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ORIGINAL ARTICLE

Comparison of Adjusted Resting Metabolic Rate in Overweight and Normal Weight Female University Students

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ABSTRACT
The purpose of the present study was to compare adjusted resting metabolic rate (RMR) and correlation between RMR, anthropometric indices and body composition in normal and overweight female university students. In this case-control study, 100 female university students (50 normal weights and 50 overweights) aged 18-30 years, within the BMI range of 18.5 to 29.9 kg/m² were enrolled from August to December 2012. Basal characteristic, body frame size, anthropometric indices, body composition, dietary intake, physical activity and RMR were evaluated. Mean age and BMI of participants were 22.5 years and 24 kg/m², respectively. Overweight girls reported more dietary fat (p<0.01) and less carbohydrate (p=0.2) and protein intake (p=0.1) compared to normal weights. In overweight girls, RMR was significantly more than normal weights (1468 vs.1271 kcal/day). After adjusting RMR for confounder factors (body composition, body frame size, dietary intake and sleep duration), no significant differences were observed between the two groups (p=0.05). Moreover, in overweight and normal weight group, body weight indicated the highest correlation with RMR (r=0.57; r=0.45, respectively and p<0.05 in both groups). It seems, there are no significant differences in adjusted RMR between normal and overweight female university students and body weight is the best indicator for RMR value in both groups.
Keywords; *Resting Metabolic Rate, Overweight, Normal Weight, Dietary Intake*

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INTRODUCTION

The increasing prevalence of overweight and obesity in many developed and developing countries in the recent decades is a result of the imbalance between energy intake and energy expenditure [1]. Interactions between environmental and genetic factors are involved in the development of obesity. Dietary patterns, physical activity level, socio-economical and cultural differences are the main environmental factors of overweight and obesity [2]. Previous studies have indicated that some individuals lose weight slowly during the treatment of obesity and regain weight faster than others [3, 4]. Following these observations, a hypothesis regarding the effect of low resting metabolic rate on obesity was established.

Resting metabolic Rate (RMR) is defined as the amount of energy required for vital body functions such as circulation and respiration. RMR is the largest component (60-70%) of the total energy expenditure and is affected by the environmental factors (diet, physical activity, and temperature), individual characteristics (age, sex, body composition, body size, weight) and genetics [5]. It plays a major role in the regulation of energy balance [6]; Therefore, RMR is the main focus of studies on obesity treatment and weight maintenance. Some previous studies indicated that RMR in obese individuals is more than those of non-obese (normal and underweight) ones. Foster *et al*., compared black and white obese American African women, and they concluded that differences in the prevalence of obesity between black and white subjects may be due to the differences in their RMR value. It was assumed that a low RMR may be involved in lesser weight reduction when following weight-lose strategies [4]. Whilst several factors are involved in RMR regulation, normalizing RMR is an important measure. According to a study by Namini *et al*., on obese and normal weight subjects, RMR in obese individuals was more than normal weight participants, but after adjusting RMR for Fat Mass (FM) and Fat Free Mass (FFM), no significant differences were observed between the two groups [7]. In addition, Buscemi *et al*., reported an association between low RMR and weight gain among Caucasian Italians during a 12 year study after adjusting RMR according to FFM [3]. Some studies have introduced FFM or body weight as the best indicator for RMR [4, 8, 9], but there is a discrepancy about which anthropometric indicators have the strongest correlation with RMR in BMIs of different ranges.

Given to limited studies on the comparison of adjusted RMR in different ranges of BMI, the primary aim of the present study was to determine and to compare adjusted RMRs between normal and overweight female university students. The secondary aim was to determine the correlation between RMR, anthropometric indices and body composition in normal and overweight female university students.

MATERIAL AND METHODS

Participants and study design

In this study, 100 female university students (50 normal weights and 50 overweights) aged 18-30 years, within the BMI range of 18.5 to 29.9 kg/m^2 were enrolled from August to December 2012. Participants were randomly selected from female students who participated in a study about body image at Tabriz University of Medical Sciences. Subjects with diabetes mellitus, cardiovascular diseases, thyroid disorders and those taking medications with any possible effects on RMR such as some anti-obesity, anti psychotic, corticosteroid and diuretic medications during the last 3 months were not included. Protocols of the present study were approved by the ethics committee of Tabriz University of Medical Sciences. At the baseline, all steps were explained to the eligible subjects and volunteers signed an informed consent.

Anthropometric indices measurements

Weight was measured with the minimum amount of clothes, without shoes with a precision of 0.1 kg. Height was measured without shoes using a SECA stadiometer with a precision of 0.1 cm. Body Mass Index (BMI) was calculated by dividing the weight (in kilograms) to the square of the height (in meters). According to the World Health Organization, subjects within the BMI range of 18.5-24.9 and 25-29.9 kg/m^2 were considered normal and overweight subjects, respectively. Waist circumference (WC) was measured twice at the minimum circumference between the iliac crest and the rib cage. Hip circumference was measured twice at the maximum protuberance of the buttocks using a non-elastic measuring tape. Mean of twice measurements were recorded. Then, the Waist to Height (WtSH) and Waist to Hip ratio (WHR) were calculated. For determination of body frame size, wrist circumference was measured using a non-elastic measuring tape, and then the height was divided by the wrist circumference. Among those mentioned ratios more than 11, between 10.1 to 11 and less than 10.1 indicate small, medium and large body frame sizes, respectively.

Body composition and physical activity measurements

Body composition was measured overnight using a TANITA Bioelectrical Impedance Analysis (BC-418 MA, 50 kHz). The TANITA bioimpedance measures the amounts of Fat Mass (FM) and Fat Free Mass (FFM). Accuracy of this instrument in measuring FM and FFM was±0.1%. Previous studies reported a significant correlation between TANITA and Dual Energy X-Ray absorptiometry test (as a gold standard) for body composition [10-12].

International Physical Activity Questionnaire (IPAQ) was used to estimate the physical activity levels by means of face to face interviews. Based on the calculated scores, subjects were classified as being sedentary, moderate or severely active.

Dietary Intake Assessment

Dietary intakes were evaluated using a 3-day food dairy (two weekdays and one weekend). At the beginning of the study, all the participants were provided with instructions on how to use a food scale and record their food intake. Reported portion sizes in the dietary dairies converted to gram using household measures. Dietary intakes were analyzed using the nutritionist IV software (First Databank Inc., Hearst Corp., San Bruno, CA) containing the database from tables of content and nutritional values modified for Iranian food.

RMR Measurement

RMR was measured from 8:30 am to 11:00 a.m after a 12-14h fasting period that was free of psychological stress. Subjects were asked to avoid consuming caffeinated beverages (for 4-h), severe physical activity (for 24-h), smoking and drinking alcohol (for 2-h) before the RMR measurements were made. Participants wore a Fitmate mask over their nose and mouth, in a quiet room with a temperature of ~25°C in a supine position. The FitMate uses a turbine flow meter which is located at the end of a disposable face mask for measuring minute volume and galvanic full cell oxygen sensor for analyzing the FeO_2. FitMate calibrated itself automatically before each measurement. They were asked to breathe for 15 min into the mask. FitMate™ (Cosmed, Rome, Italy) is an indirect calorimetry tool that measures RMR based on the volume of oxygen consumption (VO_2) and CO_2 production (VCO_2) by using a respiratory quotient (RQ) of 0.85. Previous studies indicated that Fitmate is an alternative tool for the douglas bag system with an acceptable accuracy in measuring RMR in adults within a wide range of BMIs [13, 14].

Statistical Analysis

All data were presented as Mean ±SD. The normality of the distribution of data was evaluated by Kolmogorov-Smirnov test. Student's t-test and chi-square test were used to compare quantitative variables with normal distribution and qualitative variables, respectively. FFM, cholesterol and PUFA between two groups were compared using the Mann-Whitney U test. ANCOVA test was used to compare RMR between two groups considering confounder factors. Partial correlation test was used for determination of correlation between variables controlling for confounder factors. SPSS version 15.0 was used for all data analysis and $p<0.05$ considered significant.

RESULTS

As shown in Table 1, no significant differences were observed between the two groups except for sleep duration during the evening. Overweight subjects reported longer sleep durations than normal weight females ($p<0.01$). All anthropometric indices (except height) and body composition were different between the two groups as expected ($p<0.05$ for all variables) (Table 1). Based on their body sizes, 9.5, 33.4 and 57.1% in overweight girls and 24.5, 71.4 and 4.1% in normal weight group were considered small, medium and large, respectively. There was a significant difference in body frame size between the two groups ($p<0.01$). Comparison of the dietary intake between normal and overweight participants indicated significant differences in Poly unsaturated Fatty Acid (PUFA) and Mono unsaturated fatty acid (MUFA) intake. Overweight girls reported more dietary fat intake ($p<0.01$) and less carbohydrate and protein intakes ($p=0.2$ and $p=0.1$, respectively) compared to the control group. Also the PUFA and MUFA intakes in the overweight were significantly more than the normal weight subjects ($p=0.01$ and $p=0.02$, respectively) (Table 2). As presented in Table 2, the basal metabolic rate in overweight girls was more than that of normal weight subjects ($p<0.01$). Further, RMR-for-FFM (RMR/FFM) in the overweight was more than the normal weight subjects, but its difference was not significant ($p=0.4$). Also after adjusting RMR for FM, FFM, body size, dietary intake and sleep duration as confounding factors, no significant differences were observed between the two groups ($p=0.05$).

Table 1- Basal characteristic, anthropometric indices and body composition in the study subjects

Variable	Normal weight (n=50)	Overweight (n=50)	P*
Age (year)	23.0±2.6†	22.5±2.9	0.3
Sleep duration at night (hour)	7.2±1.8	7.5±1.5	0.3
Sleep duration during the evening (hour)	1.1±0.3	1.5±1.1	<0.01
Menace age (year)	12.8±1.1	13.2±1.5	0.1
Menstrual cycle (%)			
Follicular phase	53	48	0.3**
Luteal phase	47	52	
Physical activity level (%)			
Sedentary	81	83	0.1**
Moderate	19	17	
Weight(kg)	55.4±5.6	70.9±7.4	<0.01
Height(cm)	160.8±6.2	161.8±4.4	0.3
BMI(kg/m^2)	21.3±1.2	27.0±2.4	<0.01
Waist Circumference (cm)	72.1±4.8	84.2±6.9	<0.01
Hip Circumference (cm)	97.8±4	106.5±7.4	<0.01
WHR	0.7±0.04	0.7±0.09	<0.01
WtSH	0.4±0.02	0.5±0.04	<0.01
Fat Mass (%)	25.8±4.2	33.5±4.0	<0.01
Fat Free Mass (%)	74.2±4.6	66.5±9.7	<0.01***

Body Mass Index (BMI); Waist to Hip ratio (WHR); Waist to Straight Height (WtSH); †Mean±SD; *Student t-test; p<0.05 considered significant; **Chi Square; p<0.05 considered significant;*** Mann Whitney t-test; p<0.05 considered significant

Table 2- Comparison of dietary intake and RMR between two groups (N=100)

Variable	Normal weight (n=50)	Overweight (n=50)	*P-value
Energy(kcal/day)	1742±441†	1821±453	0.4
Carbohydrate(gr/day)	247.5±66.4	230±79.1	0.2
Protein(g/day)	58.1±1.2	54.4±18.8	0.1
Fat(g/day)	57.7±26.3	75.9±33.3	<0.01
SFA (g/day)	17.1±6.9	19.3±7.4	0.1
PUFA (g/day)	18.9±13.7	24.7±14.1	0.02**
MUFA (g/day)	14.9±7.3	21.3±13.6	0.01
Cholesterol (mg/day)	190.5±171.6	177.7±137.3	0.5**
RMR (kcal/24h)	1271.3±133.6†	1468±117.7	<0.01*
RMR:FFM (kcal/FFM)	31.9±2.7	33.3±9.4	0.4*
Adjusted RMR (kcal/24h)	1322.9±21.8	1401.5±25.3	0.05***

Saturated Fatty Acid (SFA); Poly Unsaturated Fatty Acid (PUFA); Mono Unsaturated Fatty Acid (MUFA); Resting Metabolic Rate (RMR); Fat Free Mass (FFM)
†Mean±SD
* Student t-test
**Mann Whitney test; p<0.05 considered significant
***ANCOVA: adjusted for dietary intake, sleep duration, body composition; p<0.05 considered significant

A Correlation between RMR, anthropometric indices and body composition has been shown in Table 3. After adjusting the confounding factors (body frame size, sleep duration and dietary intake), in all subjects (n=100), there was a significant correlation between RMR and all variables (p<0.05 in all variables). Weight and BMI had the strongest correlation with RMR (r=0.66; r=0.63; p<0.05 in both). After a classification on the basis of BMI, in the overweight group, a significant correlation between RMR and all anthropometric indices was observed except in WHR and WtSH. Weight and BMI had the highest correlation with RMR (r=0.57; r=0.54; p<0.05). But in normal weight girls, the variables that had a significant correlation with RMR were: weight, BMI and WC. In addition, body weight was the best indicator for the measurement of RMR (r=0.45; p=0.02).

Table 3- Correlation between RMR and anthropometric indices and body composition in two groups

Variable	Normal weight(n=50) r†	Overweight(n=50) r	TOTAL (n=100) r
Weight(kg)	0.45*	0.57*	0.66*
BMI(kg/m2)	0.31*	0.54*	0.63*
Waist Circumference (cm)	0.34*	0.33*	0.56*
Hip Circumference (cm)	0.29	0.46*	0.55*
WHR ratio	0.17	0.03	0.2*
WtSH ratio	0.12	0.24	0.4*
Fat Mass (%)	0.28	0.42*	0.52*
Fat Free Mass (%)	0.28	0.52*	0.49*

BMI (Body Mass Index); WHR (Waist to Hip ratio); WtSH (Waist to Straight Height)
†Partial correlation; Adjusted for body frame size, dietary intake and sleep duration
*p<0.05 considered significant

DISCUSSION

The research question of the present study was to answer the following question: "Is RMR of overweight subjects lower than normal weights or not?".However, RMR in overweight female university students was more than normal weights, but there was no significant difference between both groups after adjusting for body composition, body size, sleep duration and dietary intake. Further, body weight had the strongest correlation with RMR in normal and overweight girls.

Many factors such as age, gender, body composition, BMI, hormone, dietary intake and physical activity can affect RMR [15], therefore it is important to consider the confounding factors affecting RMR values. In the present study, as it was expected, due to the greater FM and FFM values in overweight females which also affect RMR, a difference in the RMRs of about 200 kcal/ 24h was observed between the normal and overweight girls. Our results were in line with some previous studies [7, 16, 17]; Elbelt *et al*., indicated that RMR measured using Sense Wear™ indirect calorimetry in German subjects with various degrees of obesity and normal weight subjects increased with BMI, but after adjusting for activity thermogenesis, no significant differences were observed [16]. Also Namini *et al*., reported that RMR in overweight/obese healthy subjects, was more than normal weights but after adjusting for FM and FFM, no significant differences were observed [7]. Based on a study by Johannesen *et al*., RMR in the obese pre-menopausal women was about 96 kcal/24h; which was more than lean women and after adjusting for FM and FFM, no significant differences among these groups were reported [17]. Further, Busemi *et al*., demonstrated that in Caucasian Italians with a BMI=17.5-63.4 kg/m^2, there was an inversely correlation between RMR and changes in weight and FM after adjusting for FFM [3]. Differences between RMR in obese and non-obese subjects in the studies mentioned above may be due to the differences in sex, age, BMI, dietary intake, physical activity and race among the study subjects. In our study, RMR was adjusted for dietary intake and sleep duration which had not been considered in the previous studies. Furthermore, phases of the menstrual cycle that can affect RMR, particularly the follicular phase was evaluated and no significant differences were observed between two groups. Overall, it seems as if there is a correlation between RMR and weight gain, although it is weak, a low RMR during a long period of time can lead to considerable gain in weight.

In the present study, all anthropometric indices and body composition had a positive correlation with RMR before the classification subjects into two groups. Body weight and WHR/WtSH indicated the highest and lowest correlation with RMR in both groups. Hassan *et al*. measured the RMR (using Fitmate indirect calorimetry) and body composition (using in body 720 BIA) in young Arab females aged 18-30 years old with BMIs less than 30 kg/m^2. They concluded that RMR had a correlation with FM and FFM. Moreover, FFM had the highest correlation with RMR. But Hassan *et al*. did not evaluate the correlation between RMR and anthropometric indicators [18]. Meanwhile, Luis *et al*., demonstrated that there is a significant correlation between RMR and FFM in non-diabetic obese subjects [19]. Based on Armellini *et al*'s study, on pre-menopausal women, age, FFM, visceral and subcutaneous fat were indicators for RMR [20]. Our study was in line with Foster *et al*'s study; They reported that weight was the best indicator for RMR in African American and Caucasian women. Moreover, RMR (measured using DeltaTrac) in obese subjects had lesser reduction in weight than others [4].

Some limitations of the present study are: 1) small sample size 2) Enrolment of volunteers within a narrow range of BMI and 3) Single RMR measurements which could not estimate the intra-individual variation. Taking into consideration the effects that the several confounding factors on RMR could be mentioned as the strong point of the present study.

CONCLUSION

It seems, there are no significant differences in adjusted RMR between normal and overweight female university students and body weight is the best indicator for RMR value in both groups. More studies with larger sample size in different races and ranges of BMI are needed to clarify the association between obesity and RMR.

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