Correlation between SES and BMI and gender-disparity of mediation of lifestyle among Chinese people aged 45 and over

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Research article

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Abstract

Background: Previous studies suggested the relationship between SES and BMI is different in developing countries and developed countries and lifestyle is medication between SES and BMI. Little research focused on relationship between SES and BMI among the middle and the elderly and gender-disparity of mediation of lifestyle. Methods: The data for this study were obtained from the 2015 follow-up data of the China Health and Retirement Longitudinal Study (CHARLS). Structural equation model (SEM) was used to explore the relationships among SES, lifestyles and BMI. Results: Among men, the effect of SES on sleeping time and smoking were not statistically significant. SES had a direct positive effect on BMI ($b=0.306$, $P<0.001$). Smoking had a direct positive effect on BMI ($b=0.180$, $P<0.001$). Among women, SES had a direct negative effect on physical activity ($b=-0.048$, $p<0.05$), a direct positive on sleeping time ($b=0.048$, $P<0.05$), smoking ($b=0.098$, $P<0.001$) and BMI ($b=0.168$, $P<0.001$). Physical activity had a direct negative effect on BMI ($b=-0.050$, $P<0.01$). Sleeping time ($b=0.066$, $p<0.001$) and smoking ($b=0.088$, $p<0.001$) both had a direct positive effect on BMI. Conclusion: A positive relationship was found between SES and BMI both among middle and old men and women. The gender-disparity of mediation of lifestyle was existed.

Background

The global prevalence of overweight and obesity is a major threat to public health because of its steep increase in recent years[1, 2]. In 2016, 39% of adults (39% of men, 40% of women) over 18 years old were overweight, and one third (11% of all men and 15% of all women) of those were obese from The World Health Organization (WHO)[3]. In Italian, 11.3% of adults were obesity and 34.5% were overweight in 2012-2013[4]. In China, 13.4% of adults were obesity and 37.3% were overweight in 2005[5] , and the number of overweight/obesity will reach 325 million in 2022, which meant the prevalence of overweight and obesity were not only high in developed countries, but also in developing countries. The report of WHO in 2011 had confirmed that the problem of obesity was rapidly increasing in developing countries with more than 115 million people suffering from obesity related problems[6]. Excess body weight has not only been linked to health outcome, such as lower self-esteem, eating disorders, depression, psychological distress and chronic diseases, but also to the personal appearance which affected many aspects of our social lives including how we present ourselves to others, how we treat others, and how we are treated[7-9]. What's more, the excess body weight had an immense effect on individual and national healthcare budget[10].

The socioeconomic status (SES) is a major factor shaping the multiple strands of the life course, including family, work, and health trajectories. Socioeconomic status is closely related with inequality of health[11]. One study suggested that socioeconomic factors accounted 75.8% of the existing inequalities in childhood obesity[12]. Many studies in US have confirmed that higher overweight/obesity prevalence was among group of low SES[13, 14]. Most of the results were similar in developed countries[15-18]: the lower level SES, the more likely to be obese. But many researches in developing countries had the converse results. In China, adults with higher household income and education level were more likely to be overweight and obesity[19]. In Singapore, men were more likely to be obese if they had higher life course SES[20]. In poor regions of South Africa, those with higher SES are more likely to be overweight and obese[21].

Overweight and obesity were always defined using the WHO, Asian and Chinese criteria according the body mass index(BMI)[22] which meant the BMI was the evidence of the definition of overweight and obesity. Rose pointed that BMI was better represented as a continuous variable than a categorical variable with categories that delineate “overweight” and “obese” cause[23]. Mojgan Padyab found that women from North Sweden who were always in the lower SES group had a significantly higher BMI compared to those who were continuously in the higher SES group[24]. One study found that European women and men showed an inverse relationship of increasing BMI with decreasing SES, while in Asia, the positive relationship was found between SES and BMI[25]. Carren Ginsburg et al. revealed a positive association between BMI and household SES in urban South Africa adolescents[26].

Some studies found that lifestyles played a mediated role between SES and BMI, such as physical activity, smoking and sleeping behavior do influence BMI[27-29]. Furthermore, systematic review suggested that the relationship among SES, lifestyles and BMI among men and women was different in the developing countries[30]. Antoneta Granic et al. aimed that in UK, higher SES helped people get greater economic resources and more prestigious occupation, which may provide greater interest in health risks and in implementing sustained healthier lifestyles then enhanced the individual’s sense of control their BMI[31]. Sofie Compernolle et al. found that Mid-European urban regions residents with low SES reported more unhealthy behaviors(less transport-related physical activity, less leisure-time physical activity and less vegetable intake), and these unhealthy behaviors were related to higher BMI[32]. In the research of Jenny Godley, higher SES helped women engaged in healthier behaviors(exercise more, eat more fruits and vegetables) which contributed to lower BMI, while for men with higher SES were more likely to go along with unhealthy behaviors(exercise less, work long hours) which contributed higher BMI[33].

These observations, coupled with evidence of increasing global prevalence of overweight/obesity and obesity-associated chronic diseases, which are also socioeconomically patterned, highlight the importance of understanding the socioeconomic patterns of BMI and the relationship among SES, lifestyles and BMI. However, many of researches exploring the correlation of SES, lifestyles and BMI were focused on children, adolescents or adults, among middle or elderly were relatively small. Hence, the main objective of our study was using data of CHARLS in 2015 to explore and confirm the correlation of SES, lifestyles and BMI, and the mediated role of lifestyle factors between SES and BMI in China among the mid-aged and elderly by genders. Two theoretical hypotheses were given as follows:

1.The positive relationship between SES and BMI was existed among Chinese people aged 45 and over.

2.Gender-disparity of mediation of lifestyles on the correlation between SES and BMI was existed.

Materials And Methods

Data collection

The data for this study were obtained from the data of the China Health and Retirement Longitudinal Study (CHARLS)[34], which is administered by the National School for Development (China Center for Economic Research) and approved by the Biomedical Ethics Review Committee of Peking University (IRB00001052-11015), and the data are available at http://charls.pku.edu.cn/en. Samples of households with members 45 years of age or above were selected using multistage probability sampling within 28 provinces. The interviews took place in the respondents' home using computer-assisted personal interviewing (CAPI) technology with interviewers who were trained at Peking University by CHARLS staff members, and physical examinations were also carried out by trained interviewers in the households. The specific method of sampling and investigation of CHARLS is mentioned in the literature[22]. Follow-up is conducted with the respondents every 2 years via face-to-face interviews. We used the 2015 follow-up data which conducted between July 2015 and September 2015 and involved 21,095 respondents. We limited our sample to respondents who completed a physical examination and the physical activities questionnaire. A total of 5173 subjects were included.

Variables measurement

BMI

BMI(kg/m^2) was calculated as weight in kilograms divided by height in meters squared. The height and weight were taken with the participants wearing light clothes and without shoes.

SES

SES is a complex phenomenon predicted by a broad spectrum of variables that is often conceptualized as a combination of financial, occupational, and educational influences[35-38]. We chose education, occupation, income, age and community type as the SES variables. Education is the most basic and widely used indicator of socioeconomic status cause educated people often had better knowledge about risky health behaviors, relevant health care and use health care services effectively and had a better chance to choose a better job and economic situation[39]. Level of education was categorized into four levels in this study: illiteracy, elementary school and below, middle school, high school and above. Occupation or employment represents individual's position in social structure and explains access to resources, expose to psychological and physical risk factors and impact on lifestyles and health[40]. Occupational status (if the participants retired, chose the occupation before retired) was categorized into two groups: non-agriculture work and agriculture work.

Income has a significant relation with the employment, work condition and reflection of resources available in a given time[41], because it represents the flow of economic resources in a period of time[40]. Measuring income raises many well-known difficulties. Income had much measurement error and varies greatly over years and over the life-cycle. A different measure of longer run household resources, preferred by many economists, is expenditure. This was a better measure of long-run resources than current income, particularly so in low-income rural settings, where incomes can vary so much year to year because of variation in weather, pests, plant diseases, and so on. Expenditure varied much less over time than income because households tried to smooth their consumption. Expenditure included the value of food production which was self-consumed, which ought to be included in income, but may not be in all measures of income[42]. Expenditure also tends to be measured with less error than income[43]. Thus, we chose the household expenditure per capita as the income indicator and categorized into four groups: less than 5000 RMB, 5000~9999 RMB, 10000~19999 RMB, and 20000 RMB or more.

In addition, age is also one of the indicators of SES[6]. As individuals aged, advantages held by members of higher socioeconomic strata, such as having more financial resources and better health, become magnified[44], which is often referred to as the cumulative advantage and disadvantage hypothesis. Age groups were categorized into six: 45~49 years old, 50~54 years old, 55~59 years old, 60~64 years old, 65~69 years old, and 70 years old and older. The reason of choosing community type as one of the SES indicators because it accounted for some to the BMI of the population[45]. Many researches had confirmed that different community type had the different prevalence of overweight and obesity[46, 47]. Levi Z et al. also added community type as one of SES indicators[48]. And in China, the big gap of economics was also existed between rural and urban areas, so we chose the community type as one of the indicators to describe SES. Community type was categorized into two groups: rural area and urban area.

Lifestyle variables

Lifestyle factors which have been shown to have the most influence on health[49] are added as the mediated factors. We added smoking, drinking, sleeping time and physical activity as the lifestyle factors, all of those had been proved had effect on BMI[33, 50-52]. Drinking was divided into more than once a month, less than once a month and never drinking; smoking was divided into smoking, smoking cessation and non-smoking. The level of physical activity was measured by Global Physical Activity Questionnaire (GPAQ)[53]. The questionnaire asks about three specific levels of activity: walking, moderate- and vigorous-intensity activities, and their frequency (days per week) and duration (minutes per day) and the total volume of physical activity was calculated by weighting each type of activity by its energy requirements defined in METs[54], thus the level of physical activity was divided into three groups: high, medium and low. The sleeping time (h/d) was a continuous variable.

According the assignment of variables in Table 1, all of the SES indicators, the higher assignment linked the better situation, so the higher score of the latent variable (SES) in SEM model represented the better socioeconomic status. And the higher assignment of physical activity linked high level of physical activity; higher assignment of smoking linked the less likelihood to smoke; higher assignment of drinking linked less likelihood to drink. Sleeping time and BMI were continuous variables, so higher score of sleeping time meant longer sleeping time and higher score of BMI meant higher BMI.

Table 1 Assignment of the variables

Variable	Assignment
Gender	1=male；2=female
Age(years old)	1=≥70；2=65~69；3=60~64；4=55~59；5=50~54；6=45~49
Community type	1= Ural area；2= Urban area
Occupation	1= Agriculture；2= Non-agriculture
Education level	1= Illiteracy；2= elementary school and below；3= middle school；4= High school and above
Household expenditure per capita (RMB)	1=<5000；2=5000~9999；3=10000~19999；4=≥20000
Physical activity	1= Low；2= Middle；3= High
Smoking	1= Smoking；2= Smoking cessation；3= Non-smoking
Drinking	1= More than once a month；2= Less than once a month；3= Never drinking
	Never drinking

Statistical analysis

The present analysis is based on 5173 participants (2555 male and 2618 female) for whom all the variables were available. Chi-squared test, t-test and nonparametric test were used to test the variables by gender. The nonparametric test was used to test the correlation between SES indicators, lifestyle indicators and BMI. Structural equation model (SEM) was used to explore the relationships among SES, lifestyles and BMI. Lifestyle factors which were identified to be independently associated in nonparametric test analyses were included in the SEM model (Figure 1). First, a-coefficients were calculated by regressing each of the potential mediators on the predictor variable. Second, b-coefficients were calculated by regressing the outcome variable (BMI) on the potential mediators adjusted for the predictor variable. Finally, coefficients a and b were multiplied to assess the mediating effects (ab). By multiplying the b-coefficient of the multiple mediation models by the a-coefficient, individual mediated effects were computed for each mediator and summed to compute the total mediated effect[55]. The SEM uses bootstrap maximum likelihood estimation. The fit between the current data and hypothesized model was assessed through several indicators, adjust goodness of fit index (AGFI), a goodness of fit index (GFI), normed fit index (NFI), comparative fit index (CFI), incremental (IFI), and Tucker-Lewis index (TLI) of 0.90 or above, a root mean squared error of approximation (RMSEA) less than 0.08, indicated an acceptable model fit[56]. Statistical inference is based on 95% confidence intervals (CIs) and the significance level was set at 0.05. The statistical analyses were performed using SPSS software, Version 23.0 and Amos software, Version 19.0.

Results

Participant’s baseline characteristics

Among 5173 survey respondents, 2555 were men, accounting for 49.4%, slightly lower than women (50.6%). The average age of the population was 59.6 ± 8.7 years old. The distributions of age, occupation, education level, marital status, physical activity, sleeping time, smoking, drinking and BMI by gender were statistically significant. The proportion of women aged 70 years old and over was 11.6%, less than that of men (15.7%). The proportion of women engaged in agriculture was 68.7%, more than that of men (52.2%). The proportion of women who were illiteracy was 37.5%, which was much higher than that of men (10.6%). The average sleeping time of women was 6.8±2.3h/d, slightly shorter than that of men (7.2±1.9h/d). The proportions of women who were smoking and drinking were 4.4% and 15.7% respectively, much lower than that of men (54.6%, 60.2%). The proportion of women with high level of physical activity was 61.9%, slightly lower than that of men (64.8%). The average BMI of women was 24.3 kg/m^2, more than that of men (23.4kg/m^2).

The result of normality test showed that the data was not normally distributed with each group of gender (Kolmogorov-Smirnov: P<0.001, Shapiro-Wilk: P<0.001), so nonparametric test was used to test the variables by BMI in different gender. According the nonparametric test, the mean rank of men was lower than women. There were not differences in the distributions of household expenditure per capita and community type by gender (P>0.05) (Table 2).

Table 2. Characteristics of the study population [N (%)]

	Male (2555)	Female (2618)	Total (5173)	χ^2/t	P
Age (years old)				55.590	<0.001
≥70	402(15.7)	304(11.6)	706(13.6)		
65~69	394(15.4)	315(12.0)	709(13.7)		
60~64	526(20.6)	571(21.8)	1097(21.2)		
55~59	455(17.8)	432(16.5)	887(17.1)		
50~54	521(20.4)	617(23.6)	1138(22.0)		
45~49	257(10.1)	379(14.5)	636(12.3)		
Occupation				147.454	<0.001
Agriculture	1333(52.2)	1798(68.7)	3131(60.5)		
Non-agriculture	1222(47.8)	820(31.3)	2042(39.5)		
Education level				546.555	<0.001
Illiteracy	272(10.6)	981(37.5)	1253(24.2)		
elementary school and below	1187(46.5)	1017(38.8)	2204(42.6)		
middle school	713(27.9)	418(16.0)	1131(21.9)		
High school and above	383(15.0)	202(7.7)	585(11.3)		
Household expenditure per capita (RMB)				2.113	0.549
<5000	613(24.0)	646(24.7)	1259(24.3)		
5000~9999	687(26.9)	738(28.2)	1425(27.5)		
10000~19999	733(28.7)	718(27.4)	1451(28.0)		
≥20000	522(20.4)	516(19.7)	1038(20.1)		
Community type				1.370	0.254
Urban area	582(22.8)	561(21.4)	1143(22.1)		
Ural area	1973(77.2)	2057(78.6)	4030(77.9)		
Physical activity				6.103	0.047
Low	246(9.6)	250(9.5)	496(9.6)		
Middle	653(25.6)	748(28.6)	1401(27.1)		
High	1656(64.8)	1620(61.9)	3276(63.3)		
Sleeping time(h/d)				7.067	<0.001
	7.2±1.9	6.8±2.3	7.0±2.1		
Smoking				2668.453	<0.001
Smoking	1394(54.6)	116(4.4)	1510(29.2)		
Smoking cessation	591(23.1)	63(2.4)	654(12.6)		
Non-smoking	570(22.3)	2439(93.2)	3009(58.2)		
Drinking				1158.072	<0.001
More than once a month	1261(49.4)	241(9.2)	1502(29.0)		
Less than once a month	277(10.8)	169(6.5)	446(8.6)		
Never drinking	1017(39.8)	2208(84.3)	3225(62.3)		
				Z	P
BMI				-8.548	<0.001
Mean rank	2407.33	2762.34			

The correlation between SES, lifestyles and BMI

According to the results (Table 3) of the nonparametric test, the difference in the distribution of BMI among all of the SES indicators was statistically significant both in men and women (P<0.05). The difference in the distribution of BMI among sleeping time and smoking was statistically significant in men (P<0.05). The difference in the distribution of BMI among physical activity, sleeping time and smoking was statistically significant in women (P<0.05).

Table 3 Nonparametric test of BMI by gender

variables	Male			Female		
	N	Mean rank	Z/c2	N	Mean rank	Z/c2
Age (years old)			104.783***			66.487***
≥70	402	988.13		304	1094.62	
65~69	394	1230.95		315	1166.56	
60~64	526	1246.46		571	1266.68	
55~59	455	1335.17		432	1338.34	
50~54	521	1432.70		617	1406.48	
45~49	257	1453.27		379	1474.42	
Community type			-8.945***			-4.395***
Ural area	1973	1207.10		2057	1275.60	
Urban area	582	1518.36		561	1432.82	
Occupation			-8.310***			-3.901***
Agriculture	1333	1161.88		1798	1270.58	
Non-agriculture	1222	1404.67		820	1394.83	
Education level			51.376***			33.623***
Illiteracy	272	1098.40		981	1206.76	
elementary school or lower	1187	1219.70		1017	1342.94	
middle school	713	1351.15		418	1437.47	
High school or higher	383	1450.05		202	1375.25	
Household expenditure per capita (RMB)			31.298***			7.906*
<5000	613	1147.78		646	1242.64	
5000~9999	687	1275.77		738	1316.69	
10000~19999	733	1315.04		718	1355.99	
≥20000	522	1381.84		516	1318.24	
Physical activity			2.851			13.350**
Low	246	1326.96		250	1356.43	
Middle	653	1304.21		748	1384.67	
High	1656	1260.39		1620	1267.55	
Sleeping time(h/d)			-43.779***			-44.316***
	2555	1278.00		2618	1309.50	
Smoking			118.956***			30.364***
Smoking	1394	1132.74		116	947.28	
Smoking cessation	591	1450.08		63	1177.84	
Non-smoking	570	1454.83		2439	1330.13	
Drinking			2.631			2.806
More than once a month	1261	1266.67		241	1233.38	
Less than once a month	277	1345.22		169	1336.19	
Never drinking	1017	1273.74		2208	1315.77	

*:P<0.05**:P<0.01***:P<0.001

The mediation of lifestyles between SES and BMI

The SEM was established to assess the relationship among SES, lifestyles and BMI. According to the results of nonparametric test, sleeping time and smoking were chose as lifestyles indicators in men and physical activity, sleeping time and smoking were chose as lifestyle indicators in women. We fitted the data and the theoretical model through the generalized least squares and modified the theoretical model according to model fit indices. In men, the overall model fit indices of the modified hypothetical model were AGFI=0.988, CFI=0.968, NFI=0.956, IFI=0.968, TLI=0.947, RMSEA=0.031, and in women these were AGFI=0.982, GFI=0.991, NFI=0.938, CFI=0.950, IFI=0.951, TLI=0.918, RMSEA=0.038, all of them satisfied reference value, suggesting acceptable model fit.

Bias-corrected bootstrap with 2000 replications using maximum likelihood estimation was employed for each path, the final output models were shown in figure 2 and figure 3 which presented correlation and effect path of variables. Among men, the effect of SES on sleeping time and smoking were not statistically significant. Smoking had a direct positive effect on BMI ($b=0.180$, $P<0.001$). SES had a direct positive effect on BMI ($b=0.306$, $P<0.001$). Among women, SES had a direct negative effect on physical activity ($b=-0.048$, $p<0.05$), a direct positive on sleeping time ($b=0.048$, $P<0.05$), smoking ($b=0.098$, $P<0.001$) and BMI ($b=0.168$, $P<0.001$). Physical activity had a direct negative effect on BMI ($b=-0.050$, $P<0.01$). Sleeping time ($b=0.066$, $p<0.001$) and smoking ($b=0.088$, $p<0.001$) both had a direct positive effect on BMI.

The results of the mediation analysis among men were shown in Table 4. If the 95%CI of the estimation of the mediate effect does not include 0, it means that the mediate effect is statistically significant. Among men, regarding the path between SES and BMI, the indirect effect was not statistically significant, which means the mediate effect of lifestyles between SES and BMI doesn't exist among men.

Table 4 Significance of the mediating test(men)

Model pathways	Estimate	95%CI	
		Lower	Upper
Total effects			
SES→Smoking	0.025	-0.024	0.073
SES→sleeping time	0.026	-0.018	0.072
SES→BMI	0.306	0.261	0.352
Smoking→BMI	0.180	0.143	0.219
Sleeping time→BMI	0.001	-0.034	0.038
Direct effects			
SES→Smoking	0.025	-0.024	0.073
SES→sleeping time	0.026	-0.018	0.072
SES→BMI	0.301	0.261	0.352
Smoking→BMI	0.180	0.143	0.219
Sleeping time→BMI	0.001	-0.034	0.038
Indirect effects			
SES→BMI	0.005	-0.005	0.013
Each mediating pathway			
SES→Smoking→BMI	0.00450	-0.04861	0.19226
SES→sleeping time→BMI	0.000026	-0.01061	0.01983

The results of the mediation analysis among women were shown in Table 5. Among women, Table 4 shows that the 95%CI of the estimation of the three mediation paths do not include 0, indicates that the mediate effect of physical activity, smoking and sleeping time between SES and BMI were all statistically significant. This indicated that women with high SES had a longer sleeping time, a lower level of physical activity and smoked less, and these factors were associated with having a higher BMI.

Table 5 Significance of the mediating test (women)

Model pathways	Estimate	95%CI	
		Lower	Upper
Total effects			
SES→Physical activity	-0.049	-0.099	-0.001
SES→Smoking	0.098	0.060	0.136
SES→sleeping time	0.048	0.009	0.087
SES→BMI	0.168	0.127	0.207
Physical activity→BMI	-0.050	-0.089	-0.014
Smoking→BMI	0.088	0.044	0.131
Sleeping time→BMI	0.066	0.025	0.104
Direct effects			
SES→Physical activity	-0.049	-0.099	-0.001
SES→Smoking	0.098	0.060	0.136
SES→sleeping time	0.048	0.009	0.087
SES→BMI	0.154	0.111	0.193
Physical activity→BMI	-0.050	-0.089	-0.014
Smoking→BMI	0.088	0.044	0.131
Sleeping time→BMI	0.066	0.025	0.104
Indirect effects			
SES→BMI	0.014	0.008	0.022
Each mediating pathway			
SES→Physical activity→BMI	0.002450	0.00257	0.07806
SES→Smoking→BMI	0.008624	0.04689	0.19210
SES→sleeping time→BMI	0.003168	0.00423	0.09343

Discussion

In this study, a positive relationship was found between SES and BMI both among middle and old men and women, same with some literatures in developing countries. Mocanu V pointed that a positive relationship of SES and BMI was existed in China and Russia[57]. However, in developed countries, there was an inverse relationship between SES and BMI. Kilson Moon et al. found a negative relationship in German adults[58] and a negative relationship between SES and BMI was found in Europe and American[59, 60]. The possible explanations for the positive relationship between SES and BMI in this research maybe the lifestyle and nutritional determinants attaching with rising SES, such as decreased physical activities, sedentary lifestyle, altered eating patterns, and increased fat content of the diet[61]. What's more, individuals with higher SES may have the widespread ownership of televisions, computers and cars, and the supermarket system of high calorie food, which caused the higher BMI[62, 63].

The mediation role of lifestyles was only existed in women, but not in men. Women with high SES had a lower level of physical activity, which was related to a higher BMI. The inverse relationship between SES and physical activity may be caused by occupation of the participants. 68.7% of the women' occupation was agriculture which leaded to a high level of physical activity and higher level of physical activity always linked with more energy consumption and a lower BMI[64].

Women with high SES had a longer sleeping time, which was related to a higher BMI. In this study, age, education and income were the SES indicators and the younger age, higher education, higher income linked the higher score of SES. Bliwise found that sleep duration often declines across the lifespan[65] and Rachel P pointed that short sleep duration had been associated with lower education and income, so these may lead people with higher SES associated with the longer sleep time[66]. Kristen L. Knutson found that long sleep was examined in relation to obesity[67]. Westerlund et al. also found that shorter sleep durations during nights were associated with an increased consumption of high calorie foods and then lead the lower BMI[68]. What's more, most studies reporting positive associations rely on self-reported measures of sleep, indicating that long sleepers may be reporting more time in bed but not more time spent asleep[68], and in our study the sleep time was self-reported. Moreover, some research found that the association between less sleep and weight gain may be more consistent among children and weaken with age[69]. However, many studies had the converse conclusion that less sleeping time contributed to the weight gain[50, 70, 71]. In their studies, sleep reduction or deprivation may affect the vary of the hormones (like leptin and ghrelin) and then disturb the metabolism and energy balance of our body, and lead to the weight gain[72].

Women with high SES smoked less, which was related to a higher BMI. Many researches had the same conclusion with our study. Cornelie Nienaber-Rousseau et al. found women in Europe[60] and South Africa[73] smoking less associated with higher BMI and Kilson Moon et al. found that smokers had a lower BMI than non-smokers[58]. Mechanisms for a possible relationship between smoking and a lower BMI may include as following: firstly, maybe the reduction of appetite lead the metabolic efficiency increased or the caloric absorption decreased [27, 74]. Secondly, smokers were more likely to choose smoke instead of consuming desserts[74]. Thirdly, people with higher BMI may give up smoking due to their poor health then increased the BMI among non-smokers[75]. While Alicia García-álvarez et al. found that current smoking especially high intensity have been associated with increased risk of weight gain[52]. A possible mechanism they gave for a greater BMI among high intensity smokers was the higher fasting plasma cortisol concentrations seen in smokers as compared to non-smokers, which was strongly associated with visceral adipose tissue (VAT) and in turn strongly associated with BMI, and the higher cortisol concentrations could be a consequence of the stimulation of sympathetic nervous system activity that is induced by smoking.

Among women, the association between SES and BMI was partly mediated by lifestyles. Women with higher SES were more likely to have healthy habits. Comparing to the lower SES group, women with higher SES were more likely concentrated on the health related information and easier to adopt new lifestyle related behaviors since they were more likely to afford the high cost of newer, exotic habits and had better access to high-quality healthcare and health recommendations[76]. Thus over time, people with higher SES were more likely to develop healthier behaviors like reduction of tobacco smoking and the sufficient sleep and avoid harmful ones comparing to people with lower SES[77, 78]. Besides of lifestyles, sex itself (sex hormones affect the amount and distribution of body fat) was also a factor influencing body composition, its oxidation and mobilization[79], which can cause more storage of fat in women than that in men. What's more, gave birth to a child was associated with increased long-term central obesity and higher BMI for women[80],but this never happened in men.

While among men, SES was not significantly related with lifestyles, and only the smoking was positively related with BMI, which meant the smokers were less likely to have excess BMI. Comparing to women, the rate of smoking in men was significantly high, up to 54.6% and the rate of smoking cessation was 23.1%, which may make the influence of SES not significant on smoking. What's more, the variability of sleep time among men was small, and then may lead the difference between sleep time and SES among men not significant. Moreover, comparing to men, women of all ages were displaying more weight-related concern, regarding eating habits, body weight, and physical appearance[81] which may make the distribution of lifestyles between SES and BMI among men was not significant. Furthermore, other lifestyles like the intake of energy didn't include may lead the mediation of lifestyles among men not significant.

Conclusions

Excess body weight is an urgent public health problem. The positive association with SES and BMI was found in this study, which was consistent with many researches in developing countries but inconsistent with many studies in developed countries. In developing countries, people with higher SES were more likely to have excess body weight, so interventional measures employed to reduce the obesity epidemic should pay attention to the population with higher SES. However, this association among SES, lifestyles and BMI was obvious in women not in men. The mediating effect of sleeping time, smoking and physical activity were proved existed between SES and BMI in women, so more attention should be pay on the lifestyles in women so as to help women get a heathier BMI. For men, further researches on the mediating factors between SES and BIM and more lifestyle factors like nutrition should be taken consider.

Limitations

Some limitations need to be considered. Firstly, the definition of SES indicators maybe different, most of studies choose income, occupation and education as the SES indicators, but some researches may add some other indicators like gender, age and so on or maybe delete some which may reduce the comparability with the results of other studies. Secondly, the additional indicators which indeed influence the BMI, such as dietary intake factors and nutrition factors, were not taken in to consideration in this study. Thirdly, the temporality of the given associations was unclear because of the cross-sectional design of this study. Fourthly, this study used a single survey item: self-reported sleeping and many other sleeping factors like sleep-disordered breathing and sleep quality didn't include, so further studies are warranted in order to evaluate the specific association between socio-economic status, lifestyles and BMI.

Declarations

Competing interests: The authors declare that they have no competing interests.

Author Contributions: Li Xue, Xiaohui Ren conceptualized the idea. Li Xue performed the analyses and wrote the first draft of the manuscript. Xiaohui Ren critically revised the manuscript. All the authors read and approved the final manuscript.

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Figures

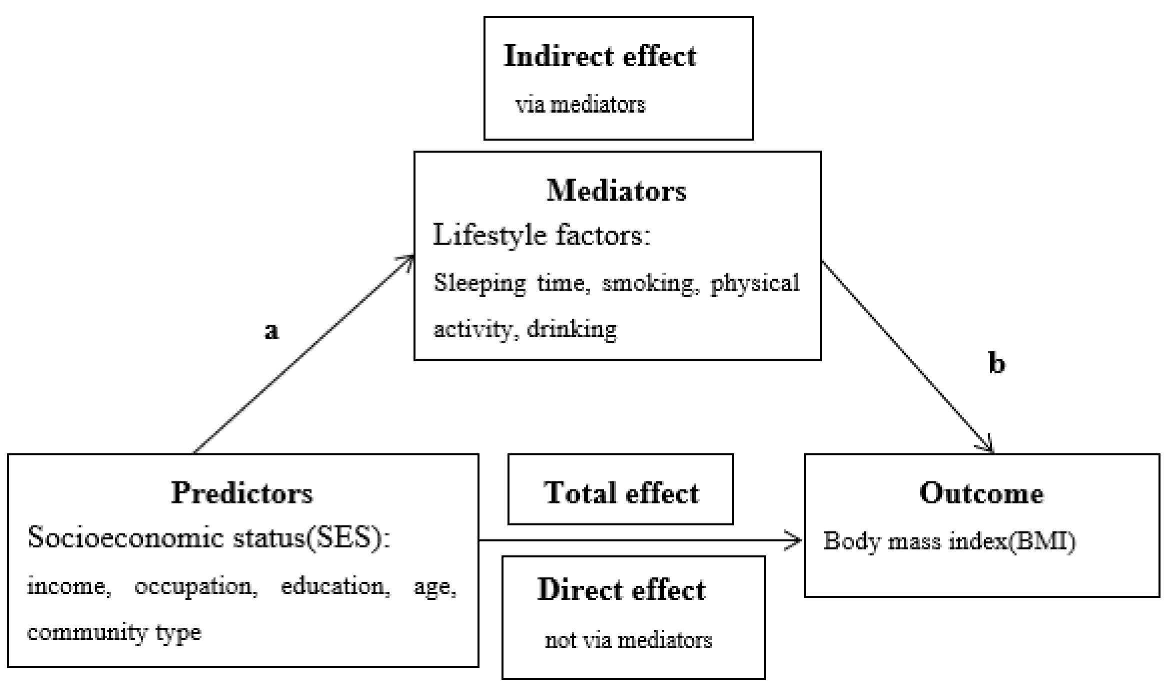

Figure 1

SEM model

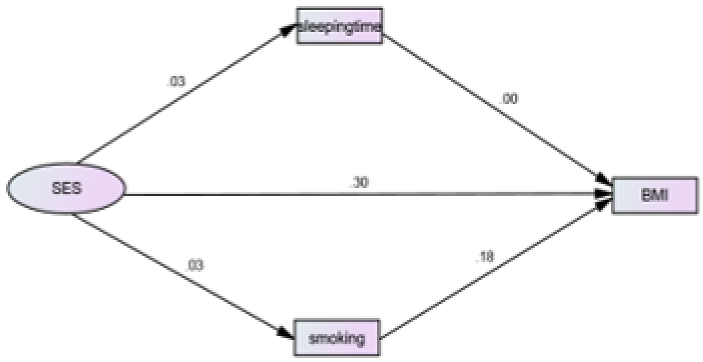

Figure 2. The final model and standardized model paths. (Men)

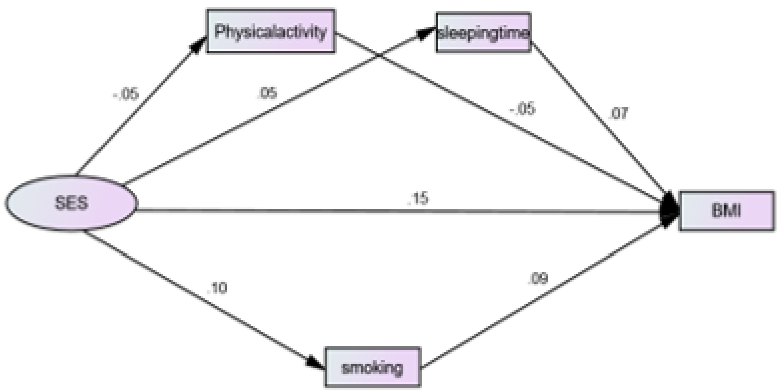

Figure 2

The final model and standardized model paths. (Women)