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A comparison of bone mineral densities and body composition between Southeast Asia college students and Chinese college students

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Abstract

The aim of this study was to compare bone mineral densities (BMDs) and body composition between Southeast Asia college students and Chinese college students, in order to provide a certain reference enhancing college students' physical fitness.

A total of 1694 Chinese college students (294 men and 1400 women, aged 18–22 years) and 250 Southeast Asia college students (148 men and 102 women, aged 19–22 years) were included in the study. Weight, height, and body mass index were measured anthropometrically. BMD values were determined by ultrasound bone densitometer and body composition was determined by body composition analyzer.

Southeast Asia college students were overweight than Chinese college students (250 vs 1694) ($P < 0.05$). Chinese college students had a significantly lower body weight, fat mass, lean tissue mass, lean body weight, estimation of bone mass, protein, and metabolic rate but higher BMD at the calcaneus compared with Southeast Asia college students ($P < 0.05$ for all parameters). However, body water, intracellular fluid, and extracellular fluid were not significantly different between Chinese college students and Southeast Asia college students ($P > 0.01$ for all parameters).

The results of this cross-sectional study suggest that Chinese college students had a higher BMD but lower body composition than Southeast Asia college students, which may be associated with genes, diet, exercise, and other factors.

Abbreviations: BMD = bone mineral density, BMI = body mass index.

Keywords: body composition, bone mineral densities, Chinese, college students, comparison, Southeast Asia

1. Introduction

Recently, a study pointed out that approximately 60% of the adult population in the world is clinically defined as overweight or obese,[1] and the number of individuals clinically defined as obese (BMI 30 kg/m^2) has increased by 50% over the past decade.[2] As we all know, being overweight and obesity are important risk factors for many chronic diseases, such as diabetes, cardiovascular disease, and so on. Further, it is a global public health problem which seriously affects the quality of life and increases the financial burden. A study has pointed out that the heavier the weight, the more chances of having high blood pressure, and researchers found that because of too many fat cells there is a need to secrete too much insulin in the pancreas, in order to convert the blood sugar into energy. When the pancreas is overloaded, the function is weakened, so sugar in the blood increases, which cannot be fully utilized and is discharged in vitro. Obese women are 4 times more likely to develop diabetes than normal women, and 70% of patients with diabetes are obese. In patients with diabetes due to obesity, after weight loss, the condition improves and the metabolic function of sugar returns to normal.

At the same time, studies evaluating self-reported data to calculate BMI suggest that approximately 27%[3] to 35%[4] of college students are overweight or obese (BMI 25.0 kg/m^2). Huang had reported that overweight students were almost 3 times more likely to suffer at least one component of metabolic syndrome than students with normal weight.[5] It is difficult to reverse once obesity is established. Therefore, the development of effective strategies for the prevention of obesity arises out of extreme clinical importance.[2] Studies had pointed out that people in a university are more likely to gain weight throughout the life cycle.[2–7] Meanwhile, research points out that the trend of College Students' physical fitness is declining,[8–12] which has attracted the attention of the majority of clinical workers. The present study was conducted to measure the bone mineral density (BMD) and body composition of Chinese college students and Southeast Asia college students, and to establish a reference database of BMD in different regions, and to explore the difference of BMD and body composition among different college students.

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Table 1

Age, height, weight, and body mass index (BMI) between Southeast Asia college students and Chinese college students (average ± standard deviation).

	Male (N = 442)		Female (N = 1502)	
	Southeast Asia (N = 148)	China (N = 294)	Southeast Asia (N = 102)	China (N = 1400)
Age, y	22.57 ± 3.160	21.22 ± 1.706*	21.73 ± 1.976	20.74 ± 1.394†
Height, cm	172.52 ± 6.763	169.37 ± 5.848*	159.31 ± 6.359	157.55 ± 4.848†
Weight, kg	68.06 ± 13.142	59.73 ± 9.332*	53.94 ± 9.738	47.60 ± 5.612†
BMI, kg/m^2	22.81 ± 3.948	20.78 ± 2.831*	21.20 ± 3.400	19.15 ± 1.957†

* $P < 0.05$ versus male college students of Southeast Asia.
† $P < 0.05$ versus female college students of Southeast Asia.

2. Materials and methods

Two hundred fifty Southeast Asia college students (148 men and 102 women) and 1694 Chinese college students (294 men and 1400 women) were studied (mean age ± SD: 18.42 ± 4.52 years, range 18–22 years). Inclusion criteria: all subjects were excluded if having bone metabolism and calcium metabolism-related diseases; hormone drugs were not used in the past 3 months; without taking anti osteoporosis drugs nearly a year, etc.; all subjects were voluntarily participated and signed the consent form. Exclusion criteria for all subjects consisted of medical history of disorders that affect skeletal metabolism. The following conditions were reasons for exclusion from the study: smoking, excessive alcohol use, corticosteroids, eating disorders, diabetes mellitus, hyperparathyroidism, thyroid dysfunction, liver disease, and renal disorders. The retrospective study was approved by Guangxi Medical University Ethics Committee and informed written consent was obtained prior to all testing.

By using Ultrasonic bone density instrument to assess the BMD of left calcaneal. The main indicators are SI (bone stiffness index), calculated by BUA (ultrasonic frequency attenuation) and SOS (ultrasonic velocity) according to the following formula: SI = 0167 × (BUA) + 0128 × (SOS) − 420. Ultrasonic bone density instrument was conducted quality testing after test every day,the whole operation process is carried out by professional researchers.

Using human body composition analyzer Inbody 3.0 (Biospace, Korea) to measure body composition, the subject take off shoes and socks, and place the foot on the foot electrode, properly, his hands holding the hand electrode. After using the keyboard to enter the age, height, sex of the subjects, the body fat percentage, total body water, intracellular, liquid, protein content, mineral content, lean body weight, and muscle weight of the test subjects were measured.

Height of the subjects was measured artificially. Height was measured 3 times, and the average was taken.

Data were analyzed using the SPSS mainframe statistical programs and statistical significance was set at $P < 0.05$. Results were presented as means ± SD. Group differences in BMD were evaluated using analysis of variance (ANOVA) with follow-up Tukey multi comparison test. Due to significant differences among groups in height and weight, subsequent covariance analysis (ANCOVA) was employed, using both height and weight as covariates.

3. Results

Some characteristics of Southeast Asia college students and Chinese college students are shown in Table 1. The body weight and height of Southeast Asia college students were significantly higher than that of Chinese college students. In addition, body mass index (BMI) was significantly higher in Southeast Asia college students compared with Chinese college students ($P < 0.05$ for all parameters).

BMD results among Southeast Asia college students and Chinese college students are shown in Table 2. BQI (bone index), T, and Z were significantly higher in Chinese college students compared with Southeast Asia college students ($P < 0.05$ for all parameters).

Body composition results among Southeast Asia college students and Chinese college students are shown in Table 3. Fat free mass, muscle mass, protein, body water, extracellular fluid, estimation of bone mass, basal metabolism, total energy metabolism, fat mass, visceral fat rating, visceral fat area, visceral fat content, subcutaneous fat content, upper limbs muscle mass, lower limbs muscle mass, trunk fat, trunk fat percentage, upper limbs fat mass, upper limbs fat percentage, lower limbs fat mass, and lower extremity fat ratio were significantly higher in Southeast Asia college students compared with Chinese college students ($P < 0.05$ for all parameters). However, torso muscle mass and upper limbs muscle mass were not significantly different in Southeast Asia college students compared with Chinese college students ($P > 0.05$ for all parameters).

4. Discussion

In our sample of college students, approximately 25.2% had BMIs at baseline that would classify them as being overweight or

Table 2

The comparison of bone mineral densities among Southeast Asia college students and Chinese college students (average ± standard deviation).

	Male (N = 442)		Female (N = 1502)	
	Southeast Asia (N = 148)	China (N = 294)	Southeast Asia (N = 102)	China (N = 1400)
BQI	102.76 ± 18.087	111.18 ± 20.310*	97.78 ± 16.956	99.92 ± 14.072†
T	−0.2 (1.8)	0.3 (1.9)*	0 (1.9)	0.3 (1.2)†
Z	−0.1 (1.9)	0.4 (1.9)*	0 (1.9)	0.3 (1.2)†

* $P < 0.05$ versus male college students of Southeast Asia.
† $P < 0.05$ versus female college students of Southeast Asia.

Table 3

The body composition results among Southeast Asia college students and Chinese college students.

	Male (N = 442)		Female (N = 1502)	
	Southeast Asia (N = 148)	China (N = 294)	Southeast Asia (N = 102)	China (N = 1400)
FFM, kg	54.66 ± 6.959	51.90 ± 5.547*	37.66 ± 4.364	36.72 ± 3.020‡
Muscle mass, kg	51.83 ± 6.612	49.20 ± 5.270*	35.52 ± 3.993	34.66 ± 2.760‡
Protein, kg	15.66 ± 2.711	12.98 ± 1.878*	9.39 ± 1.086	9.09 ± 0.816‡
Body water, kg	36.29 ± 4.855	36.27 ± 4.369*	26.17 ± 3.557	25.61 ± 2.397‡
Intracellular fluid, kg	22.20 ± 3.400	22.78 ± 3.184*	15.67 ± 2.201	15.91 ± 1.600‡
Extracellular fluid, kg	14.04 ± 1.600	13.51 ± 1.268*	10.53 ± 1.498	9.73 ± 0.905‡
EBM, kg	2.83 ± 0.350	2.70 ± 0.279*	2.14 ± 0.371	2.05 ± 0.264‡
Basal metabolism, kg	1578.6 ± 214.9	1490.5 ± 167.3*	1178.7 ± 139.8	1130.7 ± 91.5‡
Total energy metabolism, kg	2344.1 ± 319.2	2213.5 ± 248.4*	1750.3 ± 207.6	1679.0 ± 136.0‡
Fat mass, kg	13.42 ± 7.404	7.85 ± 4.967*	16.30 ± 6.441	10.90 ± 3.450‡
Visceral fat rating, kg	6.11 ± 4.065	3.41 ± 2.795*	2.93 ± 2.213	1.27 ± 0.710‡
Visceral fat area, cm^2	60.13 ± 40.090	33.53 ± 27.158*	28.95 ± 21.470	12.67 ± 6.992‡
Visceral fat content, kg	1.93 ± 1.645	0.88 ± 0.927*	1.60 ± 1.133	0.74 ± 0.411‡
Subcutaneous fat content, kg	11.52 ± 5.757	6.97 ± 4.067*	14.68 ± 5.340	10.16 ± 3.055‡
Torso muscle mass, kg	26.74 ± 3.839	24.59 ± 2.606†	18.62 ± 2.677	17.65 ± 1.621‡
Upper limbs muscle mass, kg	5.69 ± 2.209	5.16 ± 0.670†	3.45 ± 1.413	3.06 ± 0.372‡
Lower limbs muscle mass, kg	19.69 ± 2.742	19.55 ± 2.354*	13.55 ± 1.450	14.05 ± 1.076‡
Trunk fat, kg	7.33 ± 4.602	4.09 ± 2.916*	8.20 ± 3.955	4.80 ± 2.055‡
Trunk fat, %	19.21 ± 9.071	12.74 ± 6.984*	27.95 ± 8.803	19.79 ± 6.268‡
Upper limbs fat mass, kg	1.01 ± 0.631	0.67 ± 0.363*	1.34 ± 0.757	0.84 ± 0.329‡
Upper limbs fat, %	26.2 ± 11.8	19.6 ± 8.8*	50.2 ± 15.5	37.8 ± 10.5‡
Lower limbs fat mass, kg	5.18 ± 2.325	3.20 ± 1.748*	6.87 ± 1.880	5.38 ± 1.110‡
Lower extremity fat ratio, %	38.2 ± 10.85	25.2 ± 9.66*	63.5 ± 9.53	52.3 ± 6.78‡

Due to significant differences among groups in height and weight, subsequent covariate analysis (ANCOVA) was employed, using both height and weight as covariates.
EBM = estimation of bone mass, FFM = fat free mass.
* $P < 0.05$ versus male college students of Southeast Asia.
† $P > 0.05$ versus male college students of Southeast Asia.
‡ $P < 0.05$ versus female college students of Southeast Asia.

obese (25.0 kg/m^2), of which the percentage of college students in Southeast Asian countries is 27, the percentage of Chinese college students is 24. These findings agree well with the estimates by Huang and colleagues.[3,5] However, they are somewhat less than that estimated by reported heights and weights.[13] The results of our study clearly support the notion that college students experience significant weight gain in the university. Meanwhile, in our study, the obesity rate of college students in Southeast Asian countries is higher than that of Chinese college students, and the difference is statistically significant ($P < 0.05$). There may be several reasons about that: different genetic gene, Mejía-Benítez[14] pointed out that genetic differences, the incidence of obesity are not the same, the number of AMY1 copy can reduce obesity risk when the living environment is different, the incidence of obesity is not the same. Papas pointed out there has a relationship between built environment features and the prevalence of obesity, lower SES neighborhoods are a primary concern.[15] Different diet, Um found that the absence of S6K1 protects against age and diet-induced obesity while enhancing insulin sensitivity. The incidence of obesity is different.[16]

BMD is influenced by many factors, such as age, sex, weight, female menopause, heredity, etc. Many cross-sectional studies have confirmed that BMD is positively correlated with body weight.[17–18] Low weight is part of the risk factors for the occurrence of osteoporosis.[19] Weight is a mechanical load factor,the greater the weight and the BMI,the greater weight the bone is to bear, relatively high mechanical load reduced bone resorption and stimulates bone formation, so as to increase the bone strength and bone mineral content, delaying the osteoporosis occurrence and reducing the degree. However, in our study, weight and BMI of college students in Southeast Asian countries were higher than that of Chinese students, but their BMD is lower than that of Chinese college students. Our result is not consistent with the reported literature.[20–22] The reason for this may be: in a certain period of time, Southeast Asia college students leave the original environment, and come to a new environment, they did not fully adapt to or accept the new environment and the new diet, therefore, BMD changes. Our study further showed that BMD changes with the environment and diet. Result is in good agreement with that of Merrilees, Wood, and Sahni.[23–25]

It is believed that BMD is affected by the mechanical stress exerted by weight.[26–30] The greater the weight, the greater the mechanical stress on the bone, and thus the greater the stimulus. However, body composition may be more important than weight, and body composition is an important determinant of BMD. Early observations indicated that the relationship between body composition and BMD was altered between sexes.[31–35] Lean body weight and body fat content have a distinct effect on bone density. The relationship between bone density and lean body mass in men is important, while in women it is just the opposite. At present, the mechanism of body composition and BMD is still not clear, whether the effect of bone density is caused by the lean body weight and body fat content is still not clear. Some researchers point out that body fat content is the decisive factor of bone density. Some researchers think that lean body mass has a relationship with BMD.[32,36–38] It was also found that there was a significant correlation between body fat and lean body mass and bone density. Such a big difference may be due to use of different research methods to draw different conclusions. However, in our study, the body fat content and lean body mass were higher in Southeast Asia college students compared with Chinese college students, but the BMD of Southeast Asia college students is lower than that of Chinese college Students. The reason may be body fat. Lean body mass have no correlation with

BMD,or a different research methods may draw different conclusions. Reid[39] pointed out that the basic mechanism of bone density and body fat content is still not clear, and it is not possible to be assigned to the mechanical load generated by the soft tissue. It is an example to showed that lean body weight is significantly associated with BMD/height, and there is no gender difference in terms of infiuence.

In conclusion, The study found that college students' obesity rate is higher than other groups, the rate of obesity among Southeast Asian countries is higher than that of Chinese university students, needing society and the country to take the necessary measures to reduce the incidence of obesity. Our study also found that the body composition of college students in Southeast Asian countries is higher than that of Chinese college students, but the bone density is lower than that of Chinese male college students. It suggested that when environment and dietary have a change,the body weight, lean body weight, fat mass, and BMD will not positively correlated with environment and dietary.

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References

[1] Ogden CL, Carroll MD, Curtin LR, et al. Prevalence of overweight and obesity in the United States, 1999–2004. JAMA 2006;295:1549–55.
[2] Yanovski JA, Yanovski SZ, Sovik KN, et al. A prospective study of holiday weight gain. N Engl J Med 2000;342:861–7.
[3] Huang TT-K, Harris KJ, Lee RE, et al. Assessing overweight, obesity, diet, and physical activity in college students. J Am Coll Health 2003;52:83–6.
[4] Dinger MK, Brittain DR, Hutchinson SR. Associations between physical activity and health-related factors in a national sample of college students. J Am Coll Health 2014;62:67–74.
[5] Huang TT-K, Kempf AM, Strother ML, et al. Overweight and components of the metabolic syndrome in college students. Diabetes Care 2004;27:3000–1.
[6] Guttman N, Salmon CT. Guilt, fear, stigma and knowledge gaps: ethical issues in public health communication interventions. Bioethics 2004; 18:531–52.
[7] El Ansari W, Stock C, Mikolajczyk RT. Relationships between food consumption and living arrangements among university students in four European countries-a cross-sectional study. Nutr J 2012;11:28.
[8] Greene GW, White AA, Hoerr SL, et al. Impact of an online healthful eating and physical activity program for college students. Am J Health Promot 2012;27:e47–58.
[9] Esslinger KA, Grimes AR, Pyle E. Effects of requiring physical fitness in a lecture-based college course: students' attitudes toward physical activity. Phys Educator 2016;73:161.
[10] Lepp A, Barkley JE, Sanders GJ, et al. The relationship between cell phone use, physical and sedentary activity, and cardiorespiratory fitness in a sample of US college students. Int J Behav Nutr Phys Act 2013;10:79.
[11] Lepp A, Barkley JE, Karpinski AC. The relationship between cell phone use, academic performance, anxiety, and satisfaction with life in college students. Comput Hum Behav 2014;31:343–50.
[12] Sengupta P, Chaudhuri P, Bhattacharya K. Screening obesity by direct and derived anthropometric indices with evaluation of physical efficiency among female college students of Kolkata. Ann Med Health Sci Res 2013;3:517–22.
[13] Lowry R, Galuska DA, Fulton JE, et al. Physical activity, food choice, and weight management goals and practices among US college students. Am J Prev Med 2000;18:18–27.
[14] Mejía-Benítez MA, Bonnefond A, Yengo L, et al. Beneficial effect of a high number of copies of salivary amylase AMY1 gene on obesity risk in Mexican children. Diabetologia 2015;58:290–4.
[15] Papas MA, Alberg AJ, Ewing R, et al. The built environment and obesity. Epidemiol Rev 2007;29:129–43.
[16] Um SH, Frigerio F, Watanabe M, et al. Absence of S6K1 protects against age-and diet-induced obesity while enhancing insulin sensitivity. Nature 2004;431:200–5.
[17] Evans AL, Paggiosi MA, Eastell R, et al. Bone density, microstructure and strength in obese and normal weight men and women in younger and older adulthood. J Bone Miner Res 2015;30:920–8.
[18] Oldroyd A, Dubey S. The association between bone mineral density and higher body mass index in men. Int J Clin Pract 2015;69:145–7.
[19] LeBoff MS, Yue AY, Copeland T, et al. VITAL-Bone Health: rationale and design of two ancillary studies evaluating the effects of vitamin D and/or omega-3 fatty acid supplements on incident fractures and bone health outcomes in the VITamin D and OmegA-3 TriaL (VITAL). Contemp Clinical Trials 2015;41:259–68.
[20] Morin S, Tsang J, Leslie W. Weight and body mass index predict bone mineral density and fractures in women aged 40 to 59 years. Osteoporos Int 2009;20:363–70.
[21] Villareal DT, Fontana L, Weiss EP, et al. Bone mineral density response to caloric restriction–induced weight loss or exercise-induced weight loss: a randomized controlled trial. Arc Intern Med 2006;166:2502–10.
[22] Verschueren S, Gielen E, O'Neill T, et al. Sarcopenia and its relationship with bone mineral density in middle-aged and elderly European men. Osteoporos Int 2013;24:87–98.
[23] Merrilees M, Smart E, Gilchrist N, et al. Effects of dairy food supplements on bone mineral density in teenage girls. Eur J Nutr 2000;39:256–62.
[24] Wood CL, Wood AM, Harker C, et al. Bone mineral density and osteoporosis after preterm birth: the role of early life factors and nutrition. Int J Endocrinol 2013;2013:902513.
[25] Sahni S, Tucker KL, Kiel DP, et al. Milk and yogurt consumption are linked with higher bone mineral density but not with hip fracture: the Framingham Offspring Study. Arch Osteoporos 2013;8:1–9.
[26] Kato T, Niwa M, Yamashita T, et al. Past sporting activity during growth induces greater bone mineral content and enhances bone geometry in young men and women. J Bone Miner Metab 2015;33:569–76.
[27] Drinkwater BL, Bruemner B, Chesnut CH. Menstrual history as a determinant of current bone density in young athletes. JAMA 1990;263:545–8.
[28] Gnudi S, Sitta E, Fiumi N. Relationship between body composition and bone mineral density in women with and without osteoporosis: relative contribution of lean and fat mass. J Bone Miner Metab 2007; 25:326–32.
[29] Drinkwater BL, Nilson K, Chesnut III CH, et al. Bone mineral content of amenorrheic and eumenorrheic athletes. N Engl J Med 1984;311: 277–81.
[30] Courteix D, Lespessailles E, Peres SL, et al. Effect of physical training on bone mineral density in prepubertal girls: a comparative study between impact-loading and non-impact-loading sports. Osteoporos Int 1998; 8:152–8.
[31] Tirosh A, de Souza RJ, Sacks F, et al. Sex differences in the effects of weight loss diets on bone mineral density and body composition: POUNDS LOST trial. J Clin Endocrinol Metab 2015;100:2463–71.
[32] Zhu K, Briffa K, Smith A, et al. Gender differences in the relationships between lean body mass, fat mass and peak bone mass in young adults. Osteoporos Int 2014;25:1563–70.
[33] Cheng Q, Zhu YX, Zhang MX, et al. Age and sex effects on the association between body composition and bone mineral density in healthy Chinese men and women. Menopause 2012;19:448–55.
[34] Yoo HJ, Park MS, Yang SJ, et al. The differential relationship between fat mass and bone mineral density by gender and menopausal status. J Bone Miner Metab 2012;30:47–53.
[35] Zhu K, Hunter M, James A, et al. Associations between body mass index, lean and fat body mass and bone mineral density in middle-aged Australians: the Busselton Healthy Ageing Study. Bone 2015;74:146–52.
[36] Ho-Pham LT, Nguyen UD, Nguyen TV. Association between lean mass, fat mass, and bone mineral density: a meta-analysis. J Clin Endocrinol Metab 2014;99:30–8.
[37] Erlandson KM, Kitch D, Tierney C, et al. Weight and lean body mass change with antiretroviral initiation and impact on bone mineral density: AIDS Clinical Trials Group Study A5224s. AIDS (London, England) 2013;27:2069.
[38] Edwards MH, Ward KA, Ntani G, et al. Lean mass and fat mass have differing associations with bone microarchitecture assessed by high resolution peripheral quantitative computed tomography in men and women from the Hertfordshire Cohort Study. Bone 2015;81:145–51.
[39] Reid IR, Plank LD, Evans MC. Fat mass is an important determinant of whole body bone density in premenopausal women but not in men. J Clin Endocrinol Metab 1992;75:779–82.