak: 0.20–0.39, moderate: 0.40–0.59, strong:0.60–0.79, or very strong: >0.80. Linear regression analysis was used to determine which predictor variables (i.e., body mass, FFM, RMR/kg, RMR/kg of FFM) best predicted BF%. Statistical significance was determined as p < 0.05.

RESULTS

- The mean ± standard deviation RMR for male and female athletes was 27.9 ± 3.2 and 25.9 ± 2.8 kcals/kg when expressed relative to body weight. A summary of percentiles for relative RMR values across male and female athletes is presented in Table 1.
- A weak relationship between BF% and body weight (r = 0.162; p = 0.026) was observed, as well as a very strong relationship between FFM and body weight (r = 0.828; <0.001) (Figure 1).

RESULTS

- When stratified by sex, there were significant differences (p<0.05) in BF% across RMR groups as summarized in Table 2.
- A strong inverse relationship between RMR/kg and BF% (r = -0.510; p<0.001) was observed (Figure 2). Lastly, a moderate relationship between RMR/kg of FFM and BF% (r = 0.366; p<0.001) was observed.
- Body mass (β = 0.162), FFM (β = -0.257), RMR/kg (β = -1.017), and RMR/kg of FFM (β = 0.934) were significant predictors of BF%. Table 3 presents a summary of linear regression analysis.

Table 1. Percentiles for relative resting metabolic rate.

		5	10	25	50	75	90	95
RMR (kcal/kg)	Males	22.6	23.2	25.4	28.1	29.9	32.8	33.5
	Females	21.9	22.6	24.0	25.5	28.0	29.7	31.4

RMR = resting metabolic rate; kcal/kg = kilocalories per kilogram.

Table 2. Summary of body fat percentage and body weight across groups.

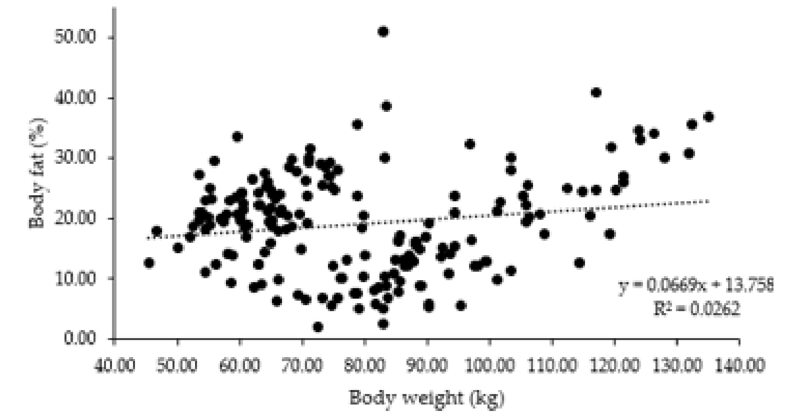
	Group	n	Body Fat (%)	Body weight (kg)	BMI (kg/m^2)
Males	Low (<26 kcal/kg)	32	20.7±9.1	103.6±18.8	30.9±4.8
	Moderate (26.1-29 kcal/kg)	32	13.5±5.8	88.7±14.4	26.9±4.2
	High (>29.1 kcal/kg)	34	13.0±9.0	86.1±14.1	26.2±3.6
	P value		<0.001	<0.001	<0.001
Females	Low (<24 kcal.kg)	30	25.5±7.4	71.6±12.8	25.2±4.7
	Moderate (24.1-27 kcal/kg)	31	23.0±4.3	63.3±8.9	22.7±2.4
	High (>27.1 kcal/kg)	31	19.7±4.5	60.8±8.1	21.3±1.8
	P value		<0.001	<0.001	<0.001

Data presented as mean ± standard deviation. BMI = body mass index; RMR = resting metabolic rate; kg = kilograms

Table 3. Linear regression summary for all athletes.

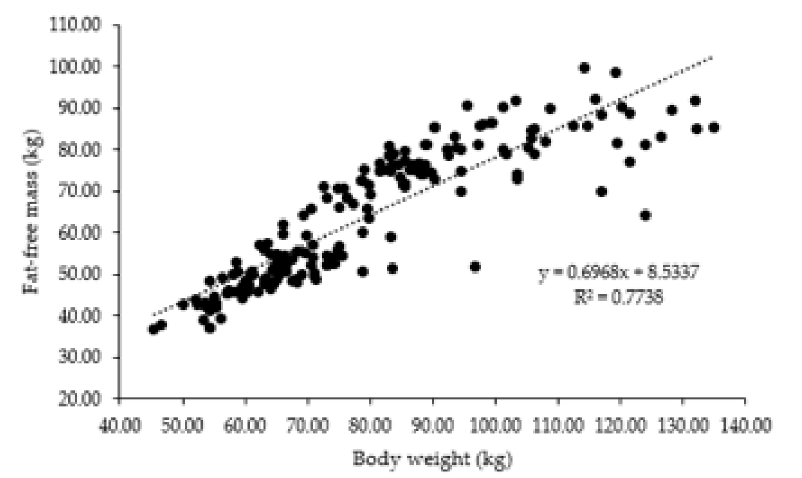
	Mean ± SD	95% CI	R^2	β	Slope	SE	p value
Body fat (%)	18.1 ± 8.3	16.8, 19.4					
Weight (kg)	81.5 ± 21.1	78.2, 84.8	0.026	0.162	13.7	8.2	0.026
Fat-free mass (kg)	66.1 ± 16.2	63.5, 68.6	0.066	-0.257	27.6	8.1	<0.01
RMR (kcals/day)	2228 ± 582	2136, 2319	0.004	-0.062	20.9	8.3	0.398
RMR / kg (kcal/kg)	27.5 ± 3.1	26.9, 27.9	0.260	-1.017	53.0	6.8	<0.01
RMR / kg of FFM (kcal/kg)	33.8 ± 4.0	33.2, 34.5	0.134	0.934	-6.6	7.4	<0.01

FIGURE 1



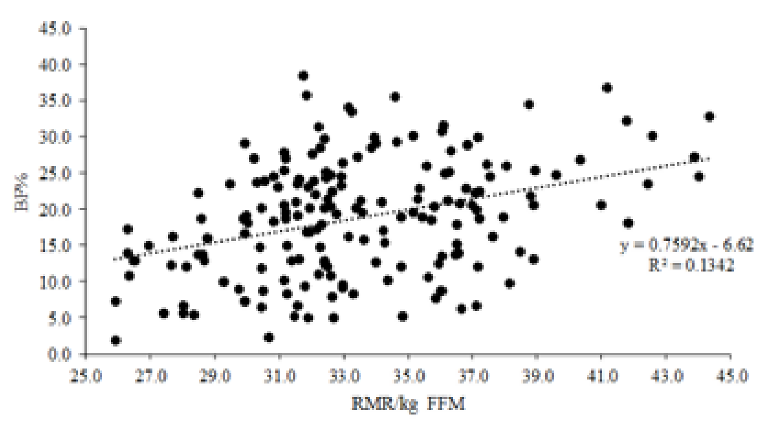
Relationships between body fat percentage and body weight.

FIGURE 2



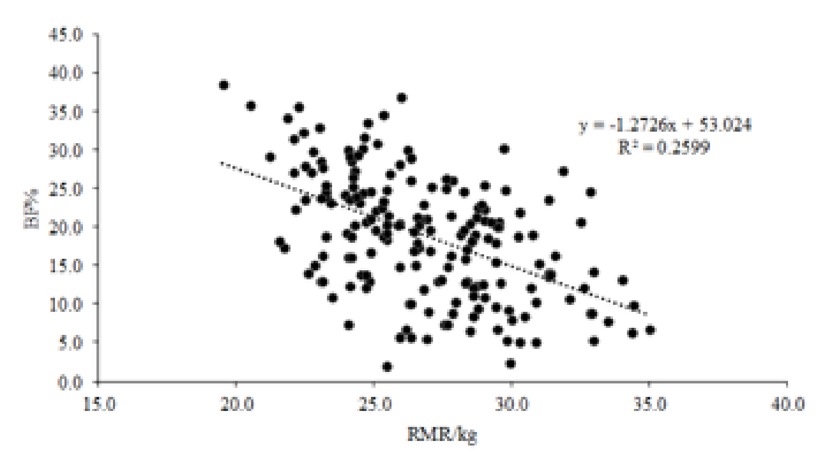
Relationships between fat-free mass and body weight.

FIGURE 3



Relationships between body fat percentage and RMR/kg of fat-free mass.

FIGURE 4



Relationships between body fat percentage and RMR/kg of body weight.

DISCUSSION

- Classifying an athlete's RMR is challenging as absolute measures of RMR are largely influenced by an athlete's body size.
- We previously [1] demonstrated that height, body mass, body mass index, fat-free mass, and fat mass were positively associated with absolute measures of RMR in male and female athletes (r = 0.4–0.8) and that body mass was the strongest predictor of RMR, accounting for 78% and 83% of the variation in RMR for male and female athletes, respectively.
- Moreover, we found that every 1 kg increase in body mass was associated with a 19 kcal and 20 kcal increase in RMR for male and female athletes, respectively

CONCLUSIONS

- Athletes with a higher relative RMR per body mass have a lower BF%, potentially as a result of increased metabolic activity and higher total daily energy expenditure.
- Therefore, athletes with a lower BF% may require an additional increase in energy intake per kilogram of body weight to help with weight gain, if desired. Future research should assess if baseline measures of relative RMR influence training adaptations and weight changes over time.

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