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RELATIONSHIP BETWEEN BIOELECTRICAL IMPEDANCE-DERIVED ESTIMATES OF BASAL METABOLIC RATE AND BODY COMPOSITION PARAMETERS IN FEMALE KOREAN COLLEGE STUDENTS

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ABSTRACT

Measurements of basal metabolic rate (BMR) and body composition parameters represent an important tool for preventing obesity. This investigation examined the relationships between bioelectrical impedance-derived estimates of BMR and various body composition parameters, including age, body mass index, intracellular water, extracellular water, protein content, mineral content, fat mass, osseous content and waist-to-hip ratio. The subjects included Korean female college students (N=717) aged 18–26 years, who visited the sport medicine laboratory at Seoul Women's University in 2013. The BMR and body composition parameters were indirectly measured using a bioelectrical impedance device, and the correlations between the BMR and other variables were analysed. The BMR showed a significant negative correlation with age (r=-0.284, p<0.001); but significant positive correlations with body mass index (r=0.477, p<0.001), intracellular water (r=0.803, p<0.001), extracellular water (r=0.205, p<0.001), protein content (r=0.991, p<0.001), mineral content (r=0.093, p=0.013), fat mass (r=0.234, p<0.001), osseous content (r=0.962, p<0.001), and waist-to-hip ratio (r=0.217, p<0.001). Based on these findings, all body composition parameters correlated with the BMR in this population. Improvement of body composition parameters may lead to an increased BMR, thus this could provide an effective means for preventing obesity.

Key words: Basal Metabolic Rate; Extracellular water; Fat mass; Intracellular water; Mineral, osseous and protein content; Waist-to-hip ratio.

INTRODUCTION

According to the US Centres for Disease Control and Prevention in 2013, over 35% of American adults are obese (US Centres for Disease Control and Prevention, 2013); and, recently, the World Health Organisation reported that, worldwide, over 2.8 million people die annually as a direct result of being overweight or obese (World Health Organization, 2014). Furthermore, in Korea, the fifth Korea National Health and Nutrition Examination Survey in 2012 reported that the prevalence of obesity was 35.2% in men and 28.6% in women aged over 19 years, and the prevalence is steadily increasing (Korea Centre for Disease Control and Prevention, 2012). Obesity is associated with a number of serious health and social problems, and the benefits of maintaining a healthy weight are hence numerous (Thomas &

Albert, 2002). Measurements of basal metabolic rate and body composition parameters may be important for preventing obesity, and may thus aid in solving many of the public health and social problems associated with this condition.

It is well established that weight gain and obesity are directly caused by an imbalance in energy consumption and expenditure (Thomas & Albert, 2002). This balance has been demonstrated to be affected by a number of factors, including the socio-economic environment of the individual, family history of obesity, genetic factors, physical activity (or lack thereof) and eating habits (Thomas & Albert, 2002). Particularly, the energy expenditure of each individual is dependent on his or her body composition components, which, in turn, are dependent on the basal metabolic rate of the individual. The basal metabolic rate, which is the rate of energy expenditure at rest, is negatively affected by increased body weight; and, for this reason, an increased basal metabolic rate has many potential benefits for the treatment and prevention of obesity (Thomas & Albert, 2002).

In general, the basal metabolic rate is affected by various factors such as fat-free mass, fat mass, intracellular water, extracellular water, protein content, mineral content, body mass index, age, waist circumference, and osseous content (primary bone tissue), which is a relatively lightweight but hard composite (Keys *et al*., 1973; Fukagawa *et al*., 1990; Goran *et al*., 1994; Johnstone *et al*., 2005; Wang *et al*., 2007). However, most previous studies on the topic have been focused on Caucasian (Weyer *et al*., 1999; Lazzer *et al*., 2010) or African-American populations (Kim & So, 2013), and evidence regarding the correlation between basal metabolic rate and body composition components in Korean populations is lacking.

PURPOSE OF RESEARCH

The purpose of the present study was to investigate the relationship between bioelectrical impedance-derived estimates of basal metabolic rate and the body composition parameters of age, body mass index, intracellular water, extracellular water, protein content, mineral content, fat mass, osseous content, and waist-to-hip ratio in female Korean college students.

METHODOLOGY

Participants

A total of 717 female Korean college students aged 18–26 years who visited the sport medicine laboratory in Seoul Women's University, Seoul, Republic of Korea in 2013 were included in the study after providing informed consent. Subjects agreeing to participate in the study were instructed to answer an anonymous self-administered questionnaire. Subjects who were unwilling to participate were not analysed further.

Measurement parameters

The participants underwent a series of tests to evaluate their basal metabolic rate (BMR) (kcal), age (years), body mass index (kg/m^2), intracellular water (l), extracellular water (litter), protein content (kg), mineral content (kg), fat mass (kg), osseous content (kg), and waist-to-hip ratio (%). The body mass index (BMI) (kg/m^2) of the subjects was calculated based on their measured weight and height. The BMR, intracellular water, extracellular water, protein content, mineral content, fat mass, osseous content, and waist-to-hip ratio were measured using Inbody 720 equipment (Biospace, Seoul) according to the manufacturer's instructions.

Experimental procedures

Age was recorded using a self-reported questionnaire. The subjects were instructed to wear light clothing, and to remove all metal items that could interrupt the electric current during the measurements. The laboratory was open between 09:00 to 11:00, Monday to Friday, and the time required for measuring each subject was less than 10 minutes. All participants were prohibited from consuming any food or water for 12h, from performing any exercise for 24h, and from urinating just before the measurement. Subjects who were menstruating were excluded from the study at this stage.

Statistical analysis

All results are based on mean±standard deviation calculations. Pearson's correlation analysis was used to investigate the relationships between the BMR and age, BMI, intracellular water, extracellular water, protein content, mineral content, fat mass, osseous content and waist-to-hip ratio. Statistical significance was set at $p<0.05$. All analyses were performed using SPSS version 18.0 (SPSS, Chicago, IL).

RESULTS

The mean and standard deviation for each of the following body composition components of the subjects are presented in Table 1, namely age, height, weight, body mass index (kg/m^2), intracellular water, extracellular water, protein content, mineral content, fat mass, osseous content, fat mass percentage, waist-to-hip ratio and BMR.

TABLE 1. **BODY COMPOSITION COMPONENTS AND BMR SCORES (M±SD)**

Variable	**Scores (n=717)**
Age (years)	20.55±1.87
Height (cm)	163.12±4.98
Weight (kg)	55.55±7.06
BMI (kg/m^2)	20.86±2.28
Intracellular water (litre)	18.56±2.08
Extracellular water (litre)	10.77±1.43
Protein (kg)	8.57±1.41
Mineral (kg)	2.78±0.38
Fat mass (kg)	14.87±4.28
Osseous (kg)	2.44±0.26
Waist-to-hip ratio (%)	0.78±0.03
BMR (kcal)	1301.21±141.23

BMI= Body Mass Index BMR= Basal Metabolic Rate

The results of the correlation analyses between the bioelectrical impedance-derived estimates of basal metabolic rate and the body composition parameters of the participants are shown in Table 2 and Figures 1-9.

TABLE 2. **PEARSON'S (r) CORRELATION OF ESTIMATES OF BMR WITH BODY COMPOSITION COMPONENTS**

Components	**Correlation with BMR#** (n=717) **r**	**p-value**
Age (years)	-0.284	<0.001***
BMI (kg/m^2)	0.477	<0.001***
Intracellular water (litre)	0.803	<0.001***
Extracellular water (litre)	0.205	<0.001***
Protein (kg)	0.991	<0.001***
Mineral (kg)	0.093	0.013*
Fat mass (kg)	0.234	<0.001***
Osseous (kg)	0.962	<0.001***
Waist-to-hip ratio (%)	0.217	<0.001***

*p<0.05 ***p<0.001 BMR= Basal Metabolic Rate BMI= Body Mass Index
Bioelectrical impedance-derived BMR

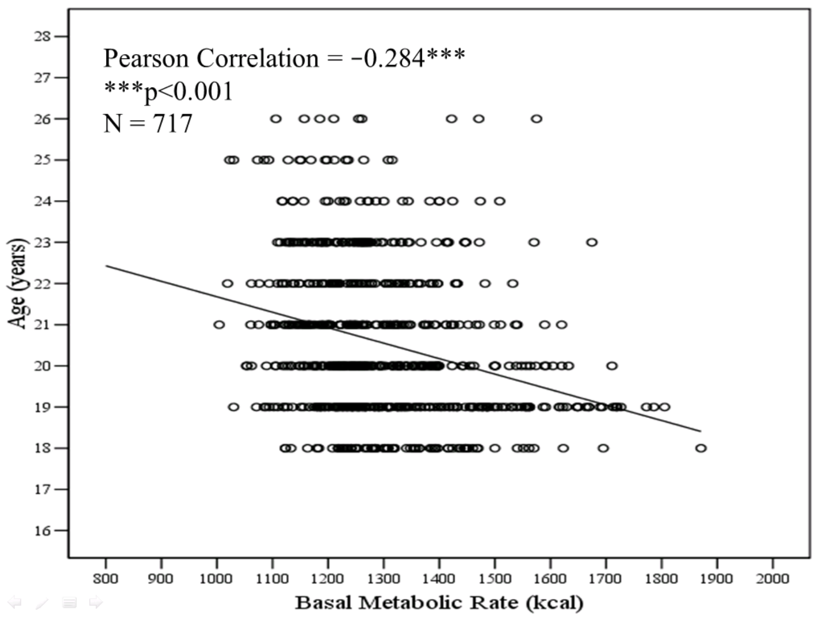

FIGURE 1. **CORRELATION BETWEEN BMR AND AGE**

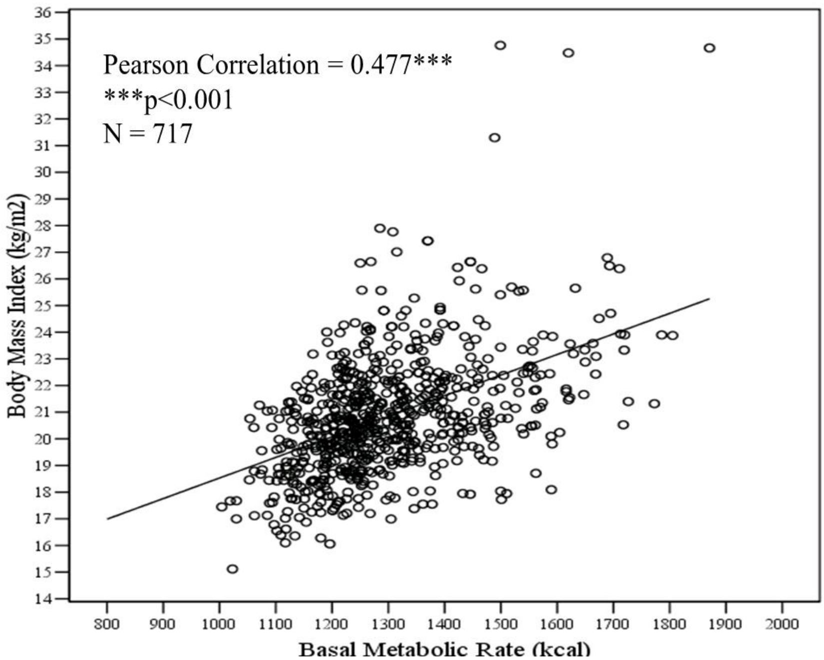

FIGURE 2. **CORRELATION BETWEEN BMR AND BMI**

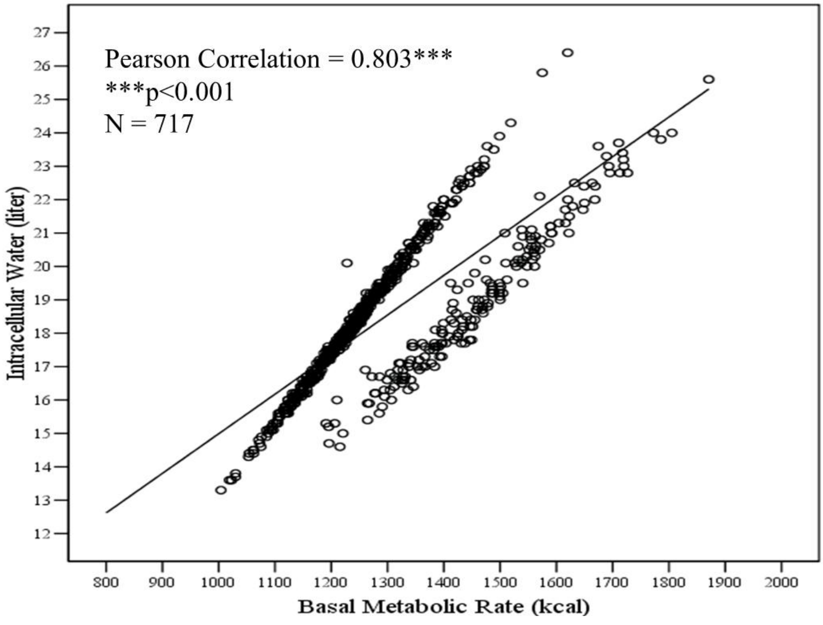

FIGURE 3. **CORRELATION BETWEEN BMR AND INTRACELLULAR WATER**

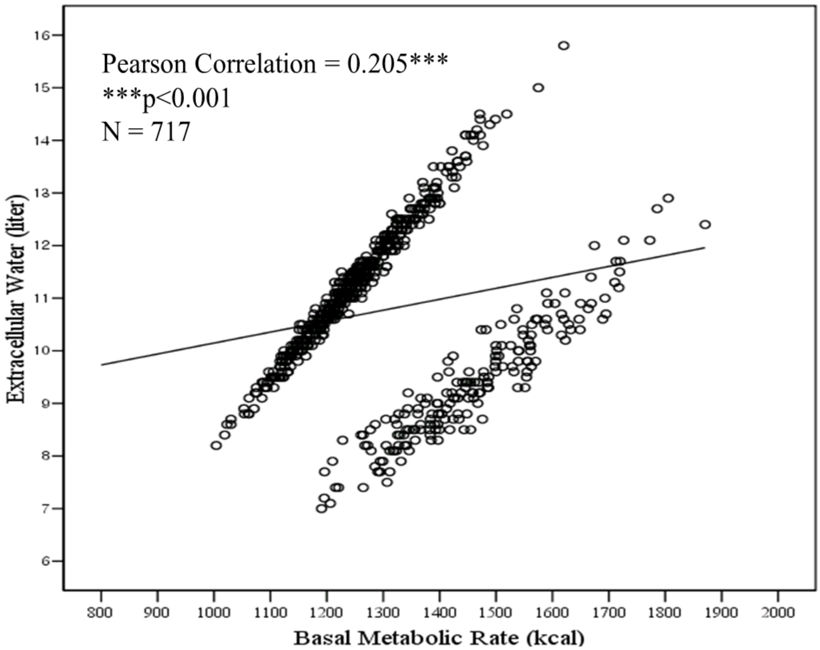

FIGURE 4. **CORRELATION BETWEEN BMR AND EXTRACELLULAR WATER**

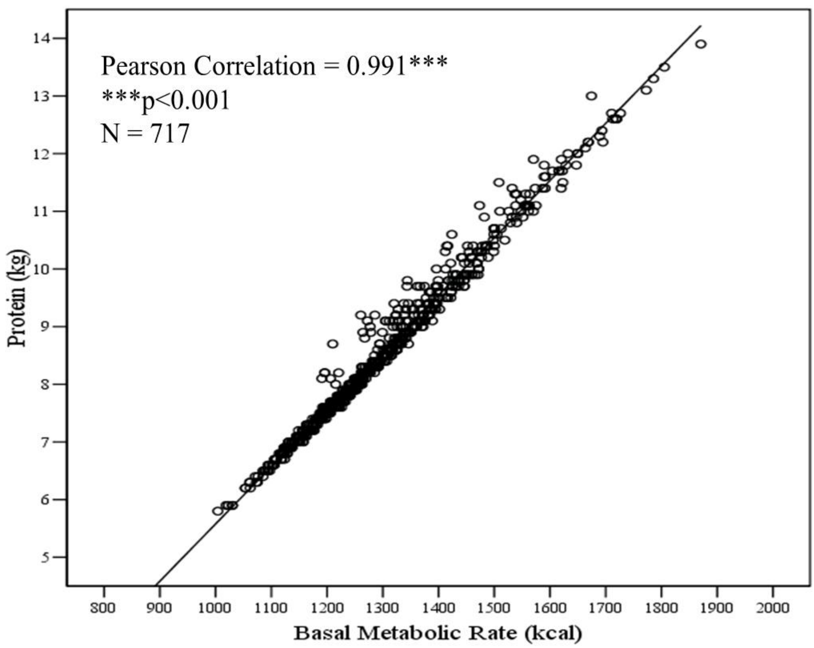

FIGURE 5. **CORRELATION BETWEEN BMR AND PROTEIN CONTENT**

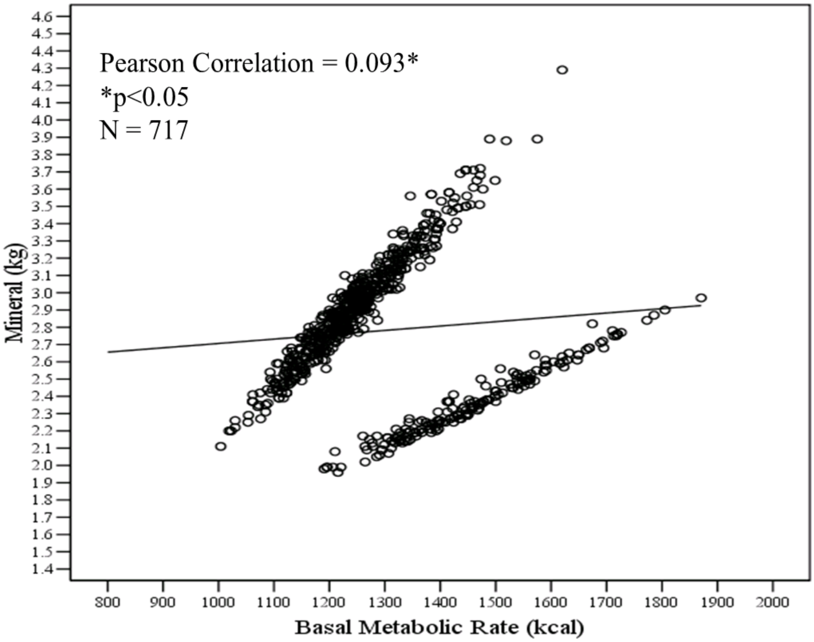

FIGURE 6. **CORRELATION BETWEEN BMR AND MINERAL CONTENT**

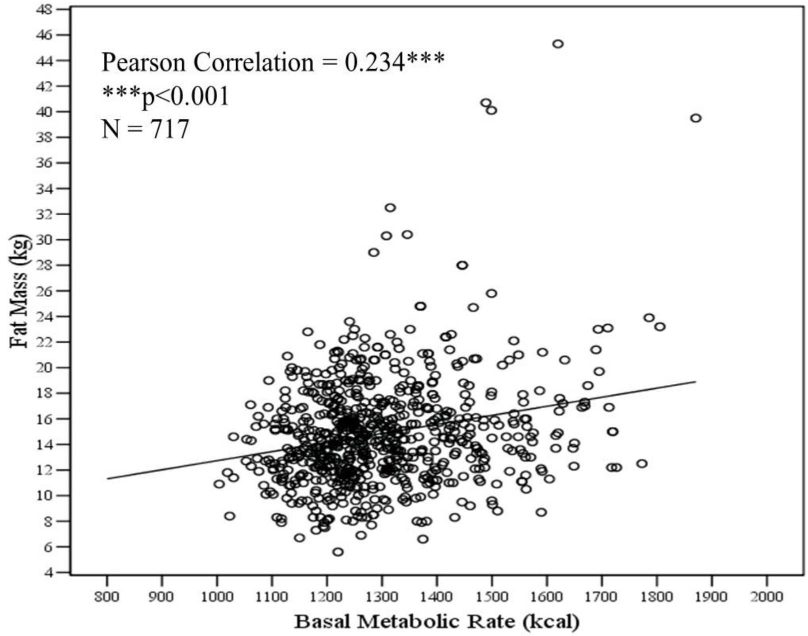

FIGURE 7. **CORRELATION BETWEEN BMR AND FAT MASS**

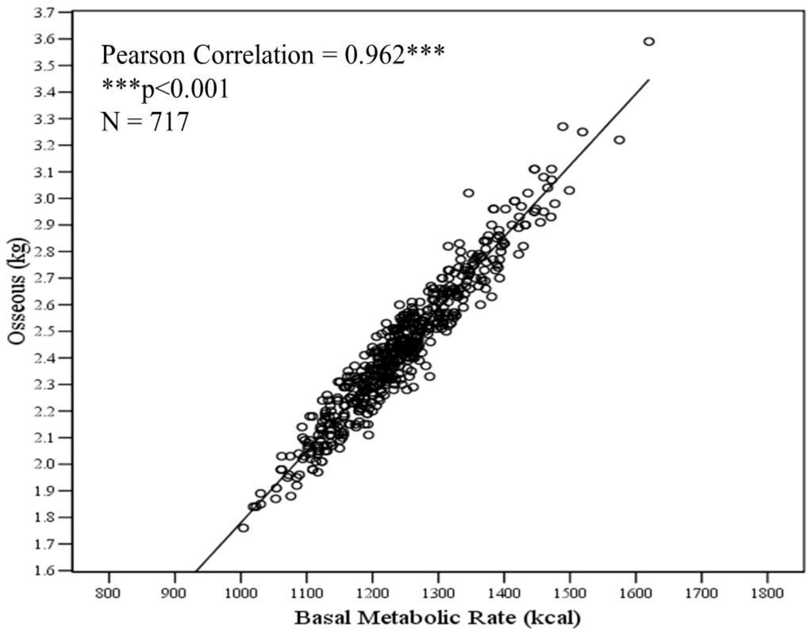

FIGURE 8. **CORRELATION BETWEEN BMR AND OSSEOUS CONTENT**

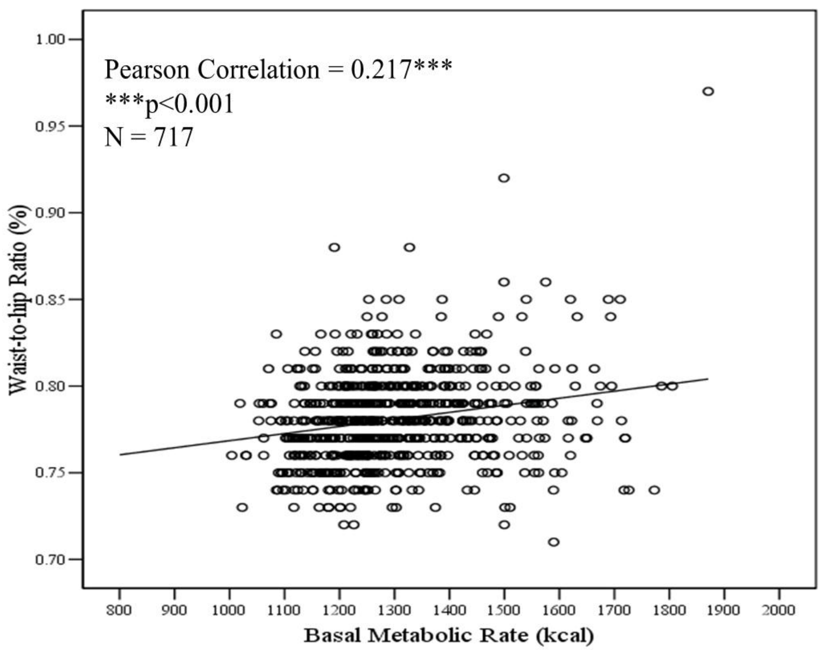

FIGURE 9. **CORRELATION BETWEEN BMR AND WAIST-TO-HIP RATIO**

The basal metabolic rate in this population (Table 2) significantly negatively correlated with age (r= -0.284, p<0.001), whereas significant positive correlations were observed between the basal metabolic rate and body mass index (r=0.477, p<0.001), intracellular water (r=0.803, p<0.001), extracellular water (r=0.205, p<0.001), protein content (r=0.991, p<0.001), mineral content (r=0.093, p=0.013), fat mass (r=0.234, p<0.001), osseous content (r=0.962, p<0.001), and waist-to-hip ratio (r=0.217, p<0.001).

DISCUSSION

This study investigated the correlations between bioelectrical impedance-derived estimates of basal metabolic rate and body composition parameters in female Korean college students. Previous studies have found that, in addition to fat-free mass, which is known to affect largely the basal metabolic rate (Cunningham, 1991; Weinsier *et al*., 1992), fat mass represents another contributing factor to the basal metabolic rate (Fukagawa *et al*., 1990; Nelson *et al*., 1992). In one recent study, it was reported that the fat-free mass, fat mass and age were the main factors influencing the basal metabolic rate (63%, 6% and 2% of the basal metabolic rate, respectively) (Johnstone *et al*., 2005). However, other previous studies have been unable to identify a relationship among these factors (Bogardus *et al*., 1986; Svendsen *et al*., 1993). Thus, the effects of many of these variables, including fat-free mass and fat mass, on the basal metabolic rate are still highly controversial, especially in Asia.

In addition, many previous studies have reported that increased age is associated with a decreased basal metabolic rate, which is most likely related to the decrease in fat-free mass during the aging process (Gallagher *et al*., 2000; Wang *et al*., 2005). The results of the current support the findings of these previous studies, and indicate that increased age is associated with a reduced basal metabolic rate in female Korean college students.

Lazzer *et al*. (2010) reported that the prediction equations based on anthropometric data, such as waist circumference and the body mass index, as well as body composition components such as fat mass, were associated with the same R^2 values and similar root mean squared errors of the estimate. This indicates that waist measurements and body mass index, similarly to waist circumference, positively correlate with the basal metabolic rate. In accordance with these results, a significant correlation between the basal metabolic rate and body mass index, waist-to-hip ratio and fat mass in the population of these 717 female Koreans were observed.

The results, moreover, demonstrated that other body composition components, such as intracellular and extracellular water, and protein, mineral, and osseous contents, significantly correlated with the bioelectrical impedance-derived estimates of basal metabolic rate (Table 2), indicating that these factors may also represent significant determinants of the BMR in this population. However, further studies should be performed to validate these results in other populations, including in males and older individuals, both in Korea and worldwide.

This study had a number of limitations. Firstly, because this was a single-institution study, the study population may not represent the general college student population in Korea. Secondly, only female subjects were included in the study, and the body compositions and MBR between female and male individuals are known to differ. Thirdly, the same apparatus was used to estimate the body composition and BMR parameters in this study. This might be associated with some conceptual problems and may present a statistical dilemma. However, the sample size of the present study (N=717) was considered relatively large, and is regarded as one of the greatest merits of this study. In addition, the fact that it was conducted in a Korean population, where currently very limited data exists concerning the associations between BMR and body composition components in non-Caucasian and non-African-American populations, adds to the merits.

For this population of female college students in Korea, BMI, intracellular water, protein content and osseous content was highly correlated with the BMR, whereas age, extracellular water, mineral content, fat mass, and waist-to-hip ratio showed low correlations with the BMR.

CONCLUSION

All body composition parameters correlated with the BMR in this population. As improvement of the body composition parameters may lead to an increased BMR, this may represent an effective means for the prevention of obesity. Further studies are warranted to confirm these findings.

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