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Abstract

Overweight and obesity in adult populations is considered to be a growing epidemic worldwide, and appears to be rapidly increasing in China. From 1992 to 2002, the incidence of overweight in adults increased by 39.0%, while that of obesity doubled. To identify the determinants of adult overweight and obesity in China, micro-level data from a questionnaire survey entitled the "Preference Parameters Study," which was conducted by the Global Centers of Excellence program at Osaka University, were analyzed. In addition to the entire sample, data from urban and rural subsamples were also analyzed in order to investigate whether the determinants of overweight and obesity differed. The results suggested that body mass index (BMI) is correlated with subjective well-being, gender, age, labor intensity and drinking and eating habits among urban respondents, and with age, monthly income, number of siblings and eating habits among rural respondents.

Keywords: Body mass index (BMI); Overweight and obesity; Urban residents; Rural residents; China

JEL classification: C21, D12, I12

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1. Introduction

Overweight and obesity among adults is considered to be a growing epidemic worldwide, particularly in the US (Popkin and Doak, 1998; Flegal et al., 1998; Mokdad et al., 1999; Philipson, 2001; Komlos and Baur, 2004; Ogden et al., 2004). Based on the criteria of the World Health Organization (WHO), the incidence of obesity doubled worldwide between 1980 and 2014. In 2014, more than 1.9 billion adults (18 years and older), or 39% of world's adult population, were overweight or obese, about 600 million (13%) of whom comprising the latter (WHO, 2015). Overweight and obesity increase the risk of chronic diseases such as heart disease, stroke, cancer and diabetes. In addition, severely obese people are likely to pay additional "penalties" for their condition in the form of discrimination in the labor and marriage markets (Mitra, 2001; Puhl and Brownell, 2001; Baum and Ford, 2004).

Biologically, the cause of weight gain is uncontroversial: all animals gain weight if they take in more calories than they expend. Humans gain approximately one pound of fat for every 3500 kilocalories net intake. However, the cause of the recent increased incidence of overweight and obesity is controversial. Culter et al. (2003) suggested that the rapid increase in the incidence of obesity in the US since 1975 is primarily the result of increased caloric intake due to rapid changes in food technology, including vacuum packing, deep freezing, artificial flavors, preservatives and microwaves, which made it possible for firms to ship mass-prepared, ready-to-eat foods to consumers. For consumers, changes in food technology have lowered the costs associated with and the time required for meal preparation and cleanup. Similarly, Lakdawalla and Philipson (2002) conducted a theoretical and empirical examination using data from the National Longitudinal Survey of Youth (NLSY) from 1976 to 1994 to explain the long-term increase in weight over time in the US, and argued that technological change contributed to obesity by lowering food prices and causing people to lead more sedentary lifestyles. In particular, they suggested that about 40% of the increase in weight over time was due to an expansion of the food supply, primarily resulting from innovation in agricultural production, and about 60% was due to increased demand resulting from decreases in physical activity as well as in market and home production.

While agreeing that technological change was playing an important role in the increasing incidence of overweight and obesity in the US, Komlos et al. (2004) hypothesized that an increase of time preference[1] would probably also result in the growth of overweight and obesity. They found that people with a higher time preference had a higher risk of being overweight or obese because they consume more calories and lead more sedentary lifestyles. In addition, Smith et al. (2005) used savings and dissavings information as the proxy for time preference to investigate whether time preference is positively correlated with body mass index (BMI). As a result, positive correlations were found between BMI and time preference among black men,

[1] Time preference refers to the consumer's inclination towards current consumption over future consumption. Having a high (resp. low) time preference means that the consumer prefers current (resp. future) consumption to future (resp. current) consumption.

black women, and Hispanic men.

Similar to physical activity hours, working hours are normally considered to have a negative effect on body mass. However, using data from Japan, Ohtake (2005) found that long working hours increased the risk of overweight and obesity by reducing the time spent in movement. In addition, people with longer working hours may allocate less time for meal preparation at home, and are therefore expected to consume fast food more frequently. Furthermore, Suzuki (2011) employed cross-sectional data from a questionnaire survey on individual lifestyle conducted in Japan to test whether working hours affect BMI. The results showed that total working hours (i.e., working hours combined with commuting time) had a significantly positive correlation with BMI.

Another factor considered to contribute to overweight and obesity is the unemployment rate. Ruhm (2000) examined the correlation between economic conditions and health using data from the Behavioral Risk Factor Surveillance System (BRFSS) from 1987 to 1995. He found that the unemployment rate had a negative effect on overweight and obesity. Moreover, the strongly negative correlation found between body mass and smoking rate led some economists to doubt whether reduced smoking increases body weight. Nemery et al. (1983) compared body weight between smokers and non-smokers and found that smokers weighed significantly less than non-smokers. Chou et al. (2002) found that the cost of cigarettes was negatively correlated with BMI, and Gruber and Frakes (2005) found that taxes on cigarettes had a negative effect on body weight, although they did not find any evidence that reduced smoking led to increased body weight.

All the studies mentioned above were conducted primarily in developed countries; however, the incidence of overweight and obesity appears to be increasing most rapidly in developing countries (Popkin and Gordon-Larsen, 2004). Hence, to fill this void in the literature, we conducted an empirical analysis in China, where a rapid increase of overweight and obesity has been occurring, using data from a questionnaire survey conducted in 2013 by the Institute of Social and Economic Research at Osaka University. In this study, three issues that were not addressed in the above-mentioned studies were examined. First, we adopted Chinese criteria for classifying overweight and obesity because it is more suitable to Chinese respondents. Second, in contrast to most of the previous studies, we added subjective well-being as an independent variable to test its effect on BMI. Third, In addition to the entire sample, data from urban and rural subsamples were also analyzed in order to investigate whether the determinants of overweight and obesity differed.

The remainder of the paper is organized as follows. The next section provides some background information on overweight and obesity in China. Sections 3 and 4 describe the methodology and data, respectively, used in this study for empirical analysis. Section 5 details our results, which are discussed in detail in Section 6. Finally, Section 7 discusses the conclusions.

2. Overweight and obesity in China

2.1 Classification of overweight and obesity in adults

BMI is a simple index of weight-for-height that is commonly used to classify underweight, normal, overweight, and obesity. It is defined as weight in kilograms divided by the square of height in meters and expressed in units of kg/m^2. The WHO set 25.00 and 30.00 as the cut-off points for overweight and obesity, respectively. Individuals with a BMI between 25.00 and 29.99 are considered to be overweight, while those with a BMI greater than 30.00 are considered to be obese. However, Asians generally have a higher percentage of body fat than white people of the same age, sex, and BMI. The BMI cut-off point for observed risk varies from 22 kg/m^2 to 25 kg/m^2 in different Asian countries, while that for high risk varies from 26 kg/m^2 to 31 kg/m^2 (WHO, 2004). Cut-off points of 24.00 and 28.00 for overweight and obesity, respectively, are recommended for Chinese adults by the Working Group on Obesity in China (Zhou and the Working Group on Obesity in China, 2002). In this study, we adopted these Chinese criteria and classified those with a BMI less than 18.50 kg/m^2 as underweight, a BMI between 18.50 kg/m^2 and 23.99 kg/m^2 as normal, a BMI between 24.00 kg/m^2 and 27.99 kg/m^2 as overweight, and a BMI greater than 28.00 kg/m^2 as obese.

2.2 Rapid increase in overweight and obesity in China

Popkin and Gordon-Larsen (2004) reported that overweight and obesity appears to be increasing more rapidly in developing countries. The Report of China Health and Nutrition Survey 2002 showed that based on Chinese criteria, the prevalence of overweight and obesity in adults in China was 22.8% and 7.1%, respectively (Ma et al., 2005). Although the prevalence of overweight and obesity in China is relatively low compared with that in the US, the important thing to note is its rapid growth; from 1992 to 2002, the incidence of overweight in adults increased by 39.0%, while that of obesity doubled.

The prevalence of overweight and obesity by age and population in 2002 is shown in Figure 1a, while changes in the incidence of overweight and obesity by age and population from 1992 to 2002 are shown in Figure 1b. The data for both figures were taken from the Report of China Health and Nutrition Survey 2002, and the classification of overweight and obesity in both figures is based on Chinese criteria. As shown in the figures, although the prevalence of overweight and obesity in 2002 was highest among urban males and individuals aged from 45 to 59 years, rural males and those aged from 18 to 44 years experienced the highest increase in overweight and obesity from 1992 to 2002. Given the different situations of overweight and obesity in age, gender, and habitation area in China, these factors need to be included in the analysis.

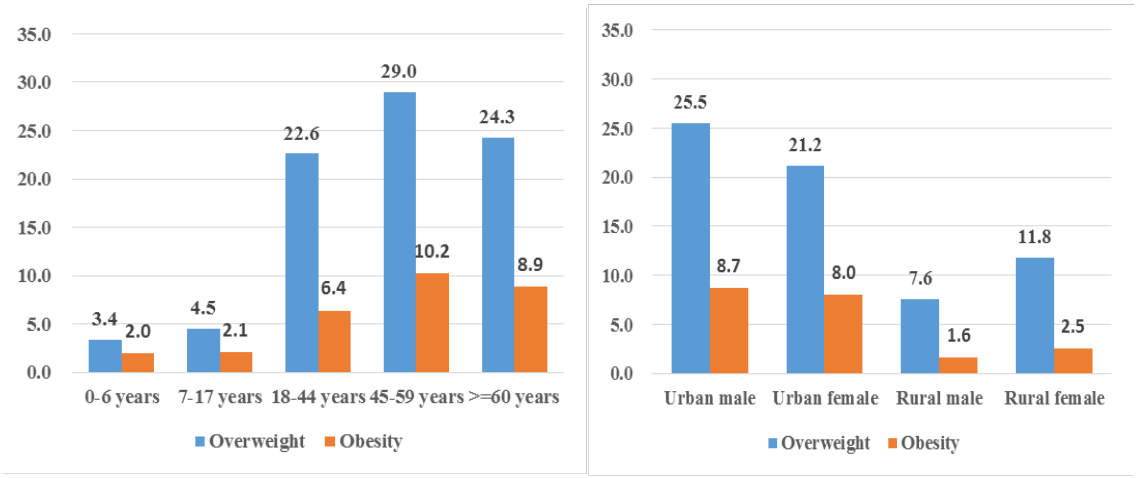

Figure 1a. Prevalence of overweight and obesity in 2002 by age and population

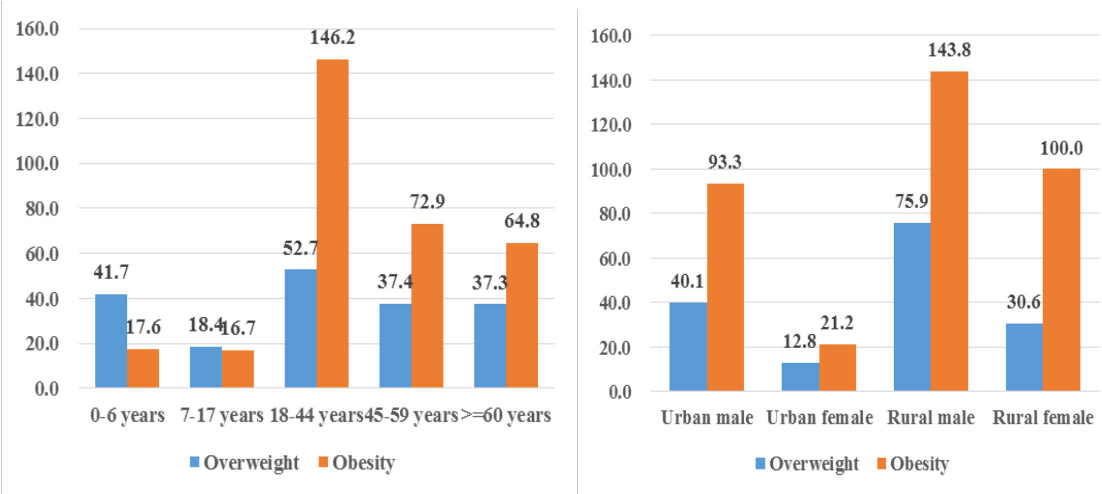

Figure 1b. Changes in the incidence of overweight and obesity from 1992 to 2002 by age and population

2.3 Increasing prevalence of chronic disease and its economic burden in China

It is well known that overweight and obesity is associated with the prevalence of chronic diseases, which represent the leading cause of death worldwide. According to the World Health Report 2003 (WHO, 2003), there were 17 million deaths resulting from cardiovascular disease, 7 million from cancer, 4 million from chronic pulmonary diseases, and at least 1 million from diabetes in 2003. In China, chronic diseases accounted for 85% of all deaths among the urban population and 84% among the rural population in 2003.

In China, the medical costs attributed to chronic diseases are astronomical; for example, chronic diseases accounted for 54% of total medical costs in 1993, and 63% in 2005. Using data from the Report of China Health and Nutrition Survey 2002 and the National Health Services Survey 2003, Zhao et al. (2008) estimated the direct medical costs attributable to hypertension, type 2 diabetes, coronary heart disease and stroke. The direct medical costs included outpatient visits, physician services, inpatient stays, rehabilitation services, nursing fees, and medications. They found that the direct costs attributable to overweight and obesity were $2.74 billion, which accounted for 25.5% of the total medical costs for the four chronic diseases, and 3.7% of the total national medical costs in 2003.

3. Methodology

The method used in this paper is based on Chou et al. (2002), who provided an elementary framework to analyze the effect of different variables on BMI. They began with the relationship between BMI and energy balance in a period of *t*. Energy balance is defined as

$$B_t \equiv C_t - E_t \tag{1}$$

where B_t is energy balance in a period of *t*, C_t is calories consumed in *t*, and E_t is calories expended in all activities in *t*.

Individual *i*'s body mass (O_i) can be defined as the accumulation of calories in a period of *t*.

$$O_i = O(\sum_i B_i\,,\ \varepsilon_i) \tag{2}$$

where ε_i is a vector of variables specific to individual *i* such as age, gender, race, and ethnicity. Equation 2 highlights the importance of explaining the determinants of calories consumed and expended. Then, by replacing B_i with calories consumed and some exogenous variable related to calories expanded, Chou et al.(2002) transform Equation 2 into Equation 3 (omitting subscript *i*) as

$$O = O(C, L, HC, EW, CS, A, G, R) \tag{3}$$

where *C* is calories consumed, *L* is active leisure, *HC* is household chores, *EW* is average metabolic rate, *CS* is cigarette smoking, *A* is age, *G* is gender, and *R* summarizes the racial and ethnic background. Given that calories, active leisure, household chores, and cigarette smoking are dependent on a set of exogenous variables, Chou et al. (2002) further transform Equation 3 into Equation 4 as

$$O = (H, F, P, S, M, EW, A, G, R) \tag{4}$$

where *H* is hours of work, *F* is family income, *P* is a vector of prices including the price of convenience foods, the price of meals consumed at fast food and full-service restaurants, the price of foods requiring significant preparation time, and the price of cigarettes, *S* is years of formal schooling completed, and *M* is marital status.

Following and expanding the variables used in Chou et al. (2002), in this paper, Equation (4) is rewritten as Equation (5) as follows

$$\begin{aligned} BMI_i = \alpha_0 + \alpha_W.W_i + \alpha_G.G_i + \alpha_A.A_i + \alpha_I.I_i + \alpha_M.M_i + +\alpha_E.E_i + \alpha_C.C_i + \alpha_{SIB}.SIB_i \\ +\alpha_R.R_i + \alpha_T.T_i + \alpha_L.L_i + \alpha_S.S_i + \alpha_D.D_i + \alpha_{EX}.EX_i + \alpha_{EAT}.EAT_i + \mu_i \end{aligned} \tag{5}$$

where *BMI* is body mass index, *W* is subjective well-being, *G* is gender, *A* is age, *I* is income, M is marital status, *E* is educational background, *C* is number of children, *SIB* is the number of siblings, *R* denotes risk aversion, *T* is time preference, *L* is labor intensity, *S* is for current smoker, *D* is for current drinker, *EX* is physical exercise, *EAT* is eating habits, and μ is an error term.

Regarding the reasons for adding subjective well-being to Equation (5), a Chinese proverb ("*Xin Kuan Ti Pan"* meaning means "Laugh and grow fat") suggests that people with high subjective well-being may be at high risk for weight gain. In addition, Kim et al. (2014) indicated that depression can lead to weight loss in middle-aged and elderly Asian populations. Hence, subjective well-being may have a positive effect on BMI. Meanwhile, the possible effect of body mass on subjective well-being should be considered. Several studies have suggested a positive correlation between these factors (e.g., Becker et al., 2001; Richardson et al., 2006; Baumeister and Harter, 2007), while others have suggested either a negative correlation (Han et al., 1998) or no correlation at all (John et al., 2005; Kress et al., 2002). This suggests the possibility that subjective well-being may be an endogenous variable.

Concerning the effects of smoking on body mass, Fehily et al. (1984) examined 493 individuals selected from the general population who had completed a 7-day weighed dietary record, and found that non-smokers had higher BMIs than smokers. To confirm these findings, we conducted an analysis with a dummy variable for smoking included as an independent variable. Moreover, although drinking in itself does not normally lead to weight gain, Okada (2006) reported that the increased appetite resulting from drinking causes an individual to eat more and get fatter. Thus, a dummy variable for drinking was also included as an independent variable. Finally, Zhou (2012) indicated that irregular eating habits could lead to weight gain. Therefore, for the purposes of this study, variables related to physical exercise and eating habits were also included as independent variables in this paper.

Based on the considerations mentioned above, we first performed standard ordinary least squares (OLS) regression analysis on Equation (5). Then, in consideration of the possibility of subjective well-being being an endogenous variable, we also performed two-stage least squares (2SLS) regression treating satisfaction of current resident area, current financial situation, and friendship as instrumental variables of subjective well-being. Next, we conducted Durbin and Wu-Hausman tests to test whether subjective well-being is an exogenous variable, as well as the weak instrument test and the overidentifying restrictions test to confirm the validity of the instrumental variables used.

Finally, to check the robustness of the results obtained from OLS and 2SLS regression analysis, we performed standard and instrumental variable probit (IV-probit) regression including a dummy variable for being overweight or obese as the dependent variable. The Wald test was then used to confirm the reliability of the results.

4. Data

The data used in this study were obtained from a questionnaire survey entitled "Preference Parameters Study," which was conducted in four countries as follows by the Global Centers of Excellence (Global COE) program at Osaka University: in Japan from 2004; in the US from 2005; in India from 2009; and in rural and urban areas in China from 2006 and 2007, respectively.

Both cross-sectional and panel surveys were carried out in China's urban areas. A cross-sectional survey was carried out in six cities—Beijing, Shanghai, Guangzhou, Chengdu, Wuhan, and Shenyang—in 2006, while panel surveys have been conducted in those same six cities annually from 2009. Regarding China's rural areas, cross-sectional surveys were carried out in four provinces—Hunan, Hubei, Sichuan, and Liaoning—in 2007, 2010, and 2013. To compare the different determinants of overweight and obesity among urban and rural populations, we combined data from the urban panel survey in 2013 with those from the rural cross-sectional survey in 2013, because that was the only year in which data were collected on weight and height. Finally, 818 and 500 valid questionnaires were returned from the urban and rural surveys, respectively, resulting in a combined sample of 1318 respondents.

Questionnaire items included self-reported height, weight, level of well-being, time preference, risk preference, working environment, and lifestyle. BMI, the focus of this paper, was calculated based on the self-reported height and weight of the respondents. To measure level of subjective well-being, respondents were asked to answer the following question on a 10-point Likert scale: "Overall, how happy would you say you currently are? Please rate your current level of happiness on a scale from 0 to 10, where '0' is 'very unhappy' and '10' is 'very happy.'" A dichotomous variable regarding current debt status (yes/no) was used as a proxy variable for time preference. Following Ikeda et al. (2009), a housing loan was not considered a loan in this study. In addition, risk aversion was measured by subtracting from 100% the answer to the following question: "How high does the chance of precipitation have to be before you will take an umbrella with you when you go out? High risk aversion (i.e., 80%) meant that the respondent would carry an umbrella even if the probability of precipitation was low (i.e., 20%).

Regarding the working environment, the questionnaire included items related to the occupation of the respondent and their spouse, industry, and labor intensity. The positive correlation found between body mass and the total hours spent at work (working hours plus commuting time) by Suzuki (2011) was confirmed in this study. No items specifically regarding working hours or commuting time were included in the questionnaire, so we used labor intensity as a proxy of the total hours spent at work.

As shown in Figure 2, the BMI distribution of the respondents in our sample (range, 15 to >50 kg/m^2) was skewed to the right and concentrated between 18.75 and 26.25 (normal to overweight).

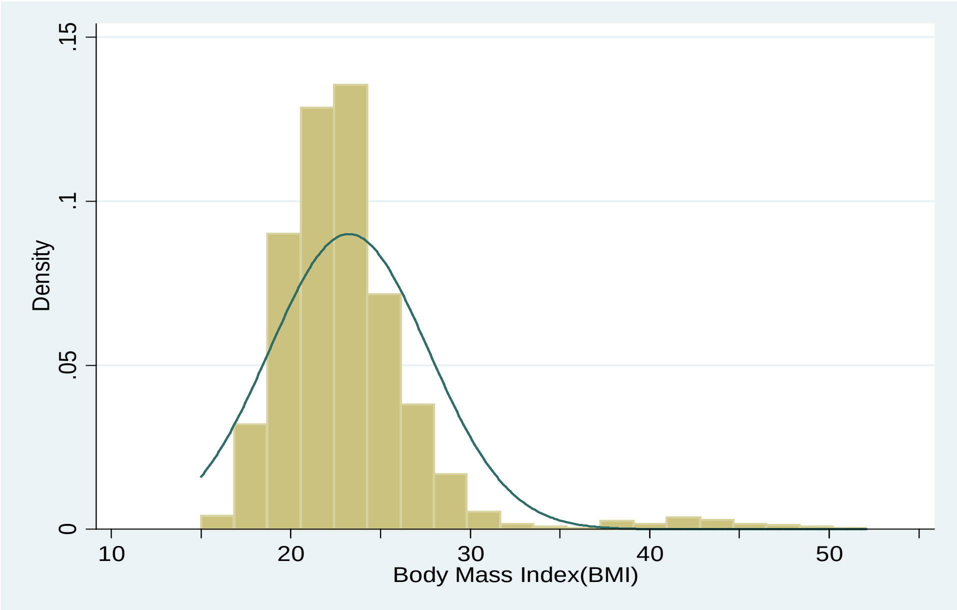

Figure 2. BMI distribution of the respondents

The definition, mean, and standard deviation of each variable used in all regressions are shown in Table 1. Based on Chinese criteria, which is slightly higher than that in the Report of China Health and Nutrition Survey 2002 (28.4%), the prevalence of overweight and obesity among the overall sample was 31.6% (28.8% and 36.13% in the urban and rural areas, respectively). A higher percentage of overweight and obesity was found in rural than in urban areas, which differs from the findings in the Report of China Health and Nutrition Survey 2002. In addition, the mean age ± standard deviation in urban areas was 44.4 ± 13.8, while that in rural areas was 43.2 ± 13.3 years, which indicates a similarity in age between the two subsamples. Although the ratio of females in the urban population (49.6%) was similar to that in the rural population (50.4%), major differences were found between urban and rural respondents in monthly income, education level, number of children and number of siblings, which suggests income inequality and an education gap between urban and rural residents in China.

Statistical means of standard variables by underweight, normal, and overweight or obese subsamples classified by BMI are shown in Table 2. The proportions of underweight, normal, and overweight and obese were 5.69%, 62.82%, and 31.49%, respectively. Mean age increased with increases in BMI, suggesting a positive correlation. Overweight and obesity were also more prevalent among those who were married, had a high monthly income, and had more children and siblings. Regarding lifestyle, overweight and obesity were more prevalent among smokers, those who engaged in physical exercise infrequently, and those who had relatively irregular eating habits in daily life.

Table 1. Definition and descriptive statistics of the variables used in this study

		Overall	Urban area	Rural area
Variables	Definition	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)
BMI	Weight in kilograms divided by height in meters squared	23.244 (4.434)	23.371 (4.934)	23.037 (3.457)
Overweight or obesity	Dichotomous variable =1 if BMI >= 24.00 and 0 otherwise	0.316 (0.470)	0.287 (0.453)	0.362 (0.481)
Age	Age of the respondent	43.932 (13.645)	44.368 (13.842)	43.22 (13.300)
Female	Dichotomous variable = 1if female and 0 if male	0.499 (0.500)	0.496 (0.500)	0.504 (0.500)
Monthly income	Monthly income of the respondent (yuan)	2810.56 (2627.77)	3395.69 (2406.39)	1843.64 (2694.16)
Marital status	Dichotomous variable = 1 if a respondent has a spouse (including common-law marriage) and 0 otherwise	0.813 (0.390)	0.795 (0.404)	0.842 (0.365)
Senior school	Dichotomous variable = 1 if the highest education level is senior school and 0 otherwise	0.281 (0.450)	0.351 (0.478)	0.166 (0.372)
College	Dichotomous variable = 1 if the highest education level is at least college and 0 otherwise	0.181 (0.385)	0.264 (0.441)	0.046 (0.210)
Children	Number of children	1.150 (0.851)	0.969 (0.682)	1.446 (1.005)
Siblings	Number of brothers and sisters	1.939 (1.615)	1.593 (1.427)	2.506 (1.742)
Risk aversion	100% minus the probability of rain have to be before you will bring an umbrella with you when you go out	46.099 (28.922)	48.215 (26.749)	42.638 (31.889)
Debt	Dichotomous variable = 1 if respondent is in debt and 0 otherwise	0.061 (0.240)	0.060 (0.237)	0.064 (0.245)
Labor intensity	Likert scales from 1 (work but have a lot of downtime) to 5 (could not work any harder than currently)	3.650 (1.067)	3.690 (0.967)	3.595 (1.188)
Subjective well-being	Likert scales from 0 (very unhappy) to10 (very happy)	6.622 (1.372)	6.615 (1.213)	6.634 (1.599)
Smoker	Dichotomous variable = 1 if a respondent is currently a smoker and 0 if not	0.332 (0.471)	0.313 (0.464)	0.362 (0.481)
Drinker	Dichotomous variable = 1 if a respondent is currently a drinker and 0 if not	0.432 (0.496)	0.485 (0.500)	0.346 (0.476)
Exercise	Dichotomous variable = 1 if a respondent does physical exercise frequently and 0 otherwise	0.539 (0.499)	0.709 (0.454)	0.262 (0.440)
Eating habit	Likert scales from 1 (have a meal irregular) to 5 (have a meal regular)	2.423 (0.766)	2.411 (0.785)	2.444 (0.735)
Satisfaction in current resident area	Likert scales from 1 (unsatisfied) to 5 (satisfied)	3.719 (0.828)	3.703 (0.781)	3.746 (0.898)
Satisfaction in current financial situation	Likert scales from 1 (unsatisfied) to 5 (satisfied)	3.561 (0.808)	3.568 (0.806)	3.55 (0.813)
Satisfaction in friendship	Likert scales from 1 (unsatisfied) to 5 (satisfied)	3.926 (0.704)	3.890 (0.705)	3.986 0.698

Table 2. Statistical means of standard variables by BMI classification

	Underweight	Normal	Overweight or Obesity
Sample size	75	828	415
Ratio	5.69%	62.82%	31.49%
Age	38.133	42.579	47.682
Female	0.733	0.489	0.477
Monthly income (yuan)	2173.333	2804.685	2938.350
Marital status	0.733	0.793	0.865
Senior school	0.267	0.291	0.263
College	0.227	0.200	0.135
Children	1.013	1.068	1.340
Siblings	1.680	1.856	2.152
Risk aversion	46.280	45.721	46.822
Debt	0.133	0.058	0.055
Labor intensity	3.365	3.665	3.677
Subjective well-being	6.453	6.687	6.523
Smoker	0.240	0.329	0.354
Drinker	0.320	0.450	0.417
Exercise	0.600	0.568	0.472
Eating habit	2.507	2.457	2.342

5. Results

The results of regression analysis regarding factors affecting BMI and the probability of being overweight or obese are shown in Tables 3 and 4, respectively.

5.1 Factors affecting BMI

The results estimated by OLS and 2SLS for three samples (all respondents, urban respondents, and rural respondents) are shown in Table 3. The results estimated by OLS for all respondents indicated that while female sex, age, age squared, monthly income, risk aversion, drinking status, exercise, and eating habits were statistically significant, level of subjective well-being, marital status, educational level, number of children, number of siblings, debt, labor intensity, and smoking were not.

The results estimated by 2SLS for all respondents (Table 4) indicated that level of subjective well-being was negatively significant at the 1% level, suggesting that increases in level of subjective well-being are associated with decreases in BMI. Both age and age squared were statistically significant. The positive coefficient for age and the negative coefficient for age squared indicated an inverted U-shaped relationship between age and BMI, and BMI was calculated to peak at the age of approximately 49 years. Monthly income, risk aversion, and eating habits had a significantly positive effect on BMI, implying that high income, strong risk aversion, and irregular eating habits lead to increases in BMI. Interestingly, drinking was statistically and negatively significant, which indicates that being a drinker is associated with a lower BMI.

The Durbin and Wu-Hausman tests were performed to compare the validity of the OLS and 2SLS results. Both results rejected the null-hypothesis that the variable under consideration—level of subjective well-being—was exogenous, which implied that level of subjective well-being is an endogenous variable and that the 2SLS model is more valid than the OLS model. Similarly, we preformed these two tests on the results of regression analysis for the urban and rural subsamples. The 2SLS model was more reliable for urban respondents, while the OLS model was more reliable for the rural respondents.

Another issue that needed to be confirmed was the validity of the instrumental variables. For an exogenous variable to be valid, an instrumental variable must be sufficiently correlated with an endogenous variable, but uncorrelated with the error term. Therefore, the weak instrument test was conducted to confirm whether the instrumental variables were sufficiently correlated with the endogenous variables in the first-stage regression. The F statistic was estimated to be 15.121, which satisfies the requirement suggested by Stock et al. (2002) that it exceed 10 for inference based on the 2SLS estimator to be reliable. In addition, the test of overidentifying restrictions was conducted to confirm whether the instrumental variables were correlated with the error term in the main regression (i.e., the second-stage regression). Wooldridge’s robust score was estimated to be statistically insignificant at the 10% level, suggesting that the instrumental variables used were not correlated with the error term and therefore valid.

With respect to factors affecting BMI for urban and rural respondents (Table 3), age, age squared, and eating habits were statistically significant in both subsamples. Moreover, level of subjective well-being, female sex, labor intensity, and drinking status were negatively significant for urban respondents, but not statistically significant for rural respondents. Finally, monthly income and number of siblings were statistically significant for rural but not urban respondents.

5.2 Factors affecting the probability of being overweight or obese

The results of probit and IV-probit regression regarding factors affecting the probability of being overweight or obese for three samples (all respondents, urban respondents, and rural respondents) are shown in Table 4. Based on the results of the Wald test, the null hypotheses that level of subjective well-being was an exogenous variable could not be statistically rejected for any sample; this implies that the probit model is more reliable for all three samples.

For all respondents, female sex, current drinker, and frequent exercise were estimated to be significantly negative, suggesting that these factors are less likely to be associated with overweight and obesity. Similar to the factors affecting BMI, age also affected the probability of being overweight or obese in an inverse U-shaped pattern. Furthermore, people with strong risk aversion, smokers, and those with regular eating habits were more likely to be overweight and obese.

Among urban respondents, the significantly negative coefficients of female sex and labor intensity suggested that urban females and urban workers who have high labor intensity are less likely to be overweight or obese. Monthly income was a significant and positive coefficient, suggesting that urban residents with higher incomes are more likely to be overweight or obese. On the other hand, among rural residents, female and eating habit were estimated to have a positive effect on the probability of being overweight or obese, while number of siblings was estimated to have a negative effect. Similar to the results seen for all respondents, age and age squared were estimated to be positively and negatively significant, respectively.

Table 3. Results from regression analysis regarding factors affecting BMI

	All respondents				Urban respondents				Rural respondents			
	OLS		2SLS		OLS		2SLS		OLS		2SLS	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Level of Well-being	-0.116	0.097	-1.345***	0.447	-0.335**	0.155	-2.124***	0.633	0.107	0.111	-0.386	0.553
Female	-0.846**	0.332	-0.882**	0.352	-1.556***	0.444	-1.486***	0.496	0.489	0.469	0.424	0.469
Age	0.394***	0.094	0.312***	0.100	0.392**	0.153	0.354**	0.167	0.389***	0.104	0.349***	0.112
Age squared	-0.004***	0.001	-0.003***	0.001	-0.004**	0.002	-0.004**	0.002	-0.004***	0.001	-0.003***	0.001
Log (monthly income)	0.493**	0.226	0.563**	0.243	0.454	0.473	0.677	0.506	0.435**	0.218	0.483**	0.228
Marital status	-0.494	0.447	-0.223	0.477	-0.811	0.681	-0.540	0.719	-0.253	0.532	-0.120	0.547
Senior school	-0.223	0.331	-0.132	0.347	-0.445	0.495	-0.260	0.522	0.185	0.433	0.242	0.429
College	-0.118	0.392	-0.134	0.423	-0.123	0.526	-0.060	0.592	-0.235	0.716	-0.337	0.683
Children	0.074	0.188	0.0609	0.219	-0.050	0.386	-0.004	0.442	0.190	0.224	0.138	0.233
Siblings	-0.077	0.090	-0.019	0.100	0.111	0.165	0.137	0.185	-0.195*	0.109	-0.172	0.110
Risk aversion	0.0108**	0.005	0.0124**	0.005	0.008	0.007	0.007	0.008	0.008	0.006	0.010	0.006
Debt	-0.642	0.514	-0.883	0.570	-0.385	0.785	-0.690	0.831	-0.482	0.659	-0.656	0.703
Labor intensity	-0.107	0.152	-0.170	0.164	-0.552**	0.252	-0.503*	0.258	0.283	0.180	0.215	0.194
Smoker	0.156	0.291	0.215	0.319	0.193	0.368	0.339	0.444	0.525	0.448	0.477	0.451
Drinker	-0.662**	0.276	-0.746**	0.308	-1.005***	0.385	-0.949**	0.429	-0.061	0.387	-0.139	0.396
Exercise	-0.681**	0.293	-0.418	0.317	-1.001**	0.450	-0.630	0.489	-0.110	0.376	0.060	0.429
Eating habit	0.504***	0.166	0.565***	0.188	0.485**	0.242	0.525*	0.270	0.488**	0.210	0.536***	0.230
Constant term	10.680	2.654	19.739	3.698	15.132	5.232	25.467	6.115	7.305	2.645	10.990	4.677
n	1014		1014		587		587		427		427	
R-squared	0.0701		-		0.1044		-		0.0953		0.0466	
Durbin test			Chi2(1)=9.990***				Chi2(1)=12.509***				Chi2(1)=0.830	
Wu-Hausman test			F(1,995)=9.977***				F(1,568)=12.528***				F(1,408) =0.801	

Note: * p<0.10, ** p<0.05, *** p<0.01. S.E. is robust standard error.

Table 4. Results from regression analysis regarding the probability of being overweight or obese

	All respondents				Urban respondents				Rural respondents			
	Probit		IV-Probit		Probit		IV-Probit		Probit		IV-Probit	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Level of Well-being	-0.021	0.031	-0.144	0.131	-0.047	0.047	-0.277*	0.160	-0.002	0.042	-0.210	0.268
Female	-0.180*	0.109	-0.181*	0.109	-0.478***	0.144	-0.449***	0.145	0.355*	0.191	0.310	0.209
Age	0.090***	0.031	0.080**	0.033	0.053	0.050	0.047	0.049	0.146***	0.044	0.121**	0.059
Age squared	-0.001**	0.000	-0.001**	0.000	-0.0003	0.001	-0.0003	0.001	-0.002***	0.000	-0.001**	0.001
Log (monthly income)	0.067	0.065	0.072	0.065	0.226*	0.125	0.243**	0.123	0.116	0.084	0.130	0.083
Marital status	0.067	0.139	-0.002	0.140	-0.164	0.196	-0.115	0.195	0.044	0.211	0.098	0.213
Senior school	-0.076	0.108	-0.065	0.107	-0.054	0.145	-0.028	0.143	0.146	0.180	0.164	0.171
College	-0.071	0.136	-0.070	0.135	0.001	0.169	0.010	0.167	0.102	0.392	0.061	0.380
Children	0.089	0.069	0.086	0.070	0.053	0.150	0.051	0.144	0.049	0.087	0.0259	0.094
Siblings	-0.039	0.031	-0.032	0.031	-0.039	0.051	-0.037	0.050	-0.085**	0.042	-0.070	0.047
Risk aversion	0.003*	0.002	0.003*	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.002
Debt	-0.054	0.176	-0.076	0.177	-0.066	0.262	-0.095	0.260	-0.059	0.265	-0.126	0.265
Labor intensity	0.009	0.042	0.003	0.042	-0.114*	0.062	-0.101*	0.060	0.100	0.061	0.066	0.078
Smoker	0.187*	0.109	0.191*	0.108	0.203	0.140	0.215	0.139	0.303	0.189	0.268	0.197
Drinker	-0.193**	0.097	-0.199**	0.097	-0.186	0.130	-0.173	0.130	-0.172	0.159	-0.197	0.158
Exercise	-0.262***	0.092	-0.232**	0.098	-0.175	0.133	-0.119	0.137	-0.172	0.153	-0.093	0.187
Eating habit	0.162***	0.057	0.165***	0.056	0.094	0.079	0.096	0.076	0.237***	0.088	0.244***	0.088
Constant term	-3.525	0.805	-2.558	1.320	-3.393	1.376	-1.907	1.734	-5.857	1.247	-3.982	3.031
n	1014		1014		587		587		427		427	
Log likelihood	-576.584		2316.889		-294.123		-1213.586		-258.648		-1050.914	
Wald test			chi2(1)=0.90				chi2(1)=2.07				Chi2(1)=0.830	

Note: * p<0.10, ** p<0.05, *** p<0.01. S.E. is robust standard error.

6. Discussion

Several studies concerning the effect of body mass on subjective well-being have been conducted, with some finding a positive correlation (Becker et al., 2001; Richardson et al., 2006; Baumeister and Harter, 2007), some finding a negative correlation (Han et al., 1998), and others finding no correlation (John et al., 2005; Kress et al., 2002). In this paper, following a famous Chinese proverb ("Laugh and grow fat"), we predicted that level of subjective well-being would have a positive effect on body mass; however, contrary to our hypothesis, level of subjective well-being had a negative effect on BMI for all respondents and urban respondents (Table 3). This could be because people with a high level of subjective well-being may change their eating habits or take part in physical exercises more frequently, and as a result, have a lower BMI.

Regarding the effect of individual characteristics, several studies (Suzuki, 2011; Chou et al., 2002) have confirmed that age has an inverted U-shaped relationship with BMI. We obtained identical results in this study. BMI peaked at the age of 47 years for urban residents and at 50 years for rural residents. Suzuki (2011) estimated that the peak age for BMI was 53 years using a Japanese sample, while Chou et al. (2002) estimated that this was 57 years using an American sample. However, whether Asians have a younger peak age of BMI than other populations remains unclear. Regarding gender, a considerable number of studies have found that females have a lower BMI (Aoyagi et al., 2006; Rashidy-Pour et al., 2009). In this study, although the results for urban respondents supported these findings, those for rural respondents did not.

In terms of socioeconomic status, including educational background, income, and occupation, Winkleby et al. (1992) reported that higher educational attainment and socioeconomic status were associated with a lower level of BMI; however, our results did not support these findings. In fact, we found a positive correlation between monthly income and BMI, which is contrary to their results. Concerning family environment factors, marital status and number of children had no effect on BMI. Only number of siblings had a negative effect on BMI for rural residents; however, no such effect was observed for urban residents.

Time preference has been reported to have a positive effect on body mass (Komlos et al. 2004; Smith et al. 2005). In this study, using debt status as a proxy variable for time preference, we found no evidence to support such findings.

Focusing on lifestyle, Zhou (2014) reported that irregular eating habits lead to a high BMI. However, in our study, we found a positive association between eating habits and BMI in both urban and rural residents. The more regularly that people eat, the higher their BMI. Working hours is similar to physical activity hours, so the negative effect of working hours on body mass could be predicted. However, Ohtake (2005) reported that long working hours may increase body mass by reducing the time spent in movement and promoting the tendency to consume fast food more frequently. In this paper, we used labor intensity as a proxy for labor time and found a negative relationship between BMI and labor intensity for urban residents. In addition, although smoking did not seem to have any effect on BMI, drinking was found to have a negative effect on BMI among urban respondents. This result is difficult to explain. One possible explanation could be that drinking alcohol is a substitute behavior for eating, and thus frequent drinking causes more infrequent eating.

Regarding the differences in factors affecting the probability of being overweight or obese between urban and rural residents, being male, having high labor intensity, and having a high monthly income were found to be risk factors for being overweight or obese among urban residents, while being female, being middle-aged, having many siblings and having regular eating habits were found to be risk factors for being overweight or obese among rural residents.

The prevalence of overweight and obesity varied by region and by ethnic group between males and females. In Iran, the prevalence of overweight and obesity is higher among males than among females (Rashidy-Pour et al., 2009). In Japan, males are more likely than females to be overweight or obese (Aoyagi et al., 2006). In this paper, we found that gender had different effects on the probability of being overweight or obese between urban and rural residents. This difference was consistent with that observed for BMI (Table 3, Figure 1a). Urban males tend to be more frequently engaged in brain labor, which makes them more sedentary. This lower caloric expenditure makes them more likely to be overweight or obese. Compared to their rural counterparts, urban females, who tend to have higher incomes and educational backgrounds, cause them to pay more attention to their appearance, which decreases their risk of being overweight or obese. Meanwhile, rural males tend to perform more physical labor, which causes higher caloric expenditure and thereby makes them less likely to be overweight or obese.

The second difference between urban and rural residents is labor intensity. It is easy to assume that labor intensity has a negative effect on being overweight or obese, as higher labor intensity results in higher caloric expenditure. However, in this study, we found that labor intensity had a negative effect on BMI and the probability of being overweight or obese for urban residents, but not for rural residents. A possible explanation for this result might be the difficulty associated with self-assessment of labor intensity by rural respondents. In the questionnaire, labor intensity was measured using the following question: “Please rate how hard you work every day on a scale from 1 to 5, where ‘1’ is ‘work, but have a lot of downtime’ and ‘5’ is ‘could not work harder.’” Labor intensity in rural jobs is very difficult to define and might be imagined differently according to the respondents’ understanding. Therefore, this question could have yielded biased and inconsistent answers based on the understanding of its meaning by the rural respondents.

Another difference observed between urban and rural residents was monthly income. Monthly income had a positive effect on the probability of being overweight or obese for urban residents, but no effect for rural residents. The mean monthly income of urban respondents (3396 yuan) was nearly twice that of rural respondents (1844 yuan). This may cause differences between urban and rural residents in the frequency of eating out and the kinds of foods being eaten, resulting in different effects on the probability of being overweight or obese.

The final difference observed between urban and rural residents was in number of siblings. Number of siblings had a negative effect on the probability of being overweight or obese for rural residents, whereas no such effect was found for urban residents. In China, rural residents tend to have a higher number of siblings than urban residents. In our study, the mean number of siblings was 2.5 for rural respondents and 1.6 for urban respondents. Given the same quantity of food, the larger number of siblings in rural areas means less food per person. According to Goran (2001) and Guo et al. (2002), rural residents tend to be underweight during adolescence, and this tendency has a continued effect into adulthood.

This study did have a few limitations. First, to calculate BMI, we used self-reported weight and height. However, it is known that respondents tend to underestimate their weight and overestimate their height when answering questionnaires (Hill and Roberts, 1998; Kuskowska-Wolk, et al., 1992); this could limit the validity of the results. Second, according to Chinese criteria, only 97 of the respondents were classified as obese; this number is too small to allow an accurate estimate of factors affecting the probability of being obese, which is strongly correlated with the prevalence of chronic diseases.

7. Conclusion

In this study, we empirically investigated factors affecting BMI and the probability of being overweight or obese in China using survey data from 2013. In contrast to most previous studies, we added level of subjective well-being into regression analysis as an independent variable in order to examine whether level of subjective well-being has effect on body mass and the probability of being overweight or obese. In addition, we also investigated data from urban and rural subsamples in order to investigate whether the factors affecting BMI and the probability of being overweight or obese differed between them.

The fact that respondents tend to underestimate their weight and overestimate their height when answering questionnaires suggests the necessity of collecting such data from medical records in future research. Matching these data with other sociodemographic variables remains challenging; however, one possible solution could be to conduct follow-up surveys when collecting data from medical records while taking all necessary precautions to protect patients' privacy.

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