Study on body composition and its correlation with obesity
A Cohort Study in 5121 Chinese Han participants
Xiongfei Liang, MD, Xianhua Chen, MD, Jing Li, MSC, Mengdan Yan, MSC, Yifeng Yang, MD

Abstract
Rare reports can be found about sex- and age-specific body composition survey among Chinese population. The aim of this study is to explore the change of body composition with aging in Chinese males and females respectively.

The present cross-sectional study was carried out in Central South University Xiangya School of Medicine Affiliate Haikou Hospital, on a random sample consisting of 5121 participants. Inbody720 body composition analyzer was used to detect the human body composition. Data collection was based on the assessment of anthropometric body composition measurements done with the help of bioelectric impedance. And the data were analyzed with SPSS19.0.

We selected 5121 participants, 3276 males and 1845 females. A significant trend (P < 0.05) for all anthropometric indices was observed with age for both genders. Body fat in men and women were 18.33 kg and 19.82 kg, respectively. Body fat percentage in men and women were 25.74% and 34.01%, respectively. Visceral fat area in men and women were 91.98 cm² and 77 cm², respectively. And, with the increase of age, body fat, body fat percentages and visceral fat area also increased, both in men and in women. Meanwhile, with the increase of BMI, the body fat, body fat percentages, and visceral fat area also increased, both in men and in women.

Significant trends were observed for body fat, body fat percentages and visceral fat area for both genders with age and both genders with BMI. Focusing on obesity-related lifestyle and prevent weight gain.

Abbreviations: BFP = body fat percentage, BIA = bioelectrical impedance analysis, BMI = body mass index, VFA = visceral fat area, WC = waist circumference, WHR = waist-hip ratio of fat.

Keywords: body composition, body mass index, Hainan population, inbody720 body composition analyzer, obesity

1. Introduction
At present, obesity is well recognized as one of the major public health issues worldwide. Prior to the 1980s, the prevalence of obesity has been very stable, but has since increased dramatically throughout the world. According to the 2014 World Health Organization (WHO), a rough estimate of 600 million obese adults worldwide. A Chinese nutrition survey shows that the prevalence of overweight and obesity was 19.2% and 15.0%, respectively. Obesity is a serious problem because of the increasing possibility of a wide range of health consequences, including hypertension, insulin insensitivity, diabetes mellitus, cardiovascular disease, and distinct types of cancers. The cost of medical care for obese patients is 30% higher than that of the normal weight peers.

Human body composition is one of the branches of human biology, mainly to study the change rule of the number of body composition in human body, the influence of various factors in vivo and in vitro on the quantitative relationship between components, as well as in vivo determination of human components. Body composition measurements not only indicate systemic nutritional status and health status, but also provide valuable information for the diagnosis and treatment of various diseases, whose quality and distribution are closely related to the health status of people at all ages. The human body consists of 4 components: fat, protein, water and inorganic salts, the proportion of its composition is an important measure of physical health standards, the proportion of dysplasia is the root cause of the development of many diseases, to maintain the proportion of body composition is normal to achieve body composition balance, and maintain the health status of a basic condition. At the same time, its composition to a certain extent, also reflects the gender, age, geographical, genetic, growth and development, nutrition, socioeconomic level, and disease and other factors.

Obesity in Saudi Arabia is a major public health concern, which is one of the fastest growing countries in the world. Azzeb and his colleague found that along with the increase of age, body mass index, waist circumference, body fat, visceral fat and...
Intracellular lean body weight, kg 3276 ± 51.39
Basal metabolic rate, kcal/d 3276 ± 1480

Therefore, with the increase of age, systematic assessment of the changes in human body components is important for human health and nutritional status. Therefore, the main purpose of this study is to explore the relationship between human body composition and age and obesity in Hainan population.

2. Materials and methods

All subjects declared their written informed consent and were familiar with the aims, methods and risks of participating in the study in accordance with the Helsinki Declaration and rules of Good Clinical Practice, as the study was approved by the Ethics Committee of the Central South University Xiangya School of Medicine Affiliate Haikou Hospital. The ethics number for the study is 2015-039.

We recruited 5121 participants in physical examination center of Central South University Xiangya School of Medicine Affiliate Haikou Hospital from December 2015 to April 2017, which including 3276 males (aged 9–88 years) and 1845 females (aged 7–90 years). When participants have the following diseases or tumors, we will be excluded, such as cardiovascular diseases, metabolic diseases, chronic diseases, etc., pregnant women are also excluded.

Inbody720 body composition analyzer (Biospace Co., Korea) was used to detect the human body composition based on the recommendation provided in the user manual (according to the principle of bioelectrical impedance, the size of the different components in the body through current is different, have different electrical impedance). The subjects were tested in the quiet state after fasting emptying in the morning. When the test subjects barefoot standing on the pedal plate electrode, hands naturally hang down, hold the hand electrode gently, and the angle between the trunk and upper limbs is maintained at 15°, the subject is in a relaxed state, the test indexes including basal metabolic rate, lean body weight, intracellular fluid, extracellular fluid, protein content, mineral content, body water content, skeletal muscle, body fat, abdominal obesity, etc. Weight in kilograms with no shoes in a minimal clothing state by a digital scale (Beurer, Germany), height in centimeters was measured. BMI was calculated as the weight in kilograms divided by the square of the height in meters (kg/m²). According to the working group on obesity (WGOC) recommended BMI classification criteria: underweight (<18.5 kg/m²), normal weight (18.5 to 24 kg/m²), overweight (24 to 28 kg/m²), and obesity (≥28 kg/m²).

Descriptive anthropometry and body composition are presented as the means and standard deviation for men and women separately. Student’s t test analysis was performed to investigate differences in mean values of anthropometric measures between men and women. According to the age criteria of WHO, young people are subdivided into those under 30 and 30 to 45, so, the subjects were divided into one of the following 4 age groups: <30 years old, 30 to 45, 45 to 60, >60 years old. Use <30 years old as a reference, to analysis the trends of baseline characteristics of both genders with age brackets in male and female. According to the working group on obesity (WGOC) recommended BMI classification criteria: underweight (<18.5 kg/m²), normal weight (18.5 to 24 kg/m²), overweight (24 to 28 kg/m²), and obesity (≥28 kg/m²). Use normal weight (18.5 to 24 kg/m²) as a reference, we used variance analysis to analysis the relationship between the body composition and BMI in male and female. Data analysis was performed using the Statistical Package for Social Sciences (SPSS) software version 19. A P-value <.05 was considered statistically significant.

3. Results

3.1. Baseline characteristics of study sample stratified by gender

From Table 1, the mean of BMI was calculated in males and females, 24.48±3.37 for males and 23.18±3.33 for females. The basal metabolic rate of males and females were 1480±142.88

| Number | Mean ± SD | Number | Mean ± SD |
|--------|-----------|--------|-----------|
| Height, cm | 3276 | 168.65 ± 6.3 | 1845 | 157.38 ± 6.17 |
| Age, years | 3276 | 43.8 ± 15.53 | 1845 | 45.55 ± 14.7 |
| Weight, kg | 3276 | 69.72 ± 10.83 | 1845 | 57.41 ± 8.86 |
| Body mass index, kg/m² | 3276 | 24.48 ± 3.37 | 1845 | 23.18 ± 3.33 |
| Basal metabolic rate, kcal/d | 3276 | 1480 ± 142.88 | 1845 | 1181.92 ± 109.65 |
| Lean body weight, kg | 3276 | 51.39 ± 6.62 | 1845 | 37.59 ± 5.08 |
| Intracellular fluid, kg | 3276 | 23.54 ± 3.32 | 1845 | 16.92 ± 2.34 |
| Extracellular fluid, kg | 3276 | 14.29 ± 1.99 | 1845 | 10.64 ± 1.6 |
| Protein, kg | 3276 | 10.17 ± 1.43 | 1845 | 7.32 ± 1.01 |
| Mineral content, kg | 3276 | 3.42 ± 0.39 | 1845 | 2.74 ± 0.22 |
| Body water content, kg | 3276 | 37.78 ± 5.24 | 1845 | 27.56 ± 3.72 |
| Skeletal muscle, kg | 3275 | 28.67 ± 4.01 | 1843 | 20.09 ± 3.3 |
| Body fat, kg | 3276 | 18.33 ± 6.49 | 1845 | 19.82 ± 5.97 |
| Body fat percentage, % | 3276 | 25.74 ± 6.42 | 1845 | 34.01 ± 6.51 |
| Visceral fat area, cm² | 3276 | 91.96 ± 34.96 | 1845 | 77 ± 33.77 |
kcal and $1181.92 \pm 109.65$ kcal, respectively. Body fat in men and women were $18.33 \pm 6.49$ and $19.82 \pm 5.97$. The body fat percentage in men and women were 25.74% and 34.01%. Visceral fat area in men and women were $91.98 \pm 34.95$ cm² and $77 \pm 33.77$ cm², respectively.

3.2. Trends of baseline characteristics of both genders with age brackets

According to WHO’s age criteria, the subjects were divided into one of the following 4 age groups: <30 years old, 30 to 45 years old, 45 to 60 years, and >60 years old. Use <30 years old as a reference, to analyze the trends of baseline characteristics of both genders with age brackets in male and female. From Table 2, with age, the body composition will follow the change. According to the age group, under 30 years, 30 to 45 years old, 45 to 60 and 60 years, in men, the mean value of protein were $10.40 \pm 1.37$, $10.21 \pm 1.19$, $9.26 \pm 1.18$, and $8.68 \pm 0.98$ kg; the mean of extracellular fluid were $10.21, 10.66, 10.85$, and $10.37 \pm 1.19$ kg. According to the age group, under 30 years, 30 to 45, 45 years old, and 60 years, in men, the mean of protein were $10.4, 10.37, 10.37$, and $10.37 \pm 1.19$ kg; the mean of extracellular fluid were $10.21, 10.66, 10.85$, and $10.37 \pm 1.19$. According to BMI stratification, the differences of different components and indexes in different sex groups were analyzed. Table 3 shows the analysis of variance ANOVA for the correlated variables and BMI. It is clear from Table 3 that with the increase of BMI, the mean of protein content, body fat, and basal metabolic rate also increased, both in men and women.

3.3. Correlation between body composition and BMI

According to BMI stratification, the differences of different components and indexes in different sex groups were analyzed. Table 3 shows the analysis of variance ANOVA for the correlated variables and BMI. It is clear from Table 3 that with the increase of BMI, the mean of protein content, body fat, and basal metabolic rate also increased, both in men and women.
and 31.15 ± 4.79 kg. For body fat percentage, in men, 22.11%, 15.16%, 28.09%, and 32.97%, respectively; in women, in order, 32.33%, 25.12%, 37.63%, and 42.89%.

### 4. Discussion

In 2014, WHO declared that the worldwide prevalence of overweight and obesity affected about 1.9 billion adults aged 18 years or older. This study is the first directly comparative study of body composition and obesity-related in Hainan population. Our results showed that with the increase of age, body fat, body fat percentages and visceral fat area also increased, both in men and in women. Meanwhile, with the increase of BMI, the body fat, body fat percentages and visceral fat area also increased, both in men and in women. Significant trends were observed for body fat, body fat percentages, and visceral fat area for both genders with age and both genders with BMI.

In our study, body fat in men and women were 18.33 and 19.82. The body fat percentage in men and women were 25.74% and 34.01%. Visceral fat area in men and women was 91.98 and 77 cm². And, with the increase of age, body fat, body fat percentages and visceral fat area also increased, both in men and in women. Meanwhile, with the increase of BMI, the body fat, body fat percentages and visceral fat area also increased, both in men and in women. Studies by Yusuf et al. showed that after middle age, body fat accumulation began to increase with age and tended to accumulate in certain areas of the body. In general, the fat accumulation of males is "pear type," and their fat mainly accumulates below the waist to the thigh part. The "Apple type" is more dangerous than "pear type" in the heart disease. Using InBody 720 body composition analyzer to measure 1121 obese adults overweight body mass index, body fat percentage, waist-hip ratio of fat and

### Table 3

|                          | Male | Female |
|--------------------------|------|--------|
| **BMI group**            | N    | Mean ± SD | P  |
| **Protein, kg**          |      |          |    |
| 18.5<b<24                | 1374 | 9.62 ± 1.09 |    |
| <18.5                    | 111  | 8.51 ± 1.21 | .007 |
| ≥18.5                    | 447  | 11.3 ± 1.33 | <.05 |
| **Intracellular fluid, kg** | |        |    |
| 18.5<b<24                | 1374 | 22.26 ± 2.51 |    |
| <18.5                    | 111  | 19.69 ± 2.79 | .006 |
| ≥18.5                    | 447  | 24.22 ± 2.63 | <.05 |
| **Extracellular fluid, kg** | |        |    |
| 18.5<b<24                | 1374 | 13.49 ± 1.42 |    |
| <18.5                    | 111  | 12.11 ± 1.59 | <.05 |
| ≥18.5                    | 447  | 14.62 ± 1.54 | <.05 |
| **Mineral content, kg**  |      |          |    |
| 18.5<b<24                | 1374 | 3.27 ± 0.52  |    |
| <18.5                    | 111  | 2.86 ± 0.41  | .007 |
| ≥18.5                    | 447  | 3.57 ± 0.66  | <.05 |
| **Body water content, kg** | |        |    |
| 18.5<b<24                | 1374 | 35.75 ± 3.89 |    |
| <18.5                    | 111  | 31.84 ± 4.36 | <.05 |
| ≥18.5                    | 447  | 38.44 ± 4.81 | <.05 |
| **Lean body weight, kg** |      |          |    |
| 18.5<b<24                | 1374 | 48.65 ± 5.36 |    |
| <18.5                    | 111  | 43.17 ± 5.96 | <.05 |
| ≥18.5                    | 447  | 52.88 ± 6.54 | <.05 |
| **Skeletal muscle, kg**  |      |          |    |
| 18.5<b<24                | 1374 | 27.03 ± 3.27 |    |
| <18.5                    | 111  | 23.68 ± 3.64 | <.05 |
| ≥18.5                    | 447  | 29.58 ± 4.32 | <.05 |
| **Body fat, kg**         |      |          |    |
| 18.5<b<24                | 1374 | 13.87 ± 3.62 |    |
| <18.5                    | 111  | 7.69 ± 2.31  | <.05 |
| ≥18.5                    | 447  | 20.62 ± 3.43 | <.05 |
| **Body fat percentage, %** | |        |    |
| 18.5<b<24                | 1374 | 22.11 ± 5.07 |    |
| <18.5                    | 111  | 15.16 ± 4.58 | <.05 |
| ≥18.5                    | 447  | 28.09 ± 4.25 | <.05 |
| **Basal metabolic rate, kcal/d** | |        |    |
| 18.5<b<24                | 1374 | 1420.77 ± 115.88 |    |
| <18.5                    | 111  | 1302.46 ± 128.57 | .001 |
| ≥18.5                    | 447  | 1512.22 ± 121.76 | <.05 |

BMI = body mass index. 
P < .05 indicates statistical significance.
visceral fat area, and compare the body composition changes in different groups. The results suggested that Han ethnicity males and Uighur men had significantly difference in BFP, WHR, and VFA than that in Han men and women. Heo et al. analysis the trend of percentage of body fat in 3 race-ethnicity groups (non-Hispanic whites, non-Hispanic blacks, and Mexican Americans), and the results shown that the body mass index increases, the percentage of body fat also increases no matter in male group and female group. One research in Kuwait people revealed that the body fat percentages of males and females are 23.3% and 37.7%, respectively, females were greater than that for males, and males have a significantly higher proportion of obesity than women. This result is consistent with the findings of other studies in other countries. Although the trend of body fat rate is similar in different countries, there are still some differences. Body fat percentages differ among countries depending on genetic factors, eating patterns, regular exercise, and other life-style habits. Studies revealed that obesity is associated with the occurrence of various diseases, such as insulin resistance, T2DM, stroke, CVD, MetS, non alcoholic fatty liver disease. The accumulation of visceral fat also related to T2DM, CVD, insulin resistance. Some research found that weight gain in adulthood appears to increase the risk for colon cancer. Valdes et al. pointed that obesity is not only related to shortened life expectancy, but also related to accelerated aging. So, focusing on obesity-related lifestyle and prevent weight gain is very important.

Extracellular fluid refers to exist in the extracellular fluids, including plasma, tissue fluid and lymph, is the internal environment of the body; Intracellular fluid is a kind of body fluids, which can directly affect cell metabolism and physiological function. Determination of the internal and external fluid amount to the cells of our bodies can not only reflect the status of the function of the body’s tissues, can also display cell physiology. In our research, we found that under 30 years, 30 to 45 years old, 45 to 60 and 60 years, in men, mean of intracellular fluid were 24.06, 24.16, 23.63, and 21.41 kg; the mean of extracellular fluid were 14.32, 14.4, 14.39, and 13.48 kg. While in women, the mean of intracellular fluid were 16.5, 17.19, 17.31, and 16.21 kg; the mean of extracellular fluid were 10.21, 10.66, 10.85, and 10.37 kg. The research shows that after the age of 45, intracellular fluid has a tendency to decline, and the extracellular fluid has a tendency to rise. One research revealed that the middle-aged male group had the highest intracellular fluid and extracellular fluid volume, and the middle-aged group had significant differences with the young group and the elderly group. The middle-aged women also showed the highest level of intracellular and extracellular fluid, but there was no significant difference in the intracellular fluid between the young and middle-aged women. The mean intracellular fluid was the lowest in the elderly group, which was significantly different from the middle-aged group. The physiological state of the elderly cells are greatly reduced, while large differences between individuals. At the same time, in our study found that as the growth of the age, with lower protein content. The study found that the volume change of extracellular fluid and intracellular fluid can reflect the conditions of nutrition metabolism of the body, poor nutrition can lead to the abnormal distribution of extracellular and intracellular fluid, shown that extracellular fluid increases, intracellular fluid decreases, and more serious the degree of malnutrition. And to a certain extent, the decrease of intracellular fluid is associated with an increased protein catabolism. For obese people, with the increase of body fat, extracellular fluid volume also increased. Several other studies have examined extracellular fluid is a kind of body fluid, can reflect the physiological state of the human body, and can be used to determine the body composition. The study shows that extracellular fluid is related to accelerated aging. So, focusing on obesity-related lifestyle and prevent weight gain is very important.

Bioelectrical impedance analysis (BIA) was first proposed by Lukaski, and it assumes that the body is composed of fat and nonfatty substances, to use the conductive differences of human body fat, water and other components of the body to determine the content of body composition. The study shows that bioelectrical impedance method is one of the important methods of body composition measurement, which can reflect the weight and distribution of body fat and can be evaluated nutritionally, has the advantages of simple operation, fast detection, safe, noninvasive, economy, reliability, and validity, etc., suitable for large-scale research group, has an important value in the diagnosis obesity or malnutrition.

There are several potential limitations of the present study: Firstly, we used the Inbody 720 body composition analyzer, which originally developed and validated only in the Korean population. There are genetic differences in the Korean and the Chinese population; there may be significant differences in body fat composition. This may create a systematic bias in the analysis. Secondly, in order to get more accurate and reliable results, the sample size is still not big enough, and the sample size needs to be adjusted according to the occurrence probability of Type 1 and Type II errors. Thirdly, this study inevitably has a certain bias in the selection of the respondents. In order to strengthen the strength of its argument and verify its conclusion, large-scale, multi-category research is still needed.

5. Conclusions

In our research, we found that significant trends were observed for body fat, body fat percentages and visceral fat area for both genders with age and both genders with BMI. Focusing on obesity-related lifestyle and prevent weight gain. In recent years, studies have showed that the body composition anomalies is closely related to lipid metabolic disorder diseases, such as obesity, diabetes and other disease, these may be a risk factor for cardiovascular disease. According to the results of body composition analysis, can be found the body composition change and adipose accumulation as early as possible, in order to change lifestyle of each age overweight and obese people, improve the subhealth.

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Author contributions

Conceptualization: Yi feng Yang.
Data curation: Xian hua Chen, Jing Li, Meng dan Yan.
Formal analysis: Xiong fei Liang, Xian hua Chen, Jing Li, Meng dan Yan.
Funding acquisition: Yi feng Yang.
Methodology: Jing Li, Meng dan Yan.
Project administration: Yi feng Yang.
Software: Xian hua Chen.
Writing – original draft: Xiong fei Liang.
Writing – review & editing: Yi feng Yang.
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