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Gender Differences in the Body Composition, Resting Energy Expenditure, and Leptin Levels of Obese Adults*

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The objective of this study was to examine how circulating leptin concentrations and resting energy expenditures (REE) are related to body composition in obese adults, and to examine differences in these parameters according to gender. Twenty-three subjects, 6 males and 17 females, were recruited from patients with a body mass index (BMI) of greater than 27 at the Obesity Clinic of the K University Hospital. Anthropometric assessments and biochemical analyses were performed, and REEs were measured. In spite of having similar BMI values, the plasma leptin levels of females (20.0±6.5 ng/ml) were significantly higher ($p < .05$) than those of males (14.2±6.0 ng/ml). In females, plasma leptin concentrations were found to be positively related to body weight, BMI, waist-hip ratio (WHR), fat mass (FM), body fat, and to the circumferences of forearm, waist and hip ($p < .0001$). However, in males, plasma leptin concentrations were positively related only to suprailiac thickness ($p < .05$). The higher plasma leptin levels in females compared to males may, at least partially, be explained by the females' higher subcutaneous fat mass. Plasma leptin concentrations appeared to reflect not only total fat mass but also regional fat distribution, especially in females. REE values of males (2254.3±256.2 kcal/day) were significantly higher ($p < .01$) than those of females (1799.1±454.7 kcal/day). REE values for females were positively related to body weight, BMI, lean body mass (LBM), FM, body fat, and to the circumferences of waist and hip ($p < .05$); however, REE values for males were (positively) related only to LBM ($p < .05$). REE values were not related to plasma leptin concentrations for either males or females, indicating that the plasma level of leptin might not be a predictor for REE value.

Key Words : Obese, body composition, resting energy expenditure, leptin, gender difference

INTRODUCTION

Major risk factors of obesity could be a low resting metabolic rate and/or a low rate of fat oxidation with low levels of physical activity.[1-4] The resting metabolic rate is commonly referred to in the literature as resting energy expenditure (REE), and is generally defined as the energy consumed by an individual at rest after an overnight fast. The basal energy expenditure (BEE), the obligatory metabolic cost for maintenance of physiological processes and cellular functions, accounts for approximately 60% of total energy expenditure.[4-6] REE measured at rest is approximately 10% above the BEE.[5] It has been reported that genetic factors controlling energy expenditure might be of importance in the development of obesity.[7]

Another possible factor associated with obesity is a high level of leptin.[8] It has been known that leptin is secreted by adipose tissue and seems to be involved in signaling the level of body fat stores to the central nervous system, thereby possibly controlling appetite.[9] On the other hand, the absence of leptin in the *ob/ob* mouse leads to severe obesity, and the administration of leptin reduces food intake and increases energy expenditure.[10,11]

In the last few years, a large number of studies have dealt with the determinants of leptin concentration under various physiological and pathological conditions. Although gender and amount of body fat are strong contributors,[12-14] it is not clear that these two factors can fully explain the wide variability of leptin concentrations; indeed, individuals with similar levels of BMI have very different leptin levels.[15,16] The results from clinical studies examining whether fat distribution plays a role in determining serum leptin concentrations are conflicting.[17,18] Further investigation is needed to clarify the relationship between leptin secretion and fat distribution.

The objective of this study was to examine how circulating leptin concentrations and resting energy expenditures (REE) are related to body composition in

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obese adults, and to examine differences in these parameters according to gender.

SUBJECTS AND METHODS

1. Subjects

Twenty-three obese adults (6 males and 17 females), with a body mass index (BMI) of greater than 27 kg/m^2 were recruited from patients at the Obesity Clinic of the K University Hospital between December, 2000, and August, 2001. Female subjects who did not use oral contraceptive agents or hormone replacement therapy (HRT) were selected. Selection criteria were: (i) the absence of clinical signs or symptoms of chronic diseases; (ii) no history of body weight fluctuations in the preceding 4 months; and (iii) no use of medications known to affect metabolic rate or body composition. All subjects gave their written consent to participate in the present study.

2. Anthropometric Measurements

The height, weight, fat mass, lean body mass (LBM), and total body weight (TBW) were measured for each subject by a Body Fat Analyzer (TBF-202, Japan). Subjects were dressed in light clothing and wore no shoes. Measurements were recorded to the nearest 0.1cm or 0.1kg. The circumferences - including upper arm, forearm, waist, hip, thigh, calf, and wrist - were measured using a measuring tape and recorded to the nearest 0.1cm. Skin fold thicknesses of the triceps, subscapular, suprailiac, abdomen, and thigh were each measured three times on the left side of the body by skin-fold calipers, and were then recorded to the nearest 0.1mm. The average of the three records was taken as the final result for each parameter.

3. Resting Energy Expenditure (REE)

REEs were measured by a portable indirect calorimeter (Metavine-N, Vine Bio-Dynamic Systems, Inc. Tokyo, Japan) at the Obesity Clinic of the K University Hospital. REEs were measured after subjects had been wakened and placed in a comfortable sitting position for 30 minutes. The room temperature ranged from 20℃ to 25℃. Subjects had nothing to eat or drink for at least 2 hours before their REEs were measured. During each measurement, the subjects wore a face mask and breathed normally for 3 minutes. The average of three measurements was taken as a final result for each subject.

4. Biochemical Analysis

Blood samples were collected in test tubes containing ethylenediamine tetraacetate(EDTA) and trasylol (Miles Pharmaceutics, Rexdale, Canada) using a venous catheter. These samples were drawn early in the morning from a basilic vein after a 12-hour overnight fast. Plasma insulin levels were determined by a radio-immuno assay (RIA) using polyethylene glycol separation.[19] Fasting plasma leptin levels were determined by RIA using a commercially available kit (Linco Research. St. Louis. Mo., USA).[20] Fasting plasma levels of FFA were measured by the colorimetric method.[21]

5. Statistical Analysis

Statistical calculations were performed using the Statistical Analysis System (SAS), version 6.12. All values are given as the mean ± SD. The nonparametric U Mann-Whitney test for unpaired values was used for comparisons between groups of subjects. Pearson's correlation analysis was performed among the values of leptin, REE and the other variables. Levels of $P < 0.05$ were considered statistically significant.

RESULTS

1. Clinical Characteristics of the Subjects

Table 1 summarizes the clinical characteristics of the

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	Male (n=6)	Female (n=17)	P-values
Age (yrs)	41.0±10.6 (26~58)[1)]	41.4±11.0 (20~55)	NS
Height (cm)	168.3±5.5 (158.1~176.6)	162.4±4.2 (155~173.5)	NS
Body weight (kg)	84.8±5.8 (78.3~95.2)	77.5±12.8 (62.9~117.4)	0.0482
BMI (kg/m^2)	31.0±2.4 (27.9~33.5)	29.1±4.0 (27.9~45.0)	NS
WHR	0.97±0.05 (0.94~1.03)	0.90±0.04 (0.84~1.00)	0.0099
LBM (kg)	58.9±6.0 (52.7~67.0)	45.3±3.5 (38.7~49.8)	0.0004
FM (kg)	25.5±6.4 (18.8~38.5)	32.3±12.2 (18.9~72.2)	0.0478
Body fat (%)	30.6±6.4 (23.8~42.7)	40.5±7.8 (29.2~61.5)	0.0312
REE (kcal/day)	2254.3±256.2 (2062~2690.3)	1799.1±454.7 (1485.5~2338.0)	0.0060
Leptin (ng/ml)	14.2±5.9 (8.4~21.0)	19.9±6.5 (7.0~29.6)	0.0459

1) Values are mean±SD (range)
2) BMI ; body mass index, WHR ; waist-hip ratio, FM ; fat mass, LBM ; lean body mass, REE ; resting energy expenditure, NS ; not significant

subjects. In spite of similar BMI values, the waist hip ratio (WHR) values of females (0.90±0.04) were significantly lower ($p < 0.01$) than those of males (0.97 ±0.05). The LBM values of males (58.9±6.0kg) were significantly higher ($p < 0.001$) than those of females (45.3±3.5kg). The REE values of males (2254.3±256.2 kcal/day) were significantly higher ($p < 0.01$) than those of females (1799.1±454.7kcal/day). The plasma leptin levels and body fat (%) of females, at 20.0±6.5ng/ml and 40.5±7.8% respectively, were significantly higher ($p < 0.05$) than those of males at 14.2±6.0ng/ml and 30.6±6.4%, respectively.

2. Anthropometric Parameters of the Subjects

Table 2 summarizes the anthropometric parameters of the subjects. The waist circumference of the males (97.9±5.6cm) was significantly higher ($p < 0.05$) than that of the females (90.0±6.7); however, the other anthropometric parameters were not significantly different between the two groups.

Table 2. Anthropometric parameters of the subjects

	Male (n=6)	Female (n=17)
Circumferance (cm)		
Upperarm	30.4±1.7[1)]	30.6±2.4
Forearm	26.1±0.6	24.1±0.9
Waist	97.9±5.6*	90.0±6.7
Hip	103.6±3.4	101.3±4.1
Thigh	58.2±3.8	60.7±2.6
Calf	40.2±0.8	38.6±1.6
Wrist	17.4±0.9	16.4±0.3
Skinfold thickness (mm)		
Triceps	22.1±5.8	30.6±7.0
Subscapular	33.4±6.7	34.5±8.1
Suprailiac	29.2±8.6	31.2±10.4
Abdomen	38.3±6.8	35.2±9.8
Thigh	25.2±6.1	32.0±6.6

1) Values are mean±SD
* $p < 0.05$

3. Correlations Between Plasma Leptin Levels and Anthropometric Indices

Table 3 summarizes the correlations between the plasma leptin levels and anthropometric indices. For females, leptin concentrations were significantly related to body weight, BMI, FM, body fat (%), the waist and hip circumferences, and the skinfold thickness of triceps and suprailiac ($p < 0.05$). However, for males, leptin concentrations were related only to the suprailiac skinfold thickness ($p < 0.05$).

Table 3. Coefficients of correlation between plasma leptin levels and anthropometric indices

	Coefficients (r)	
	Male	Female
Age (yrs)	0.02	0.02
Body weight (kg)	- 0.13	0.76**
BMI (kg/m^2)	0.39	0.87**
WHR	0.78	0.61*
LBM (kg)	- 0.34	- 0.09
FM (kg)	0.15	0.83**
Body fat (%)	0.20	0.74**
Upperarm (cm)	- 0.58	0.67*
Forearm (cm)	0.39	0.64*
Waist (cm)	0.66	0.83**
Hip (cm)	0.34	0.89**
Thigh (cm)	0.35	0.38
Triceps (mm)	- 0.34	0.54*
Subscapular (mm)	0.39	0.45
Suprailiac (mm)	0.82*	0.48*
Abdomen (mm)	0.74	0.37
Thigh (mm)	0.43	0.35

1) BMI ; body mass index, WHR ; waist-hip ratio, LBM ; lean body mass, FM ; fat mass
* $p < 0.05$, ** $p < 0.001$

4. Correlations of REE with Anthropometric Indices

Table 4 shows the correlations between the REE values and the anthropometric indices. For females, REE values were significantly related to body weight, BMI, LBM, FM, body fat (%), and the circumferences of waist and hip ($p < 0.05$). However, for males, REE values were significantly related only to the LBM ($p < 0.05$).

Table 4. Coefficients of correlation between REE and anthropometric indices

	Coefficients (r)	
	Male	Female
Age (yrs)	0.32	- 0.09
Body weight (kg)	0.43	0.59*
BMI (kg/m^2)	0.33	0.59*
WHR	0.42	0.44
LBM (kg)	0.43*	0.45*
FM (kg)	0.53	0.63*
Body fat (%)	0.10	0.59*
Upper arm (cm)	0.34	0.51
Forearm (cm)	0.21	0.49
Waist (cm)	0.20	0.64*
Hip (cm)	0.34	0.41
Thigh (cm)	0.41	0.42
Triceps(mm)	0.10	0.02
Subscapular (mm)	0.12	0.10
Suprailiac (mm)	0.02	0.16
Abdomen (mm)	0.17	0.18
Thigh (mm)	0.42	0.39

1) BMI : Body mass index, WHR : Waist-hip ratio, LBM : Lean body mass, FM : Fat mass
* $p < 0.05$

5. Correlation Between REE and Plasma Leptin Levels

Figure 1 illustrates a simple regression between REE values and leptin levels. REE values were not related to leptin concentrations in either males or females (p = 0.43).

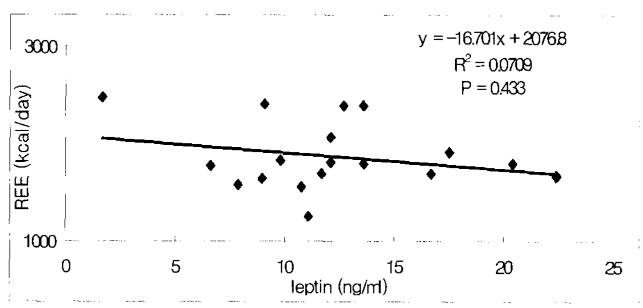

Fig 1. Simple regression between plasma leptin levels and REE

DISCUSSION

This study provided evidence that fat, expressed either as a percentage of body weight or as an absolute amount of fat mass, is a major determinant of plasma leptin concentration, and that leptin concentrations are higher in females than in males. The reasons for the higher levels of leptin in females than in males remain unclear; although the gender-related differences in amount of subcutaneous or visceral adipose tissue are important, they cannot fully account for the sexual dimorphism of serum leptin.[22] A relevant contribution to the pool of leptin by a brain secretion has been recently demonstrated.[23] Another recent study[24] shows that the prevailing levels of sex steroid hormones are instrumental in establishing gender differences in leptin levels, since cross-sex hormone therapy reverses these differences in circulating leptin levels.

In accordance with the Wiesner et al study,[25] Nielsen et al[26] found that LBM was a strong predictor of REE. In addition, Nielsen et al[26] and Dionne et al[27] found that FM might be a significant predictor of REE, especially in males, although Cumningham[28] did not agree. Oxygen consumption by adipose tissue is approximately 2.9 kcal/kg/day. Considering that adipose tissue is composed of approximately 85% fat, it can be predicted that body fat would increase REE by approximately 3.4 kcal/kg/day if only the metabolic needs of adipose tissue influenced resting oxygen consumption. The present study found a relationship between REE and fat in females, expressed either as a percentage of body mass or as an absolute amount of fat mass; this could be explained by the larger amounts of abdominal fat increasing the work of diaphragmatic breathing in the supine position.[29] These could explain the observation that REE relative to fat-free mass (FFM) appears to be greater in upper body obesity.[29]

A high fasting respiratory quotient (RQ) and low REE are independent risk factors for weight gain. Since leptin can increase fat oxidation and energy expenditure, this study examined the possibility that circulating leptin could be independently related to REE. Recent studies[30] suggest that leptin may be an important metabolic signal for energy regulation in rodents, but the role of leptin in human energy regulation remains uncertain, perhaps because adaptive variations in energy expenditure play an important role in human energy regulation. Soares et al[24] could not demonstrate any association between leptin and BMR in young and older adults. Others[31] have also noted the lack of correlation between leptin levels and energy expenditure. Perhaps the use of free rather than total leptin levels would increase the likelihood of significant associations between leptin levels and energy expenditure.[32] Tuominen et al[33] have, however, suggested that plasma leptin concentrations were significantly related to energy expenditure. In other words, circulating leptin responded to a change in energy flux. In the present study, no significant relationships were found between leptin levels and REE values.

A weak relationship was found between plasma leptin levels and subcutaneous tissue in this study. This result is in agreement with the data of Van Harmelen et al,[34] showing that subcutaneous adipose tissue secretes more leptin than the omental compartment, even when secretion rates were calculated according to the number of cells. Thus, the contribution of subcutaneous fat in secreting leptin is attributable both to its predominant mass and to its higher releasing activity per fat cell. The present study showed that subcutaneous fat mass made a more predominant contribution to the secretion of leptin in females compared to males.

In summary, the higher leptin concentrations in females may, at least partially, be explained by their higher levels of subcutaneous fat mass. However, other still unidentified factors are likely to play a role in determining the gender-related variability of leptin concentrations at comparable levels of body and fat mass. Leptin concentrations might not be a significant predictor for REE values. REE values were a significant predictor for LBM in both males and females. In addition, REE values were specifically related to the fat mass and waist circumference of females. Plasma leptin concentrations reflected not only total fat mass but also regional fat distribution, especially in females. It is recommended that further studies of the relationship between anthropometric measurements and leptin levels or REE be undertaken on a larger number of obese subjects.

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