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Original Article

Body Composition Characteristics and Anthropometric Measurements of Older Mongolian Adults

Oyuntugs Byambasukh[1], Gerel Buukuu[1], Odgerel Chinbat[2], Dulmaa Tungalag[2], Dolgorsuren Tsedendamba[2], Anuujin Batbold[1], Saruul Tsogtsaikhan[1], Sainbileg Sonomtseren[1], Suvd Junai[1]

[1]Department of Internal Medicine, School of Medicine, Mongolian National University of Medical Sciences, Ulaanbaatar, Mongolia; [2]Mongolian National Gerontology Center, Ulaanbaatar, Mongolia

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Corresponding Author
Oyuntugs Byambasukh, MD, MSc
Department of Internal Medicine, School of Medicine, Mongolian National University of Medical Sciences, Zorig Street, Ulaanbaatar, Mongolia.
Tel: +976-8800-6123
E-mail:oyuntugs@mnums.edu.mn

Objectives: The purpose of our study is to examine characteristics of body composition and anthropometric measurements in older Mongolian adults. **Methods:** This cross-sectional study included 268 individuals aged 45 years and older who visited national hospitals over a period of one month. Body weight, BMI, waist circumference (WC) and other body circumferences, and body composition (body fat percentages, fat-free mass index, skeletal mass index) were measured and the Short Physical Performance Battery (SPPB) score was used to test the physical performance. **Results:** The sample was composed of 73.7% women and 26.3% men, and the mean age was 58.1±8.9. All measurements were relatively higher than the normal range in older Mongolian adults. Obesity in women was relatively higher than men. 77.1% of all participants were obese according to BMI, 92.5% were obese according to body fat percentage, and 96.2% were centrally obese according to WC. Among people aged 45-64 years, prevalence of obesity increased and then decreased in ages 65-74 years. Age was significantly correlated with WC and the SPPB score was indirectly correlated with age ($p<0.05$). **Conclusion:** Obesity in older Mongolian adults is comparatively higher for women and tends to increase with age.

Keywords: Obesity, Aging, Body Composition

Introduction

As the lifestyle of Mongolians has changed, the prevalence of overweight and obesity has steadily increased, rising from 17.3% in 1993 to a staggering 54.5% in 2013 [1]. Obesity is a major risk factor for non-communicable diseases (NCDs) such as cardiovascular diseases (CVD) and diabetes, and CVDs are the leading cause of population morbidity and mortality, accountable for every third death in 2010 [2-4].

In 1950, no diabetes cases were reported in Mongolia. Since 1990, socioeconomic changes and westernization have dramatically increased the prevalence of diabetes, which has led to an explosion of diabetes in Mongolia. The first national survey on the prevalence of diabetes was conducted in 1999, showing the prevalence of diabetes to be 3.1%, but now is 6.9%. In Mongolia, 90% of diabetes is caused by unhealthy lifestyle and obesity [5-6]. Additionally, many studies have shown that the prevalence of overweight and obesity tends to increase with age, and an increase in body mass index (BMI) leads to the risk of many diseases and disability in people over the age of 60 [7-9].

The age composition of the population has been rapidly changing in Mongolia. The proportion of people aged 50+ is expected to increase from 10.3% in 2000 to 24. 4% in 2030 [10]. The population has increased from 2.461 million in 2000 to 3 million in 2015 and is expected to grow to 3.403 million by 2030, which is an increase of 38%. The life expectancy at birth has increased from 64 years in 2000 to 73 years in 2030. For males, it has increased from 61 to 69 years, and for females, it has increased from 67 to 78 years [4, 10].

As a result, there is a high probability of the prevalence of age and obesity-related diseases in Mongolia. Assessing body composition is important to further evaluate the risk of many diseases. In adults, being overweight or having high fat mass is associated with a higher mortality risk, and age-related loss of human skeletal muscle mass (sarcopenia) accelerates the aging process and affects the development of many diseases such as osteoporosis and rheumatoid disorders. A review article of age-related changes in total and regional fat distribution concluded that aging is associated with an increase in adiposity and redistribution of body fat, often to ectopic depots. Redistribution of fat from lower body subcutaneous fat to the abdominal or visceral regions are often reported in the elderly and can occur independently of changes in total adiposity, body weight, or waist circumference (WC) [11-13]. There has been no study to develop a reference related to age in Mongolia.

There are various methods to measure body composition and define obesity, the most widely used being BMI and WC measurements. Nowadays, researchers also use the fat-free mass index (FFMI) and waist-to-height ratio (WHtR) to determine the risk of NCDs [11, 14-15].

This is because risk assessment is measured by comparing only WC and body fat percent with the average person's reference. WC is advised to be lower than 90 cm in men (Asia) [16], but every individual's height is not comparably the same. In other words, each individual's WC is relatively different depending on his or her height. Therefore, to evaluate the risk of NCDs, it is convenient to use a body measurement method based on height. The height-based FFMI is considerably different, and risk is not relatively the same [11, 15-16]. Thus, in this study, we used several methods for assessing body composition such as FFMI, skeletal mass index (SMI), WC, WHtR, and body fat percent. The FFMI and SMI can also identify sarcopenia.

In Mongolia, where the aging population is rapidly increasing, there is no study to determine the mean values of body composition and other anthropometric measurements in older adults. The purpose of this study was to investigate characteristics of body composition and anthropometric measurements in older Mongolian adults. The specific objectives of this study were first to evaluate body composition in older Mongolian adults and second to study the dependency of body composition characteristics on age and gender.

Materials and Methods

This was a month-long cross-sectional study consisting of a total of 266 individuals, aged 45 years and older, who visited national hospitals in Ulaanbaatar, Mongolia (National Gerontology Center of Mongolia and First State Hospital of Mongolia). We classified 3 groups of age: 45-54, 55-64 and 65-74 as per the approach of the World Health Organization's STEP wise Approach to Surveillance (WHO STEPS) survey [17].

The inclusion criteria were that patients should be 45-74 years of age and have no major organ diseases. From this population, patients with diabetes, COPD, hypothyroidism, recent fractures, cognitive impairments, or muscle-degenerative diseases, such as Parkinson' disease, were excluded. The inclusion and exclusion criteria were based on reviews of medical history and records of participants.

We took anthropometric measurements such as weight, height, body fat, body composition, WC, upper arm, forearm, and thigh, and calf circumference to calculate the BMI, FFMI, SMI and WHtR. For physical performance, Short Physical Performance Battery (SPPB) was used. For risk assessment, we used the WHO STEP survey methods [17]. This study was approved by the Ethics Committee of the Health Sciences University of Mongolia (2012/12A) and written informed consent was obtained from all participants.

1. Weight and BMI

Body weight was measured with electronic scales and body height was measured using Somatometre-Stanley 04-116 device, which has the capacity to measure height in centimeters up to 2 meters with precision of a millimeter. Then, we calculated the BMI using the body weight and height, as BMI is defined as the body weight divided by the square of the body height. BMI is universally expressed in units of kg/m^2, resulting from weight measurement in kilograms and height measurement in meters. According to the WHO criteria, BMI ranges under 18.5 are underweight, 18.5 to 25 are normal weight, 25 to 30 are overweight, and over 30 are obese [18].

2. WC and WHtR

WC, upper arm, forearm, thigh, and calf circumference were measured with a tape measure. WC ranges are normal for lower 90 cm in men and 80 cm in women, and centrally obese for over 90 cm for men and 80 cm for women [16]. The WHtR is defined as the person's WC divided by the person's height. For people under 40, the critical value is 0.5, for people aged 40–50 the critical value is between 0.5 and 0.6, and for people over 50 the critical values start at 0.6 [15, 19].

3. Body fat and body composition

Body fat and body composition were measured by Bio-Impedance Analyzer (BIA) GS6.5. BIA also provides body water, protein, minerals, fat-free mass, and skeletal muscle mass, which are the components of the human body closely related to the health assessment status. The device measures body fat percent relative to the person's age, gender, weight and height. The reference values in Table 1 were used for comparative assessment of mean body fat [18].

Table 1. Body fat risk category

Gender	Body fat percentage (%)			
	Low	Normal	High	Very high
Male	<10.0	10.0-19.9	20.0-24.9	25
Female	<20.0	20.0-29.9	30.0-34.9	35≤

4. SMI and FFMI

The SMI was calculated as the muscle mass in kilograms divided by the square of the height, and FFMI is defined as the fat-free mass divided by the square of the body height in meters (kg/m^2) [14].

5. Short Physical Performance Battery

We used SPPB in order to test physical performance. This was recently recommended by the International Working Group as a standard measure of physical performance in frail elderly people [20]. Thus, the SPPB can be used both for research and clinical practice. The SPPB evaluates gait speed, balance, and chair stand. Gait speed was assessed by the walking test in which participants in the standing position were asked to walk three meters, turn around, and walk back those three meters as quickly as possible. For the chair-stand test, respondents were asked to fold their arms across their chest, stand up from a sitting position, and repeat five times as quickly as possible. To test the ability to maintain balance, the participants were asked to put the heel of one foot in front of the other and to stand still as long as possible.

Those individuals who could not complete a task were assigned a score of 0, and those who completed the tasks were assigned scores of 0–4, corresponding to the quartiles of time required to complete the task, where the best time received a score of 4. For the balance task, a score of 0 was assigned to those who were unable to perform the test, and a score of 1 was assigned to those who tried but were unable to maintain the tandem stand for >1 s. A score of 2 was assigned for those able to maintain a tandem stand for >1 s but <3 s, a score of 3 for those able to stand for 3–9 s, and a score of 4 for those who maintained the tandem stand for >10 s. The performance total score was calculated by summing the scores and could range from 0 to 12, with 0 as the worst score and 12 as the best [20].

6. Statistical analysis

Data analysis was performed using SPSS version 20.1. Outcome measures (prevalence and mean variance) and differences between groups (age, gender and BMI groups) were calculated with 95 percent confidence intervals (95% CI) and Student's-t-test and two-way-ANOVA test (p-value). A p-value of less than 0.05 was judged to be statistically significant. We analyzed correlation between age and other factors using Pearson correlation coefficient.

Results

In this study, all data was collected from people aged 45 years and older. 26.3% were male, 73.7% were female, and the mean age was 58.1±8.9. In total, 35.7% of participants were 45-54 years of age, 38% were 55-64 years, and 26.3% were 65-74 years. Table 2 shows the general characteristics of body composition and some anthropometric measurements of Mongolians aged 45 years and older.

Table 2. General characteristics of study participants

Parameter	Male		Female		p-value
	Mean ± SD	95% CI	Mean ± SD	95% CI	
Age (years)	57.1±9.6	45-74	58.4±8.7	45-74	0.453
Weight (kg)	72.31±14.5	52.5-102.4	69.05±11.3	42.2-102.8	0.013
Height (cm)	163±10.1	140-177	155±10.1	140-176	0.430
BMI (kg/m^2)	27.8±4.5	21-43.1	28.1±4.3	18.6-39.9	0.749
WC (cm)	92.89±13.2	61-137	92.4±13.3	58-138	0.173
Upper arm circumference (cm)	29.54±3.7	22-36	31.13±4.6	23-47	0.396
Forearm circumference (cm)	24.48±2.4	18-28	24.64±3.8	17-39	0.051

1. Body weight and height and BMI

There were no statistically significant differences in mean body height and BMI between genders (Table 2). Table 3 shows that anthropometric and body composition characteristics of Mongolian older adults according to age group. In both genders, mean BMI had a tendency to increase from 45-54 year-olds to 55-64 year-olds. Analysis by a two-way ANOVA (with age and gender interaction) shows that gender does have a significant effect on BMI ($p=0.039$, $r=0.46$) and age had no significant effect on BMI ($p>0.05$).

Table 3. Anthropometric and body composition characteristics of Mongolian older adults in age groups (Mean±SD)

Findings	Male				Female			
	45-54 years	55-64 years	65-74 years	p-value	45-54 years	55-64 years	65-74 years	p-value
Weight (kg)	72.1±12.3	72.6±10.5	71.9±11.5	0.218	67.1±12.1	66.8±11.5	66.5±9.8	0.176
BMI (kg/m^2)	26.1±3.7	27.3±4.2	26.8±3.1	0.087	27.5±4.5	29.1±3.9	28.3±3.7	0.053
WC (cm)	88.6±11.9	91.5±9.8	92.1±11.1	0.037	92.1±11.8	96.8±12.2	97.8±13.1	0.029
Body fat (%)	25.8±7.6	27.7±8.8	25.9±7.9	0.349	34.1±8.2	36.1±9.2	32.8±7.3	0.381
SMI (kg/m^2)	11.01±1.8	10.9±1.2	10.47±0.9	0.051	10.1±0.7	9.4±0.9	9.1±1.0	0.041
FFMI (kg/m^2)	21.9±1.9	21.36±1.6	20.9±1.8	0.067	20.96±1.3	20.6±1.5	20.3±1.6	0.055

2. WC and other circumferences

Mean WC had a tendency to increase with age (Figure 1), which was statistically significant ($p<0.05$). Other measurements of forearm, thigh, and calf decreased with age ($p<0.05$).

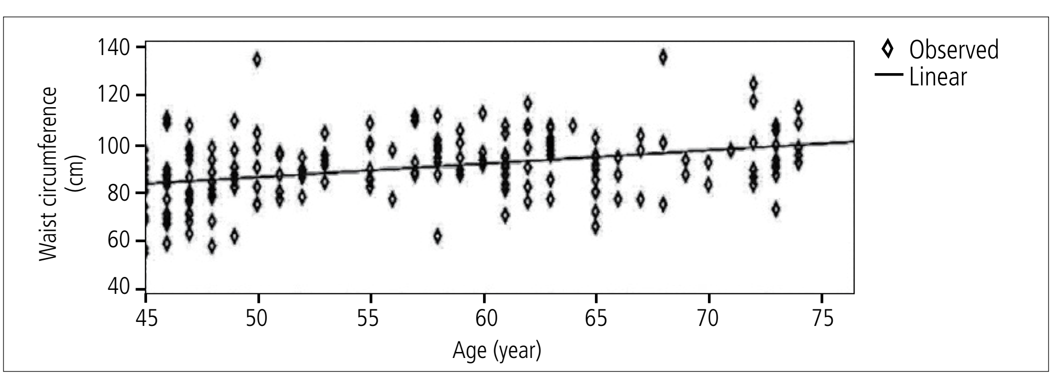

Figure 1. Increasing trend of WC with age.

3. Body fat percent and body composition

Both genders and all age groups had mean body fat percentage above reference values, meaning they were obese (Table 3). There was a significant difference in mean body fat percent (Table 2) between genders ($p<0.05$). Also, there was a statistically significant tendency for increasing body fat between 45 and 64 years of age ($p<0.05$). However, mean body fat percentage in 65-74 year-olds decreased in both genders (Figure 2).

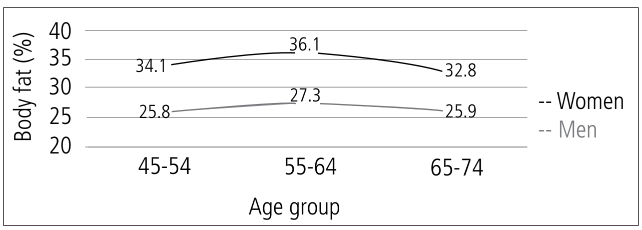

Figure 2. Mean body fat percent of age groups by gender.

Body composition can be divided to 2 compartments: fat mass and fat-free mass. Fat-free mass can be evaluated by the FFMI and SMI. Analysis of data on body composition showed, in both genders, a mean FFMI and SMI increase with increasing body fat percentage (Figure 3). This was statistically significant ($p<0.05$).

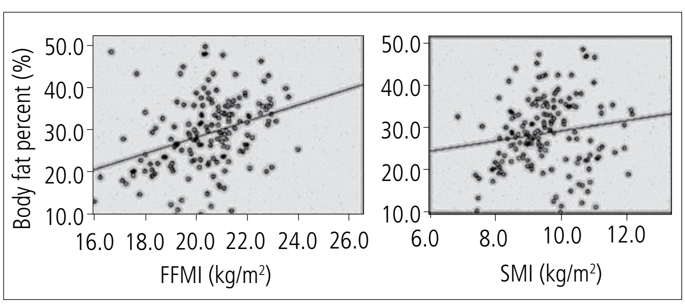

Figure 3. Correlation between body fat percent and FFMI and SMI.

We estimated that the FFMI reference values (5th-95th percentile and BMI between 18.5-24.9kg/m2) of the 45-74 years group were 18.5-21.3 kg/m2 in men and 15.7-17.9 kg/m2 in women and the difference was statistically significant ($p<0.05$).

4. Short Physical Performance Battery

Figure 4 shows correlation in SPPB with age and there was a SPPB score decrease with age, a trend that was statistically significant ($p<0.05$). Mean SPPB scores were 10.9 and 6.9 for 45-54 year-olds and 65-74 year-olds, respectively. Comparing SPPB scores, male participants (8.2±2.2) had lower scores than females (8.4±2.2), though this was not statistically significant ($p>0.05$). SPPB score indirectly correlated with some anthropometric measurements (BMI, body fat and FFMI), but the correlation with SMI ($r=-0.201$) was the only statistically significant finding ($p<0.05$).

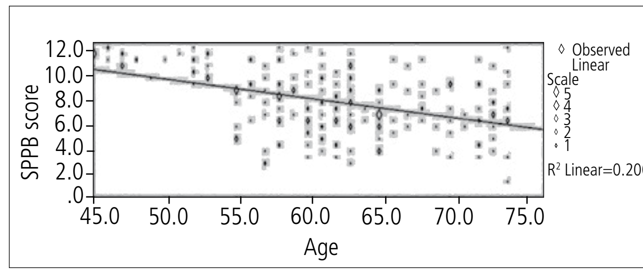

Figure 4. Correlation in SPPB with age.

5. Overweight and obesity

According to the definition of obesity, 77.1% of all participants were overweight and obese according to BMI, 92.5% were obese according to total fat mass, and 96.2% had a centrally-obese WC. Obesity in women was comparatively higher than men (Figure 5), and this was statistically significant by WC risk category and body fat percentage classification ($p<0.05$).

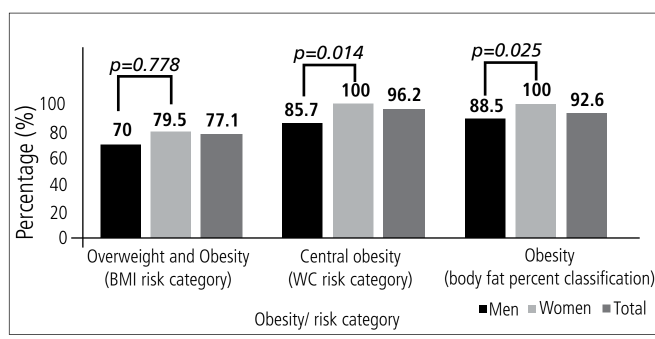

Figure 5. Prevalence of obesity by the risk categories of BMI, WC and body fat percent.

Table 4 shows the percentage of all participants who had a BMI that was underweight, normal weight, overweight, or obese divided by age group. The number of people who have normal weight sharply dropped in 55-64 year-olds and the number of obese people dropped in 65-74 year-olds.

Table 4. BMI risk categories by age groups

BMI classification	45-54 years	55-64 years	65-74 years
Underweight (BMI <18.4)	3.2%	1.0%	0%
Normal weight (BMI 18.5-24.9)	23.2%	16.2%	26.1%
Overweight (BMI 25.0-29.9)	46.3%	39.4%	40.6%
Obese (BMI >30.0)	27.4%	43.4%	33.3%

6. Effect of aging

Table 5 shows correlations between age and anthropometric measurements. There was a statistically-significant direct correlation of WC with age ($p<0.05$), and a statistically-significant indirect correlation of SPPB score with age ($p<0.05$).

Table 5. Correlation between age and anthropometric measurements

Factors	Pearson correlation coefficient	p-value
Weight (kg)	-0.040	0.597
BMI (kg/m^2)	0.126	0.061
WC (cm)	0.374	0.041
Body fat (%)	0.040	0.601
SMI (kg/m^2)	-0.015	0.842
FFMI (kg/m^2)	0.013	0.860
WHtR (kg/m)	-0.023	0.769
SPPB score	-0.179	0.018

Discussion

The results of our study show the high prevalence of obesity in older Mongolian adults. However, many studies have concluded that some anthropometric and body composition measurements used to determine obesity and assess risk of NCD's could be considerably different depending on age, gender and nationality [13, 21-22]. Thus, normal range of body composition and some anthropometric references needs to be determined for Mongolians.

The Regional Office for Western Pacific Region of WHO (WPRO), the International Association for the Study of Obesity, and the International Obesity Task Force also proposed a separate classification of obesity for Asia in 2000. This led to the proposal that adult overweight be specified in Asia as a BMI>23.0, and that obesity be specified as a BMI>25.0 (WPRO criteria) [18]. However, the WPRO criteria were not used in Mongolia due to results of several studies. One study showed differences in anthropometric and metabolic characteristics of overweight Japanese and Mongolians.

The Mongolian group had a higher prevalence of obesity and a higher level of abdominal fat, but a lesser gradation of dyslipidemia than the BMI-matched Japanese. Despite a proposal for the WPRO criteria, which take into account the differences in body composition between Caucasians and Asians, a universal Asian BMI cutoff point is inappropriate for comparisons of obesity characteristics among Asian ethnic groups, and thus WHO criteria are more appropriate for Mongolians. Another study showed that the phenotype of diabetes in Mongolians is different from other Asians, being more similar to Americans (obesity and insulin resistance) [5, 23].

In fact, there has been no study to determine a reference for WC and body fat percentage in Mongolia. For WC, we followed the guideline of International Diabetes Federation, which recommends the Asian cutoff point for WC as lower than 90 cm for men and 80 cm for women [16]. Our study shows that there should be different cutoffs for WC and body fat percentage. According to the risk categories of WC and body fat percentage, over 90% of all participants are obese, even though 22.9% have a normal BMI. Prevalence of obesity rose according to WC and body fat, which was related to aging, but according to BMI, there was a decrease in prevalence of age-related obesity. Therefore, further study must be done to determine which method of assessing obesity is sufficient for evaluating the risk of NCDs. In addition, further studies must determine specific references for Mongolians.

Many studies show age-specific differences in body composition and some anthropometric measurements. For example, a Swedish study found differences in BMI in certain circumference measurements according to age for a general elderly population [22]. According to our results, references for body composition should be tailored for each age group. We observed that many indicators were statistically significantly different among the age groups. Several methods to detect obesity showed prevalence of obesity increased with increasing ages of 45-64 years, but it then decreased in ages 65-74 years. There was a significant difference in the mean BMI and body fat percent between age groups. Also, comparison of mean WC between age groups showed it was significantly higher in 55-64 year-olds. According to the Pearson correlation, there were direct correlations of BMI and WC with age. The WHO recommends different reference of body fat percent for each age group [24]. Thus, further study is needed for the classification of body fat percent per age groups that is suitable for Mongolians.

Measuring FFMI and SMI are simple methods used to identify sarcopenia [25]. Our results showed a high possibility of the prevalence of age-related loss of human skeletal muscle mass and sarcopenia in Mongolia. Reference values of FFMI estimated for Mongolians (5th-95th percentile of BMI between 18.5-24.9 kg/m2) were relatively higher than values for other countries. Korean researchers defined that FFMI reference values are 16.3-22.3 kg/m2 for men and 13.3-17.8 kg/m2 for women [26]. For Austrians, FFMI is 18.1-21.7 kg/m2 and 15.1-17.0 kg/m2 in men and women, respectively [27]. Many studies have shown that as body fat increases, FFMI and SMI decrease; however, we found that as the mean FFMI and SMI increases, the body fat percent and BMI also increase in both genders. This could be associated specifically with the Mongolian body composition. Therefore a body composition reference for Mongolians is required.

Many studies show the importance of indicating age-related characteristics of body composition. Mezuk et al. concluded that depression is associated with significantly lower lean mass among older women [28]. Sergi et al. confirms that low BMI is an independent predictive factor of short-term mortality in elderly Italian people [29]. Our study is valuable for further research that would identify the reference values of anthropometric measurements and body composition tailored for Mongolians and evaluate risks for Mongolians using age-related body composition and anthropometric measurements. The practical value is our study included various methods of anthropometric measurement and FFMI, SMI and SPPB score which are new methods in our clinical practice.

However, there are several limitations in our study. This study is cross-sectional and study participant numbers are limited, especially the small number of male participants. We analyzed body composition by the BIA method. In fact, it is a widely-used method for estimating body composition, but researchers mainly recommend that dual energy X-ray absorptiometry (DXA) method to analyze fat-free mass. Further research needs are to establish references of anthropometric measurements and the best and most predictive measurements of obesity and its related diseases for Mongolians.

Conflict of Interest

The authors state no conflict of interest.

Acknowledgements

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