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Correlation Between Body Fat Percentage (BFP) and Basal Energy Expenditure (BEE) in Javanese Women Aged 40-60 Years Old in Sleman, Yogyakarta, Indonesia

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Abstract: The prevalence of obesity in women is increasing more than that in men. The basal metabolic rate, calculated as basal energy expenditure (BEE), is the main determinant of energy balance and weight change. However, the correlation between BEE and obesity is polemical. The aim of this study is to examine the correlation between body fat percentage (BFP) and basal energy expenditure (BEE) among 40-60 year-old Javanese women in Sleman, Yogyakarta, Indonesia. A cross-sectional study of 123 Javanese women was conducted. The anthropometric data of the subjects (hip circumference, suprailiac skinfold, body mass index for BFP, weight and height for BEE) were calculated using predictive equations. The data were analyzed using Pearson's correlations. The prevalence of obesity in the subjects, measured as high BFP, was 84.6%. The means of both BFP and BEE were higher than normal, i.e., 31.2% (SD 6.5) and 1318.6 Cal (SD 97.3), respectively. The result found that there was a significant correlation between BFP and BEE ($r = 0.929$, $p<0.001$). The result suggested that high BFP is strongly related to high BEE. It can be concluded that obese individuals have higher basal metabolic rates and BEE values than normal-weight individuals.

Key words: Body fat percentage, basal energy expenditure, obesity, Javanese women

INTRODUCTION

Obesity is an important indicator of an individual's health status, especially of nutritional status. Data from the WHO (2012) revealed that more than 1.4 billion adults experience obesity worldwide. The prevalence of obesity in women and men has reached 300 million and 200 million people, respectively. In Indonesia, overnutrition is occurring not only in urban area but also in rural communities. Based on the results of basic medical research conducted in 2013, the Ministry of Health (2013) reported that the national obesity prevalence reached 19.1% (23.8% among females and 13.9% among males).

Heber (2000) suggested that over the last decade, the prevalence of obesity in women increased by approximately 15%. Topics that remain controversial in the discussion of factors that predispose individuals to obesity include the determinants of energy expenditure, especially of the basal metabolic rate, which includes physiological components that can be derived (Van Gaal *et al*., 1999). While energy expenditure is influenced by genetic factors and metabolic efficiency, a low basal metabolic rate is also indicated by low basal energy expenditure and is associated with obesity (Astrup *et al*., 1996).

The results of an analysis by Goran and Weinsier (2007) indicate that there is no relationship between an increased prevalence of obesity and a decreased basal metabolic rate in the population, while research by Flatt (2007) shows there is no significant influence between low basal metabolism and body weight or adiposity. These results contradict the widely embraced theory that low metabolism predisposes individuals toward obesity. Whether basal energy expenditure is the main determinant of energy balance and changes in weight (Connolly *et al*., 1999) has become the main focus of obesity research. According to Martin *et al*. (2007), 60% of energy expenditure is captured by BEE in obese individuals, so a better understanding of the prediction equations and the factors that influence it is expected to help predict the effects of preventive efforts and assist in the development of holistic and comprehensive obesity management. Whether the correlation between basal energy expenditure and obesity is based on the same percentage has not been studied in Indonesia; therefore, it is important to conduct this research.

MATERIALS AND METHODS

This cross-sectional study was conducted with 123 women who were recruited from the Sleman district area and were 40-60 years old. The subjects' anthropometric measures were obtained in July and August of 2011. Subjects gave written consent to participate in the study, which was approved by the Medical Ethics Committee of the Universitas Gadjah Mada. Specially designed questionnaires were used to collect participants' age, sex, date of birth, medical history, educational, occupation and income status.

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Height, weight, hip circumference and suprailiac skinfold were measured using an anthropometer (1 mm accuracy), a digital weighing scale (1 kg accuracy), a tape measure (1 mm accuracy) and skinfold caliper (0.2 mm accuracy), respectively. Based on these measurements, body mass index (BMI), basal energy expenditure (BEE) and body fat percentage (BFP) were calculated.

BFP was calculated from anthropometric data, particularly pelvic circumference, suprailiac skinfold and body mass index (weight/height^2) using a BFP formula that has been validated for women in Southeast Asia (Pongchaiyakul *et al*., 2005): BFP = (0.42 x hip circumference) +(0.17 x suprailiac skinfold)+(0.46 x BMI)-23.75.

The optimal range for Indonesian women is set by the Indonesian Doctors Association at 20-25%. BEE is predicted using the FAO-WHO-UNU formula:

$$BEE = 8.7 \times Weight\ (kg) - 25 \times Height\ (cm) + 865$$

The normal BEE values (cals) for women 30-60 years old are adapt from a table created by Burke *et al*. (1993).

Statistical analysis: Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS), version 20. The correlation between BEE and BFP was tested using Pearson's correlation coefficients.

RESULTS AND DISCUSSION

The anthropometric characteristics (height, weight, BMI, hip circumference and suprailiac skinfold measurements) of these Javanese women are summarized in Table 2 and the mean and standard deviation (SD) for both BEE and BFP are listed in Table 3. Figure 1 presents the proportions of BEE and BFP of the Javanese women in each age group.

The basal energy expenditure (BEE) values based on a table by Burke *et al*. (1993) were classified into three groups, namely, lower BEE, normal BEE and higher BEE. The results showed that most subjects, that is, 65.9% (81), had higher than normal BEE values, 33.3% (41) had normal BEE values and 0.8% (1) had lower than normal BEE values. Basal fat percentage (BFP) was also classified into three groups, e.g., low BFP, based on the normal and optimum range set for Indonesian women by the Indonesian Doctors Association, which is 20-25% (Fig. 1).

The results showed that 104 people had higher than optimum BFP values (84.6%), 14 had normal BFP values (11.4%) and 5 had lower than optimum BFP values (4.1%). Data normality was assessed analytically using a Kolmogorov-Smirnov test, which indicated that the distribution of BEE data was not normal ($p<0.05$). The data were thus transformed using the log function and reanalyzed for normality, which showed that the value $p>0.05$, so these data are normal. The data for basal fat percentage (BFP) was tested for normality using the Kolmogorov-Smirnov test, which yielded a value of $p>0.05$, so these data are normally distributed. The Pearson correlation coefficient was used to analyze the relationship between BEE and BFP. This correlation showed a value $r = 0.929$, which indicates that the greater the BEE value, the greater the average BFP value of the research subject. This correlation also implies that if there is an increase in BEE, it is closely related to an increase in BFP.

These results indicate that high BEE values are also found in subjects with high BFPs. This situation conflicts with the results of research conducted by Astrup *et al*. (1996), which found that individuals who are obese have relatively lower basal metabolic rates. This is possibly related to lower plasma triiodothyronine levels in individuals who are obese; however, whether this is a causal relationship is unknown (Astrup *et al*., 1996). This situation also contrasts with the work of Flatt conducted in 2007, which examined 433 men and women. BEE and BFP measurements were performed either directly or indirectly (BFP was based on anthropometric measurements and BEE was a function of age, weight and height). The results revealed that there was no significant correlation between BEE and BFP; this conclusion is also supported by the results of research by Goran and Wiensier (2007), which suggests that there is no correlation between the basal metabolic rate and obesity.

Table 1: Basal energy expenditure for women (Burke *et al*., 1993)

Weight (kg)	BEE (calorie)
40	1167
45	1207
50	1248
55	1288
60	1329
65	1369
70	1410
75	1450

Table 2: Mean and standard deviation (SD) of anthropometric measurements of Javanese women 40-60 years old in Sleman, Yogyakarta, Indonesia

Variable	Mean±SD	Min	Max
Age	49.23±6.1	40.0	60.0
Weight	56.50±11.3	17.5	91.0
Height	1.50±0.0	1.2	1.7
Body mass index	24.9±4.6	12.2	37.3
Hip circumference	94.7±9.1	60.9	119.0
Suprailiac skinfold	21.6±6.6	6.8	36.4

Table 3: Mean and standard deviation (SD) of BEE and BFP of Javanese women 40-60 years old in Sleman, Yogyakarta, Indonesia

Variable	Mean±SD	Min	Max
BEE	1318.6±97.3	987.3	1617.0
BFP	31.2±6.5	9.1	48.7

BEE: Basal energy expenditure. BFP: Body fat percentage

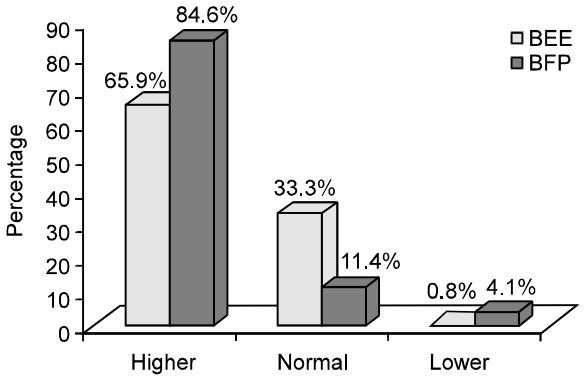

Fig. 1: Proportions of basal energy expenditure (BEE) and body fat percentage (BFP) of Javanese women 40-60 years old in Sleman, Yogyakarta, Indonesia

Research by Hoffmans *et al*. (1979) showed that the resting metabolic rate (cal/kg) of obese individuals was lower than that of normal-weight individuals. According to the research by Astrup *et al*. (1996) conducted in using a matched case-control study, the basal metabolic rate was lower in women who are obese and have a family history of obesity. They concluded that a low basal metabolic rate is a risk factor for obesity. In contrast to this study, the research by Astrup *et al*. (1996) measured body fat mass by bioimpedance, whereas the basal metabolic rate is measured via indirect calorimetry.

BEE values can also be influenced by body fat mass, sex, age, physical activity and nutrition status; however, the main determinant of BEE is non-fat body mass (organ and muscle), which contribute 75% of BEE. Decreased basal expenditure energy (BEE) in the elderly is due to a decrease fat-free mass. This claim is supported by a theory proposed by Lazzer *et al*. (2010) that basal energy expenditure (BEE) is significantly determined by fat-free mass. This is also evidenced by research by Hoffmans *et al*. (1979) indicating that the resting metabolic rate (per kg of non-fat body mass) in individuals who are obese was higher than that of people who were not obese. This result supports Molnar and Schutz's (1997) hypothesis that more fat-free mass is associated with a higher basal metabolic rate.

Based on this theory, individuals with high BFPs, which implies that the percentage of non-fat body mass is lower, will have lower than normal BEE values. Conversely, individuals with low BFPs, which implies that the percentage of non-fat body mass is higher, will have higher than normal BEE values.

Lazzer *et al*. (2010) suggested that body fat mass has a significant effect on BEE in individuals who are obese. In this study, subjects who had high BEE and BFP values may also have high leptin levels. Increases in body fat will be followed by increases in levels of leptin (Rhoades and Tanner, 2003). Increased leptin will thus provoke a physiological response from the hypothalamus via stimuli from the leptin receptors in the hypothalamic nucleus, which aims to decimate fat deposits. This will trigger neural sympathetic activity through projections from the hypothalamus to the vasomotor center. Increased energy expenditure conflicts with the reduced amount of available energy because of reduced insulin secretion, easily causing fatigue (Guyton and Hall, 2008; Rhoades and Tanner, 2003).

BEE values can also be high due to high basal metabolic rates, i.e., the amount of energy used by tissues and organs during resting conditions and at standard temperatures. Thus, BEE depends on body mass and the basal metabolic rate of tissues and organs. Lazzer *et al*. (2010) state that the amounts of energy expended during digestion and by the liver and brain are 10, 15 and 20 times greater, respectively, than that used by muscles at rest. The energy expenditure of the heart and kidneys is 35 times greater than that of muscle.

According to Guyton and Hall (2008), obese individuals with persistent excess caloric intake have high sympathetic activity levels. A possible mechanism is that leptin stimulates the adrenals to secrete epinephrine and norepinephrine. The effects of epinephrine include the excitement of heart muscle, which increases heart activity and triggers the contraction of veins and arterioles. Massive contraction of the arterioles causes the accumulation blood volume, thus increasing vascular volume in these arteries, which can increase arterial blood pressure. According to Guyton and Hall (2008), both of these hormones will increase metabolic activity and non-shivering thermogenesis, which is useful for the addition of excess weight. This type of heat generation occurs mainly in brown fat, which contains many mitochondria in unpaired oxidative phosphorylation (uncoupled oxidative phosphorylation), which means that this oxidative process generates almost no heat. However, this activity occurs only during the neonatal period and in response to cold conditions. The statement above shows that in people who are obese, excess body fat will be followed by an increase in blood levels of leptin, which will initiate sympathetic activity and increases basal metabolism, so basal energy expenditure also increases. This theory may explain the results obtained in this study, i.e., a positive correlation ($r = 0.929$; $p<0.01$) between BEE and BFP in 40-60 year-old women.

Conclusion: It can be concluded that basal energy expenditure (BEE) is significantly correlated with body fat percentage (BFP). In this study, obese subjects exhibited both high BEE and high BFP values. It can be concluded that obese individuals have both higher basal metabolic rates and higher BEE values than normal-weight individuals.

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