Original Article
EPIDEMIOLOGY/GENETICS

Obesity

Trends in Adult Overweight and Obesity Prevalence in Mongolia, 2005-2013

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Objective: To analyze trends in the prevalence of overweight and obesity among Mongolian adults during the past decade as measured by body mass index (BMI) and waist circumference (WC).

Methods: Data from the repeated cross-sectional surveys on the prevalence of noncommunicable disease risk factors conducted in 2005, 2009, and 2013 in Mongolia were used. Linear regression was used to quantify trends in mean BMI and WC, adjusted for age group, sex, and survey year.

Results: The age-standardized prevalence of obesity, denoted by the international BMI cutoff values, in men and women between 2005 and 2013 increased from 10.8% to 17.6% and from 18.9% to 26.4%, respectively. Using Asian-specific BMI cutoff values for men and women, the age-standardized prevalence of obesity between 2005 and 2013 increased from 20.0% to 32.8% and 33.4% to 43.7%, respectively.

Conclusions: The prevalence of overweight and obesity has increased markedly between 2005 and 2013 similarly across all age groups and sexes. It is important to consider the use of Asian-specific cutoffs as the burden of obesity is twice as high as when using international BMI cutoffs. These data demonstrate the urgent need for obesity treatment, prevention, and monitoring in Mongolia.

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Introduction

The prevalence of obesity has increased rapidly in a number of low- and middle-income countries in recent years (1-3), but trends have not been described for Mongolia. For thousands of years, Mongolians have adopted a nomadic way of life, moving several times a year in search of the best pastures for their livestock. This nomadic lifestyle is highly physically active, involving caring for livestock, riding across vast territories, milking, shearing, and combing. This unique lifestyle was associated with low population body mass index (BMI) in Mongolians. However, the Mongolian nomadic population has recently been in decline with people moving to cities and adopting Western lifestyles, including increased car use and consumption of high-fat foods and sugary drinks (4,5). This has resulted in a remarkable transition characterized by irregular physical activity levels along with ongoing consumption of traditional fatty meat and animal fat as well as a Western diet. However, the consequences of this transition have not been systematically assessed.

BMI and waist circumference (WC) have become the fundamental population-level anthropometric markers used to assess excess body fat (6) and hence are widely used in clinical and public health settings to predict obesity-related health outcomes (7,8). There is a high proportion of Asian people with a high risk of diabetes, and cardiovascular disease is evident at lower BMI cutoff values than those recommended by the World Health Organization (WHO) (1,9,10). However, as a number of different BMI cutoff values have been proposed for different Asian populations (2), in 2002, the WHO recommended preserving the current BMI cutoff values as the international benchmark in addition to supplementary cutoff values for Asian and other populations (11).

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Author contributions: OC and AP conceptualized and designed the study. OC commenced the study, analyzed the data, interpreted results, and wrote the manuscript. EG, WLN, and BB were involved in the statistical data management, data analysis, and review of the manuscript. CS advised the statistical analysis of the data and its interpretation. AP critically reviewed the manuscript and contributed to the interpretation of results. All authors saw and approved the final manuscript.

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TABLE 1 Characteristics of survey participants with and without missing data in 2005, 2009, and 2013

	2005		2009		2013	
	Missing	None missing	Missing	None missing	Missing	None missing
Final sample size	26	3102	125	5039	150	5119
Age (mean ± SD)	34 ± 12.3	40.9 ± 13.0	31.6 ± 8.8	38.3 ± 11.4	31.1 ± 9.3	37.3 ± 11.9
Sex (% male)	46.1	48.5	17.2	41.2	14.8	45.2
Education (% tertiary)	19.2	20.4	28.7	23.9	39.6	29.2
Employment (% employed)	38.5	56.7	57.4	60.3	58.4	65.1
Geographic location (% urban)	69.2	50.5	62.3	52.9	40.3	49.0

SD, standard deviation.

It has been increasingly understood that measures that directly measure abdominal obesity such as WC may be more accurate predictors of the metabolic risks of obesity compared with BMI (8,12). The Decoda Study Group led by Nyamdorj in 2008 found that waist measures were more closely associated with diabetes than BMI, but both central and general measures were equally strongly associated with hypertension in Asians (13).

Without a detailed analysis of obesity trends in Mongolia, nor any analysis of the impact of using different obesity measures and cutoff values, the evidence for public health policy is limited. This study examines trends in the prevalence of overweight and obesity between 2005 and 2013 among Mongolian men and women according to international and Asian-specific BMI and WC cutoff values.

Methods

Data sources

Data were analyzed from the Mongolian surveys on the prevalence of noncommunicable disease (NCD) risk factors (STEPS) conducted in 2005, 2009, and 2013 (14). The Mongolian STEPS surveys were a nationwide cross-sectional, nationally representative series of surveys using the WHO NCD STEPwise approach to chronic disease risk factor surveillance methodology with behavioral, anthropometric, and biomedical measurements (15). The series of surveys aimed to determine the prevalence of common risk factors for developing NCDs in Mongolia over time.

Study population and sample size

The STEPS surveys were designed to cover all geographical areas of Mongolia targeting people aged between 15 and 64 years, and each sample was stratified into urban and rural areas and selected using a four-stage cluster sampling process (14).

Response rates in the respective surveys were 94.7% in 2005, 95.0% in 2009, and 97.4% in 2013. We excluded participants who were under age 18 years, as well as a small number of participants who had missing values for measured height, weight, and WC (26 in 2005; 125 in 2009; 150 in 2013) and, therefore, our analysis included 3,102 participants in 2005, 5,039 in 2009, and 5,119 in 2013, respectively. In descriptive analyses we compared the demographic characteristics of those with and without missing data (Table 1).

Outcomes

BMI (kg/m^2) and WC (cm) were our primary outcome variables. They were based on interviewer-measured height (using a stadiometer, to 0.1 cm), weight (using digital scales, to 0.1 kg), and WC (using metal tape measure, to 0.1 cm) (16). For BMI we used both the international (normal weight: 18.5-24.9 kg/m^2, overweight: 25.0-29.9 kg/m^2, obesity: 30.0 kg/m^2 and over) (11) and Asian-specific (normal weight: 18.5-22.9 kg/m^2, overweight: 23.0-27.4 kg/m^2, obesity 27.5 kg/m^2 and over) cutoff values (11) to classify levels of adiposity. While BMI cutoff values have been proposed for specific Asian ethnic groups, such as Chinese (17,18), Thai (19), or Koreans (20), because such guidelines have not been created for Mongolians, we utilized the general Asian-specific cutoffs recommended by the WHO (11).

For WC we used the international (low risk: $<$94 cm in men, $<$80 cm in women; increased risk: $\geq$94 and $<$102 cm in men, $\geq$80 and $<$88 cm in women; substantially increased risk: $\geq$102 cm in men, $\geq$88 cm in women (7)) cutoff values to classify individuals. Having a substantially increased risk according to WC cutoff values was considered to be synonymous with obesity.

Covariates

We investigated the association between age, sex, and survey year and the primary outcomes of interest (BMI and WC). Survey year was treated as categorical, according to the three survey years 2005, 2009, 2013. Age was treated as categorical (10-year age categories: 18-24, 25-34, 35-44, 45-54, and 55-64) for all analyses.

Statistical analysis of the data

All analyses were performed using the statistical software, Stata® 12.0 version (StataCorp LP, College Station, TX). Summary statistics were calculated based on unweighted data to describe the characteristics of the survey participants. The distributions of BMI and WC at each time points were presented and compared using kernel density plots. The kernel density plot provides a smoothed estimate of the observed distribution of a variable (21). The Stata® svy procedures were used to adjust for the sample stratification and clustering effect in all further analyses and to apply survey weights to individual responses in the sample so as to reflect the age, sex, and geographical distribution of the Mongolian population at the time of each survey. Descriptive analyses included age-standardized mean

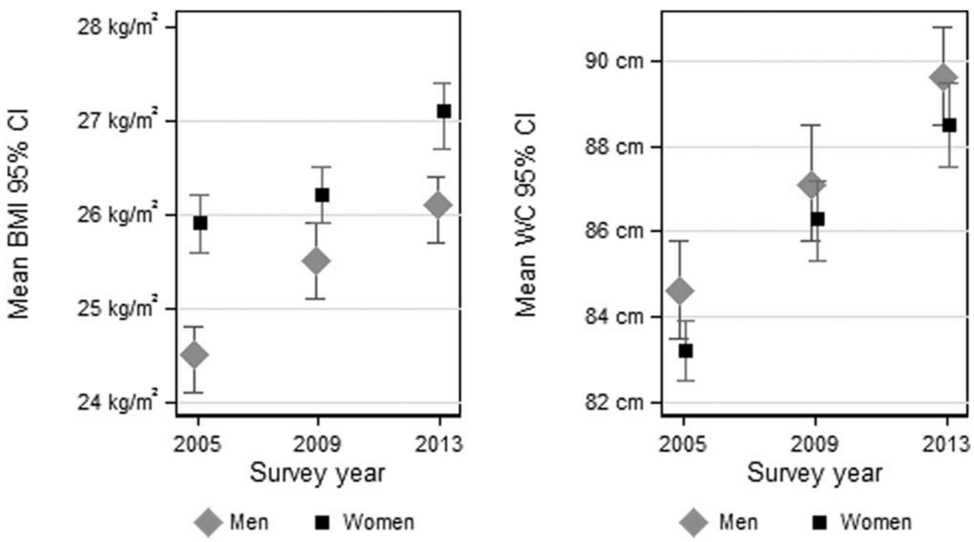

Figure 1 Age-standardized mean BMI and WC in the total sample of Mongolian adults aged 18 to 64 years by sex, 2005, 2009, and 2013.

BMI and WC within each survey year, calculated for the total sample and stratified by age group and sex.

The prevalence of each BMI and WC risk category was calculated within each survey year, both overall (age standardized) and stratified by age group and sex, using the international and Asian-specific BMI and WC cutoff values detailed above. Age standardization was performed using the direct method (22) to eliminate the effect of differences in population age structures when comparing prevalence estimates across different periods of time and different geographic areas. Linear regression was used to investigate the association between each of BMI and WC, and survey year. Linear regression analyses were adjusted for both age group and sex. An interaction term was added to the model to assess whether the association between BMI and WC and survey year differed according to either age group or sex and we retain those interaction terms where the overall F-test P value was less than 0.05.

Ethics approval

Ethics approval to conduct this study was obtained from the Human Research Ethics Committee, Monash University on April 1 2015 (CF15/1017—2015000474). The National Centre for Public Health of Mongolia, the Ministry of Health of Mongolia, and the WHO Regional Office for the Western Pacific provided ethical approval for the STEPS study.

Results

Demographic data (unweighted) for the study participants at each of the surveys are summarized in Table 1. There were differences across the surveys in the distribution of anthropometric and demographic data. The mean age was comparable across survey years. The proportion of male participants accounted for less than 50% throughout survey years. The proportion of tertiary educated and employed participants increased at each survey. In 2013, around one third and two thirds of the sample were tertiary educated and employed, respectively. Approximately half of the participants in each survey resided in urban areas of Mongolia. Those with missing data ($n = 301$) were relatively younger, predominantly female, more tertiary educated, slightly less employed, and more urban living individuals compared with those without missing data.

Mean BMI and WC of Mongolian adults increased across 2005 to 2009 to 2013 for all age groups and sexes (Figure 1). The age-standardized overall mean BMI increased by 1.4 kg/m^2, from 25.2 kg/m^2 (95% CI: 24.9 to 25.4) in 2005 to 26.6 kg/m^2 (95% CI: 26.3 to 26.8) in 2013. Similarly, the age-standardized mean WC increased by 5.2 cm, from 83.9 cm (95% CI: 83.3 to 84.6) in 2005 to 89.1 cm (95% CI: 88.2 to 89.9) in 2013. Across all time points, age-standardized mean BMI was higher for women than men. In 2013 the age-standardized mean BMI in women was 27.1 kg/m^2 (95% CI: 26.7 to 27.4) whilst in men it was 26.1 kg/m^2 (95% CI: 25.7 to 26.4). In contrast, the age-standardized mean WC was higher for men than women. In 2013 the age-standardized mean WC in men was 89.6 cm (95% CI: 88.5 to 90.8) whilst in women it was 88.5 cm (95% CI: 87.5 to 89.5).

We examined changes in the shape of the BMI (Figure 2A) and WC (Figure 2B) distribution in Mongolian adults between 2005, 2009, and 2013. The BMI and WC distribution curves appear to be shifting to the right and increasing in their skewness over time possibly suggesting a gradual increase in both the population-level mean BMI and WC over time and the proportion of people with high levels of BMI and WC.

Table 2 shows the parameter estimates from the linear regression models for BMI and WC. On average, BMI was higher in 2013 than in 2005, in older age groups than younger age groups and in women than men. For the BMI regression model we found evidence of an interaction between sex and survey year ($F_{(2,75)} = 5.02$, $P = 0.009$)

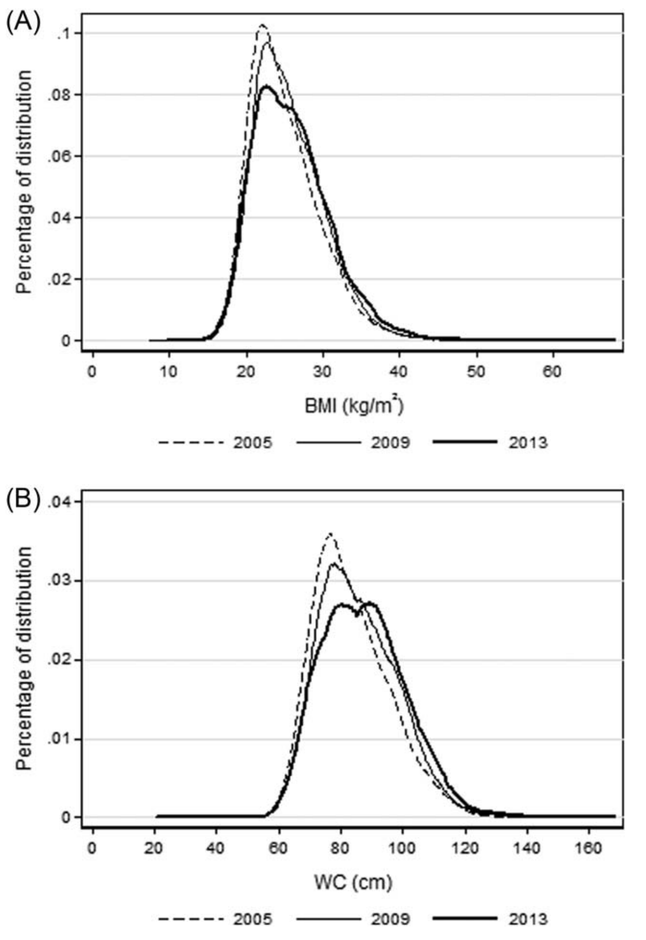

Figure 2 (**A**) Kernel density plot of the distribution of BMI for Mongolian adults aged 18 to 64 years, 2005, 2009, and 2013. (**B**) Kernel density plot of the distribution of WC for Mongolian adults aged 18 to 64 years, 2005, 2009, and 2013.

and no evidence of an interaction between age group and survey year ($F_{(8,69)} = 0.68$, $P = 0.711$). Between 2005 and 2009 mean BMI increased by an estimated 1.17 kg/m^2 (95% CI: 0.70 to 1.64) for men and 0.30 kg/m^2 (95% CI: −0.10 to 0.70) for women. Between 2009 and 2013 mean BMI increased by an estimated 0.24 kg/m^2 (95% CI: −0.23 to 0.71) for men and 0.94 kg/m^2 (95% CI: 0.52 to 1.37) for women.

On average, WC was higher in 2013 than 2005, in older age groups than younger age groups, and in men than women. For the WC regression model there was no evidence of an interaction between sex and survey year ($F_{(2,75)} = 0.05$, $P = 0.948$) or between age and survey year ($F_{(8,69)} = 1.03$, $P = 0.424$). Between 2005 and 2009 mean WC increased by 2.92 cm (95% CI: 1.39 to 4.44), whilst between 2009 and 2013 mean WC increased by 2.10 cm (95% CI: 0.39 to 3.81). Women had an estimated mean WC which was 1.42 cm less (95% CI: −2.70 to −0.15) than that of men at all survey points.

The prevalence of individuals with overweight and obesity increased across the three survey years, for both men and women and across all age groups (Table 3). According to international BMI cutoffs, the age-standardized prevalence of overweight in men and women, respectively, increased from 26.1% and 33.4% in 2005 to 35.7% and 36.9% in 2013. Similarly, the age-standardized prevalence of obesity in men and women increased from 10.8% and 18.9% in 2005 to 17.6% and 26.4% in 2013 for men and women, respectively.

The prevalence estimates for men and women differed depending on whether international or Asian-specific guidelines were used (Figure 3). Across both sexes and all survey years, the age-standardized prevalence of obesity using the Asian-specific guidelines was 1.5 to 2 times greater than prevalence estimates based on the international guidelines. The age-standardized prevalence of substantially increased risk based on WC categories in men (9.5% in 2005 to 17.7% in 2013) and women (31.2% in 2005 to 50.6% in 2013) almost doubled between 2005 and 2013.

Discussion

This is the first study to examine trends in BMI and WC in Mongolia. A large increase was observed in mean BMI and WC, hand in hand with an increase in the prevalence of overweight and obesity among Mongolian adults between 2005 and 2013. These trends were consistent across all age groups and sexes.

TABLE 2 Estimated coefficients from the linear regression models for BMI and WC

	Estimate (95% CI)
BMI regression model	
Survey year (ref: 2005)	
2009	1.17 (0.70 to 1.64)
2013	1.41 (0.92 to 1.91)
Sex by survey year (ref: men by 2005)	
Women by 2009	−0.87 (−1.45 to −0.29)
Women by 2013	−0.17 (−0.74 to 0.41)
Age group (ref: 18-24)	
25-34	2.13 (1.83 to 2.42)
35-44	3.53 (3.23 to 3.84)
45-54	4.32 (3.98 to 4.67)
55-64	4.34 (3.95 to 4.72)
Sex (ref: men)	
Women	1.25 (0.83 to 1.67)
WC regression model	
Survey year (ref: 2005)	
2009	2.92 (1.39 to 4.44)
2013	5.02 (3.36 to 6.68)
Age group (ref: 18-24)	
25-34	6.07 (5.38 to 6.76)
35-44	10.50 (9.73 to 11.26)
45-54	12.78 (11.95 to 13.61)
55-64	13.97 (12.92 to 15.02)
Sex (ref: men)	
Women	−1.42 (−2.70 to −0.15)

BMI, body mass index; ref, reference category; WC, waist circumference.
Estimates incorporate aspects of the complex survey design, such as sample stratification, clustering, and survey weights.

TABLE 3 Prevalence of BMI categories in 2005, 2009, and 2013, Mongolian adults, by age group and sex

	Age (years)	Males 2005	Males 2009	Males 2013	Females 2005	Females 2009	Females 2013
Underweight (<18.5 kg/m^2)	18-24	8.7 (5.1-14.2)	5.3 (2.6-10.7)	8.3 (5.8-11.7)	7.6 (4.2-13.3)	7.5 (4.2-13.0)	9.6 (5.9-15.3)
	25-34	2.5 (1.3-4.7)	1.3 (0.6-2.8)	2.0 (1.0-3.7)	2.8 (1.5-5.1)	3.9 (2.6-6.0)	3.4 (2.3-5.1)
	35-44	1.4 (0.6-3.3)	2.4 (1.2-4.8)	1.5 (0.6-3.7)	0.5 (0.1-2.2)	0.9 (0.4-2.0)	1.5 (0.7-3.4)
	45-54	2.0 (0.8-5.2)	0.8 (0.3-2.3)	1.1 (0.5-2.5)	0.6 (0.1-2.3)	0.7 (0.2-2.1)	0.7 (0.2-2.2)
	55-64	3.1 (1.7-5.4)	0.4 (0.4-2.7)	3.6 (1.6-7.8)	2.0 (0.7-5.6)	1.2 (0.3-4.2)	4.6 (1.7-11.8)
	Total	3.5 (2.6-4.7)	2.6 (1.6-4.2)	2.1 (1.6-2.9)	3.0 (2.0-4.5)	3.5 (2.3-5.2)	2.5 (1.8-3.4)
	Age-standardized	2.5 (1.8-3.5)	1.8 (1.2-2.8)	2.1 (1.6-2.9)	1.6 (1.1-2.3)	1.9 (1.4-2.7)	2.5 (1.8-3.3)
	Age-standardized Asian-specific cutoff	2.5 (1.8-3.5)	1.8 (1.2-2.8)	2.1 (1.6-2.9)	1.6 (1.1-2.3)	1.9 (1.4-2.7)	2.5 (1.8-3.3)
Normal weight (18.5-24.9 kg/m^2)	18-24	82.3 (75.4-87.7)	75.1 (68.0-81.0)	68.9 (62.0-75.0)	76.9 (71.6-81.5)	73.8 (68.2-78.8)	66.2 (60.4-71.6)
	25-34	75.4 (68.6-81.2)	58.5 (53.2-63.6)	52.8 (46.9-58.6)	58.1 (51.4-64.6)	53.1 (48.4-57.8)	49.6 (45.6-53.7)
	35-44	57.8 (51.3-63.9)	45.3 (38.9-51.8)	44.2 (39.5-48.9)	43.8 (39.0-48.8)	40.7 (37.2-44.3)	31.0 (27.4-34.8)
	45-54	52.0 (45.9-57.9)	43.2 (36.6-50.1)	36.3 (30.9-42.1)	35.9 (31.1-40.9)	31.6 (27.6-35.9)	22.1 (17.6-27.3)
	55-64	48.7 (42.2-55.2)	39.5 (29.7-50.2)	35.9 (27.7-45.0)	35.0 (29.6-40.8)	33.1 (27.2-39.6)	25.7 (20.0-32.3)
	Total	66.5 (62.3-70.5)	56.8 (52.5-60.9)	44.7 (41.2-48.1)	54.1 (51.4-56.8)	50.8 (47.9-53.7)	34.1 (31.8-36.6)
	Age-standardized	60.6 (56.0-65.1)	49.1 (45.2-53.0)	44.6 (41.3-48.0)	46.0 (43.4-48.7)	42.3 (40.1-44.5)	34.1 (31.8-36.5)
	Age-standardized Asian-specific cutoff	40.9 (37.1-44.8)	30.4 (27.1-33.9)	27.0 (24.4-29.7)	29.3 (26.6-32.2)	26.1 (24.0-28.4)	20.4 (18.6-22.4)
Overweight (25.0-29.9 kg/m^2)	18-24	7.4 (4.2-12.8)	16.9 (11.6-23.9)	17.7 (13.9-22.3)	13.2 (9.6-18.0)	14.9 (11.1-19.8)	17.7 (14.0-22.1)
	25-34	15.6 (11.2-21.4)	29.4 (25.7-33.4)	32.1 (28.2-36.3)	27.1 (22.2-32.6)	30.7 (26.6-35.2)	31.1 (27.8-34.6)
	35-44	31.4 (25.7-37.8)	35.1 (30.3-40.1)	36.0 (31.4-40.9)	35.3 (30.8-40.0)	39.6 (36.1-43.2)	43.4 (37.5-49.4)
	45-54	29.5 (24.8-34.7)	38.4 (32.6-44.6)	41.3 (35.5-47.4)	38.7 (34.5-43.0)	39.6 (35.3-44.1)	37.9 (32.3-43.9)
	55-64	34.4 (28.4-41.0)	31.0 (24.5-38.6)	37.4 (31.4-43.8)	40.1 (35.2-45.3)	36.1 (30.1-42.5)	34.2 (26.8-42.5)
	Total	21.6 (18.7-24.9)	28.5 (25.8-31.4)	35.7 (32.6-38.9)	28.5 (26.2-30.8)	30.4(28.1-32.8)	36.9 (34.3-39.7)
	Age-standardized	26.1 (22.8-29.8)	33.4 (30.9-35.9)	35.7 (32.6-38.8)	33.4 (30.9-36.1)	35.8 (33.6-38.2)	36.9 (34.3-39.7)
	Age-standardized Asian-specific cutoff	36.6 (33.5-39.8)	37.2 (34.6-39.9)	38.0 (35.7-40.4)	35.6 (32.9-38.4)	36.4 (34.0-38.8)	33.4 (30.2-36.6)
Obesity (≥30.0 kg/m^2)	18-24	1.5 (0.5-4.8)	2.7 (1.2-5.8)	5.0 (2.8-9.0)	2.2 (0.7-6.8)	3.7 (1.9-7.1)	6.4 (4.2-9.5)
	25-34	6.5 (3.7-11.2)	10.7 (7.3-15.6)	13.1 (9.8-17.4)	12.0 (8.5-16.3)	12.2 (9.4-15.7)	15.9 (13.3-18.8)
	35-44	9.4 (6.8-12.7)	17.2 (13.0-22.3)	18.2 (14.9-22.1)	20.3 (16.3-25.0)	18.8 (15.8-22.2)	24.0 (18.7-30.2)
	45-54	16.5 (12.1-19.1)	17.5 (13.2-22.8)	21.2 (16.9-26.2)	24.8 (20.8-29.3)	28.1 (23.6-33.0)	39.3 (33.1-45.8)
	55-64	13.8 (9.7-19.1)	29.0 (20.1-39.9)	23.1 (16.7-30.9)	22.9 (18.0-28.6)	29.6 (23.6-36.4)	35.5 (28.9-42.7)
	Total	8.3 (6.6-10.5)	12.1 (9.6-15.1)	17.5 (15.4-19.9)	14.4 (12.5-16.6)	15.3 (13.3-17.6)	26.4 (23.5-29.6)
	Age-standardized	10.8 (8.7-13.3)	15.7 (12.8-19.2)	17.6 (15.5-19.8)	18.9 (16.8-21.3)	20.0 (17.5-22.6)	26.4 (23.6-29.5)
	Age-standardized Asian-specific cutoff	20.0 (17.2-23.2)	30.6 (26.8-34.7)	32.8 (30.2-35.6)	33.4 (30.9-36.1)	35.5 (32.9-38.3)	43.7 (41.0-46.4)

Values given as mean (95% CI). All classifications are international cutoffs, unless otherwise specified. Estimates incorporate aspects of the complex survey design, such as sample stratification, clustering, and survey weights.

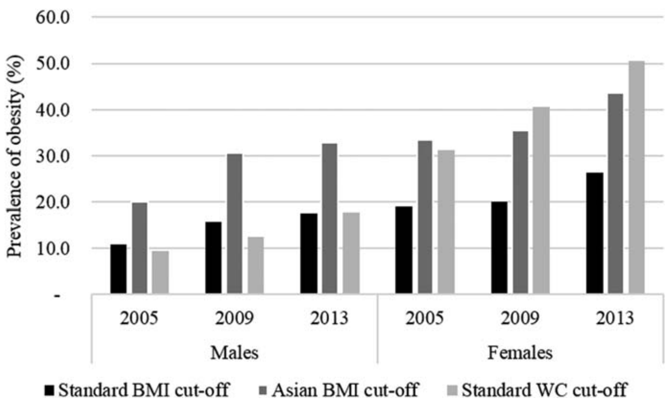

Figure 3 Age-standardized prevalence of obesity among men and women aged 18 to 64 years in 2005, 2009, and 2013 by BMI and WC. BMI, body mass index; WC, waist circumference.

The increases in BMI (1.4 kg/m^2 (95% CI: 25.2 to 26.6 kg/m^2) and WC (5.2 cm (95% CI: 83.9 cm to 89.1 cm) between 2005 and 2013 for Mongolian adults are comparable to findings from previous studies conducted in other Asian countries at a similar time. The China Health and Nutrition Survey conducted between 1993 and 2009 found that mean BMI values increased by 1.6 kg/m^2 among men and 0.8 kg/m^2 among women; and mean WC values increased by 7.0 cm among men and 4.7 cm among women (17).

However, in contrast to our study, the studies from Japan and Taiwan have found that mean BMI among women had remained stable or decreased over time (23,24). The authors speculated that gender differences in the BMI trends were associated with differences in lifestyle factors such as diet, smoking and drinking, and social norms such as individual control over eating size and personal preference regarding body image.

The substantial increases in obesity according to BMI that we observed between 2005 and 2013 were markedly higher than obesity trends observed in other Asian countries, specifically Thailand and China. In 2006 the prevalence of overweight (BMI 25-29.9 kg/m^2) and obesity (BMI $\geq$30 kg/m^2) among Thai adults was 19.0% among men and 4.9% among women (25,26). In China, in 2009, the prevalence of overweight (BMI 25.0 to 27.49 kg/m^2) was 17.1% among men and 14.4% among women and obesity (BMI 27.5 kg/m^2) was 11.4% and 10.1% among men and women, respectively (17). In contrast, the prevalence of obesity according to WC and the substantial increases that we saw in this analysis in Mongolian adults between 2005 and 2013 were similar to prevalence estimates for abdominal obesity reported for Chinese (17) and Taiwanese (24) adults. The similarities and differences in obesity prevalence estimates and trends over time between Mongolia and other Asian counterparts are likely to reflect different stages of nutrition and demographic transitions, cultural norms, and socioeconomic developments.

We observed substantial differences in the prevalence of obesity defined by the international and Asian-specific BMI cutoffs. The age-standardized prevalence of overweight men and women defined by the Asian-specific BMI cutoffs was greater than that defined by the international BMI cutoffs. Interestingly, the age-standardized prevalence of obesity in men and women across all time points defined by the Asian-specific BMI cutoffs was approximately 1.5 to 2 times that of the international BMI cutoffs. This discrepancy is similar to the findings of other studies where obesity prevalence using the Asian-specific BMI cutoffs was greater than that defined by the international BMI cutoffs (17,19,25). It was also found that the Asian-specific cutoffs for WC for the categories of "increased" and "substantially increased" risk should possibly be used to greater relevance, but these are not currently recommended internationally.

Study strengths and limitations

The major strength of our analysis is the comparability with the Mongolian STEPS surveys from which the data are sourced and results are derived. The use of consistent sampling methodology meant that a comparable sample frame was taken at all three time points. Additionally, representative sampling of participants across the entire country was reflected in the high overall response rates ranging from 95% to 98% throughout all the survey time periods. This means that trends observed were unlikely to be attributable to changing the sampling frames. Further, all three surveys used a standardized measurement of weight, height, and WC, all measured by trained personnel.

The study is limited by our inability to examine overweight and obesity trends in Mongolia before 2005, when Mongolian nationwide STEPS surveys commenced. Additionally, we had a total of 301 missing anthropometric measurements (26 in 2005, 125 in 2009, and 150 in 2013). However, we compared the samples with and without missing data. Although there were some differences in demographic characteristics between those with and without missing data, the small number of people with missing data means our results are unlikely to have been affected.

Implications

This study is the first of its kind to focus specifically on overweight and obesity in Mongolia, explicitly providing a comprehensive overview of the internationally comparable trends in data relating to body weight, according to age and sex. It also provides a detailed analysis of Asian-specific measures in addition to standard international measures. In this context, we demonstrate overwhelmingly large increases in the prevalence of obesity in Mongolian adults in recent years. These data underscore the need to understand more about what is driving this increase in the Mongolian context. Numerous economic, social, and cultural factors are likely to be linked with this emerging public health problem in Mongolia.

Since the early 2000s, Mongolia has been undergoing rapid socioeconomic changes through the shift from a centrally planned economy to a market economy (27). In the meantime, rapid urbanization has been taking place due to huge internal migration from rural to urban areas. In other settings, such as China (28) and Thailand (26), transitions of this type have been shown to be associated with increases in the prevalence of adult obesity. In Mongolia, there have also been similar shifts in the pattern, style, and portions of food consumption, which have been largely Westernized, and there is potential for these changes to be driving the increases in the prevalence of overweight and obesity. More specifically, the major contributors to this obesogenic environment are likely to be the number of new business entities, predominantly in urban settlements, and especially the introduction of fast food restaurants and new products, such as sugar sweetened beverages (SSBs), which are nonalcoholic water-based beverages with added sugar (calorically sweetened) (5,29). Numerous epidemiological studies have found significant positive associations between daily consumption of SSBs and weight gain (30,31). Interestingly, research has shown that adverse effects of SSBs on weight gain might be greater in Asians than in Caucasians (32). Mongolia today illustrates the trend for sales of SSBs to increase in most low- and middle-income countries, while the opposite is occurring in a few high-income countries.

Thus, the increased trends in overweight and obesity are likely to be mostly associated with changes in nutrition and physical activity patterns in an increasingly obesogenic environment which promotes overweight and obesity in individuals or populations. Moreover, in the past decade the Mongolians have been shifting away from agriculture into the service and motorized transportation sectors, and private vehicle ownership and technology use have become common features of daily living, reducing physical activity.

Our findings of increases in BMI, WC, and obesity in Mongolian adults between 2005 and 2013 reflect this transition in nutrition, where more processed or packaged foods and SSBs play a major role in increased energy intake. The implications of this study are that it underlines the importance of identifying the drivers for these trends and highlights the need for appropriately targeted obesity prevention and management strategies.

A long-term approach to reverse the current trends of overweight and obesity in Mongolia will require strong public health strategies to improve the environment in order to support healthy diet and physical activity behaviors and to discourage sugary drinks as part of a healthy lifestyle. Mongolia needs concerted policy actions as reflected in many international guidelines (32-34). These include taxation on SSBs and foods with added sugar, sodium, and unhealthy saturated fats, potential alternatives to SSBs, bans on unhealthy foods and SSB availability in school meals, marketing restrictions on SSBs, and guidelines on food and drink package labeling displaying the levels of sugar, salt, and fats either by traffic light or star rating symbols. Importantly, some of these policy interventions have been shown effective in countries including Hungary (35), the USA (36), the UK (34), and The Netherlands (37). Comprehensive marketing restrictions are recommended as the most effective approach by WHO to encourage healthy diets especially to children (38).

In the short term, public health interventions such as consumer educational campaigns, targeted at both the total population and high-risk individuals, may be the most affordable and feasible measure to encourage consumers to make healthier choices and warn them of the health consequences of overweight and obesity (24,33). As the nomadic lifestyle is disappearing, physical activity infrastructure is necessary to help control the rising obesity levels. Because potential causes of overweight and obesity often lie outside the health sector, it is clear that a multi-sector approach is required to address the more obvious barriers to healthy eating and increased physical activity (39,40).

Conclusion

This study provides evidence of significant increases in the prevalence of overweight and obesity for Mongolian adults between 2005 and 2013. We observed substantial differences in the prevalence of overweight and obesity as defined by the international and Asian-specific BMI cutoff points. These data demonstrate the need to prioritize obesity prevention in Mongolia. Furthermore, continued surveillance is required so that future trends in overweight and obesity status of Mongolian adults are carefully monitored. **O**

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