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Sex, Socioeconomic and Regional Disparities in Age Trajectories of Childhood BMI, Underweight and Overweight in China

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Abstract

Using a longitudinal dataset from the China Health and Nutrition Survey (CHNS), growth curve models were employed to examine age trajectories of BMI for 1,694 subjects who were aged 2-11 in 1993 and followed in four waves (1997, 2000, 2004 and 2006). Based on age- and sex-specific BMI cut-points recommended for international use, the prevalence rates of overweight and underweight in the transition from childhood to adulthood (age 6-18) were also predicted. Sex, family income, rural-urban residency and geographical location were found to be significantly associated with the onsets, slopes, and acceleration of age trajectories in BMI, overweight, and underweight (P<0.01). Children who had lower prevalence of underweight in the transition from childhood to adulthood exhibited higher prevalence of overweight than their counterparts did. Moreover, the age interval during which children were more vulnerable to an increase in underweight was different from that for overweight. There were substantial regional disparities in the age trajectories of childhood overweight and underweight. Whereas the analyses suggest that the dual burden of nutritional problems (the coexistence of overweight and underweight) in China is more like two sides of a coin than two separate health issues, the critical age period for intervening in childhood overweight is different from that of childhood underweight. Geographical indicators of childhood obesity in China deserve further attention.

Keywords

Underweight; Overweight; Age Trajectories; Body Mass Index; China; Growth-curve models

INTRODUCTION

Childhood overweight and underweight are two epidemiological problems with essential consequences not only because they often extend to adulthood but because they are associated with the early onset of a series of diseases and excess deaths (Dietz, 1998). While

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the global rise of childhood obesity and its association with demographic, socio-economic and spatial factors are drawing increasing attention from epidemiologists and social scientists, it has been argued that households in both developed and developing countries face the dual burden of nutritional problems (the coexistence of both underweight and overweight persons) during the nutrition transition (Doak, Adair, Bentley, Fengying, & Popkin, 2002; Doak, Adair, Bentley, Monteiro, & Popkin, 2004). Studies on China can shed light on the progress of the two global epidemics not only because the nutrition transition in China is believed to be intertwined with the growth of its market economy, but because a substantial increase in the prevalence of childhood overweight has been documented in this populous country once characterized by the scarcity of food and economic resources not long ago (Cui, Huxley, Wu, & Dibley, 2010; Hou, 2008; Johnson et al., 2006; Zhang & Wang, 2011). Although existing research has suggested sex, socioeconomic and regional disparities in the epidemics of childhood overweight and underweight in China, scholars remain unclear whether demographical, socio-economic and spatial characteristics at the individual level are associated with age trajectories of BMI and the likelihood of being underweight or overweight across childhood. Based on a longitudinal data from the China Health and Nutrition Survey (CHNS), growth-curve models with unstructured variance-covariance matrices were employed to examine sex, socioeconomic and regional disparities in BMI trajectories across childhood and their implications for underweight and overweight in reform-era China.

THE SOCIO-ECONOMIC GRADIENT IN CHILDHOOD BODY COMPOSITION IN REFORM-ERA CHINA

Since China fully embraced a market economy in the early 1990s, this country has grown mightily in terms of production, foreign exchange reserves, savings and exportation. While the influences of this gigantic reform have spread to every corner of social and economic life in China, there is considerable evidence showing a socioeconomic gradient in childhood body composition. Based on longitudinal data from the China Health and Nutrition Survey (CHNS), a six-year follow-up study (1991-1997) showed that children from high-income families tended to move up to a higher BMI (body mass index) quartile group six years later, whereas children from low-income families tended to move down to a lower BMI quartile group (Y. Wang, Ge, & Popkin, 2000). Based on the same dataset, a longitudinal analysis of BMI, which documented a rapid increase in the prevalence of childhood obesity (from 1.5% in 1989 to 12.6% in 1997) in urban China, revealed that China's rural-urban divide was significantly associated with the growth of childhood BMI (944 children aged 2-6 in 1989). Net of other effects, boys had higher BMI than girls.(Luo & Hu, 2002). With regard to socioeconomic measures, a cross-sectional study comprising 824 students aged 12 to 14 years demonstrated that parental education had a significantly positive effect for boys' BMI (Shi, Lien, Kumar, Dalen, & Holmboe-Ottesen, 2005). A recent study based on children surveyed from 1991 to 2006 also reported that boys and children from higher income families tended to have higher prevalence of overweight and obesity (Cui et al., 2010). Although inadequate research has been conducted on a socioeconomic gradient in childhood underweight in China, a cross-sectional study demonstrated that household income, household heads' education, provincial differentials and urban residence were significantly associated with inequality in childhood malnutrition in the year 2000. This research also highlighted spatial disparity in childhood malnutrition and its consequences, including underweight (Z. Chen, Eastwood, & Yen, 2007). Based on the 1993 China Health and Nutrition Survey, the majority of underweight households (78.6%) were concentrated in southern China (Doak et al., 2002). Furthermore, it has been argued that both the increase in the prevalence of childhood overweight and the decrease in the prevalence of childhood underweight since the early 1990s could be attributed to the availability of economic resources in the reform era (Y. Wang, Monteiro, & Popkin, 2002).

METHODS

Sample

This research is based on data from the China Health and Nutrition Survey (CHNS), an international collaborative project administered by the Carolina Population Center at the University of North Carolina. Although the CHNS is not nationally representative, this ongoing open-cohort survey provides comprehensive information on the nutrition and health status of the Chinese population in nine provinces (*Guangxi*, *Guizhou*, *Heilongjiang*, *Henan*, *Hubei*, *Hunan*, *Jiangsu*, *Liaoning*, and *Shandong*) which vary substantially in terms of geography, economy, social development, dietary patterns and health indicators. Although the CHNS is not a nationally representative survey, it has been shown that patterns and trends of key statistics generated from the CHNS data are virtually the same as those from official statistics and national surveys (Popkin, 2008). Subjects within each province were selected using a stratified clustering sampling scheme. The CHNS also includes a series of demographic and socio-economic indicators. The CHNS was initiated in 1989 and continues to the present. To examine sex, socioeconomic and regional disparities in age trajectories, the sample used for this study included 1,694 children (2-11 years old) who were interviewed in 1993. Follow-up interviews were conducted in 1997 when they were age 6-15 (N = 1,222), in 2000 at ages 9-18 (N = 1,075), in 2004 at ages 13-22 (N = 471) and in 2006 at ages 15-24 (N = 278). The total number of observations is 4,741, which means that each of the 1,694 children first interviewed in 1993 participated in 2.8 waves on average.

Anthropometric measures

The first anthropometric measure was each participant's body mass index (kg/ m^2). After subjects were asked to be barefooted and wear lightweight clothing during the measurement, trained interviewers measured both weight (in *kilogram*) and height (in *centimeter*) to the nearest 0.10 unit of measurement. BMI cut-points for overweight and underweight proposed by the *International Obesity Task Force* and recommended for international use were adopted to determine overweight and underweight status, respectively (Cole, Bellizzi, Flegal, & Dietz, 2000; Cole, Flegal, Nicholls, & Jackson, 2007). Since the discrete reference cut-points were given for six-month intervals, a polynomial method was adopted to provide continuous curves for screening overweight and underweight individuals. Results from this polynomial interpolation can readily provide age- and sex-specific BMI cut-points for an individual's exact age. These fitted continuous curves for both overweight and underweight achieved almost a perfect fit (See Figure 1: $R^2 > 0.999$ and the sum of squared residuals <0.05 for all four panels). After calculating each individual's exact age from date of birth and date of measurement, subjects with BMI equal to or above their age-specific criterion for overweight were identified as overweight, whereas subjects with BMI below their age-specific criterion for underweight were identified as underweight. Note that the overweight category included both overweight and obese sample members.

Sex, socio-economic and regional indicators

Male was a dichotomous variable denoting the sex of each subject (male=1 and female=0). Two variables measuring socio-economic status were used. *Economic advantage* was a dichotomous variable denoting whether per capita household income was at the top 25% of household income surveyed in that wave. *Parental years schooling* was a continuous variable denoting the average years of schooling of parents. Next, three measures of regional disparities were included. *Urban China* was a dichotomous variable denoting whether a household lived in an urban area in 1993. Due to China's rural-urban divide, living in urban areas in the pre-reform era defined a person's entitlement to a variety of social and economic resources, such as education, health care and housing (Fu & Ren, 2010; Wu & Treiman, 2007). Because a substantial difference in the prevalence of underweight between southern and northern China has been reported elsewhere (Doak et al., 2002), *Southern China* was a dichotomous variable denoting whether a household lived in the southern part of China. *Eastern & Middle China* was a dichotomous variable denoting whether a household lived in the middle or eastern part of China. Compared with middle and eastern regions, the western region is underdeveloped and its economic growth lags behind other regions, which led to the national go-west campaign launched in 1999. All the socio-demographic variables were taken from the first wave of CHNS (the 1993 wave) examined in the current study. This strategy has been adopted by similar studies conducting growth-curve analyses of body composition (Danner, 2008; Harris, Perreira, & Lee, 2009).

Statistical analysis

Growth-curve modeling was employed to examine sex, socioeconomic and regional disparities in age trajectories of BMI, underweight and overweight. To capture curvilinear BMI growth during childhood and adolescence, a second order of age (acceleration) was included. Using a two-stage model formulation of hierarchical linear models, this growth curve model can be expressed as follows (Raudenbush & Bryk, 2002).

Level-1 or within-person model:

$$BMI_{ij} = \pi_{0i} + \pi_{1i} \times age_{ti} + \pi_{2i} \times age_{ti}^{2} + \varepsilon_{ti}$$

Level-2 or between-person models:

$$\pi_{0i} = \beta_{00} + \sum_{q=1}^{Q_0} \beta_{0q} X_{qi} + r_{0i}$$

Intercept

$$\pi_{1i} = \beta_{10} + \sum_{q=1}^{Q_1} \beta_{1q} X_{qi} + r_{1i}$$

Slope

$$\pi_{2i} = \beta_{20} + \sum_{q=1}^{Q_1} \beta_{2q} X_{qi} + r_{2i}$$

Acceleration

These models can be reparameterized as follows by a single formula using the interactions between age (square) and other variables:

$$BMI_{ij} = (\beta_{20} + \sum_{q=1}^{Q_1} \beta_{2q} X_{qi} + r_{2i}) \times age_{ti}^2 + (\beta_{10} + \sum_{q=1}^{Q_1} \beta_{1q} X_{qi} + r_{1i}) \times age_{ti} + \sum_{q=}^{Q_1} \beta_{0q} X_{qi} + \beta_{00} + r_{0i} + \varepsilon_{ti}$$
$$= \beta_{20} \cdot age_{ti}^2 + \beta_{10} \cdot age_{ti} + \sum_{q=1}^{Q_0} \beta_{0q} X_{qi} + (\sum_{q=1}^{Q_1} \beta_{2q}) \cdot X_{qi} \cdot age_{ti}^2 + (\sum_{q=1}^{Q_1} \beta_{1q}) \cdot X_{qi} \cdot age_{ti} + \beta_{00}$$
$$+ r_{2i} \cdot age_{ti}^2 + r_{1i} \cdot age_{ti} + r_{0i} + \varepsilon_{ti}$$

The unstructured variance-covariance matrix for level-2 random effects is given as below. To account for dependence among random components, $\tau_{ij}\,(i \neq j)$ is not restricted to be zero in the estimation.

$$T = \begin{bmatrix} \tau_{00} & \cdot & \cdot \\ \tau_{10} & \tau_{11} & \cdot \\ \tau_{20} & \tau_{21} & \tau_{22} \end{bmatrix}$$

Based on the age- and sex-specific cut-points for overweight and underweight generated by the aforementioned polynomial method, prevalence rates of overweight and underweight from childhood to adulthood (age 6-18) were predicted by hierarchical logistic models using the same set of independent variables and estimation strategy, with the exception that nonsignificant random components at the level-1 slope and acceleration were omitted to achieve statistical convergence. A three-point moving-average data-smoothing process was applied to the predicted prevalence.

RESULTS

The anthropometric, demographic and socioeconomic characteristics of the 1,694 subjects aged 2-11 in 1993 are shown in Table 1. The subjects had an average BMI of 15.79 and were, on average, 6.86 years old. More than half of these children were boys (53.8%). This is not surprising given the well-established unbalanced birth sex ratio in China (Zeng et al., 1993). Less than 20 percent of these children came from high-income families and the average years of schooling of their parents was 7.198 years. Children residing in urban China constituted about 20% of the sample surveyed in 1993. The majority of children lived in southern China. About 30% of the children were initially interviewed in western China. The characteristics of individuals tracked in the subsequent survey waves (1997, 2000, 2004 and 2006) are also shown in Table 1. As expected, both BMI and age showed monotonic increases over the period of study. While the growth patterns of other covariates are less clear and year-to-year changes were modest, individuals tracked in more recent years tended to be from high-income families or resided in urban areas.

With regard to age trajectories of BMI over childhood, results obtained from growth curve models are shown in Table 2. As indicated by the Model 1 in Table 2, both age and age square had significant effects on BMI, while the average BMIs in 1997, 2000 and 2004 were higher than that in 1993, net of other effects. When a series of socio-demographic indicators are included in Model 2, all of them except urban residence have significant effects on BMI. Net of other effects, males and subjects from high-income families had higher BMI, whereas subjects with higher parental years of schooling or located in southern or western China had lower BMI. Yet, results from both Model 1 and Model 2 have concealed heterogeneity in the BMI trajectories from childhood to adolescence, which was addressed in Model 3. When the interactions between age (square) and these indicators were taken into account in Model 3, the main effects of socio-demographic variables essentially correspond to differential intercepts of age trajectories across socio-demographic groups. Whereas males and individuals from southern and non-western China had significantly higher intercepts of age trajectories of BMI than their counterparts did, individuals from high-income families or urban China had significantly lower intercepts of age trajectories than their counterparts did. Meanwhile, the significant main effect of age (square) on BMI has been explained by its interactions with socio-demographic variables. With regard to the interaction between age and socio-demographic variables (or the level-1 slope), the age trajectories of BMI increased significantly faster for individuals from high-income families, urban China, northern China or families with lower parental years of schooling. Yet, these increases (or decreases) in age trajectories were moderated by the interactions between age square and socio-demographic variables (or level-1 acceleration) because the sign of level-1 acceleration is opposite to that of the level-1 slope for each socio-demographic group. In particular, the moderating effects on age trajectories of BMI are significant for almost all socio-demographic groups (except sex). Finally, the validity of assuming random components during estimation is supported by the significant off-diagonal elements in the variance-covariance matrix from Model 1 to Model 3.

To examine the implications of age trajectories in BMI on childhood overweight and underweight, age trajectories of overweight and underweight prevalence rates in the transition from childhood to adulthood (age 6-18) were predicted. In Figure 2, overweight and underweight prevalence rates were estimated based on partial coefficients of full models (the same set of covariates as those in Model 3 of Table 2). The levels and patterns of overweight prevalence are similar to these estimated from nationally representative studies, such as the Chinese National Survey on Students Constitution and Health (C. Ji, 2007; C. Y.

Ji & Cheng, 2009). The socio-demographic disparities in age trajectories were generally greater for underweight than for overweight, except for those in southern and northern China. Over the age interval investigated, the prevalence rates of underweight grew steadily from age 6 to age 13, then either leveled off or declined afterwards. The age trajectories in the prevalence of overweight largely showed a long-term decline, although the decline slowed down around age 12 for most socio-demographic groups. In particular, females' prevalence rates of underweight were consistently higher than those of males. Although males had higher prevalence rates of overweight than females, the sex disparity in overweight was barely noticeable until age 12 when the sex difference widened. This modest sex disparity is in line with findings from existing studies using the CHNS 1993 (Luo & Hu, 2002; Youfa Wang, 2001). Children from high-income families had lower prevalence rates of underweight and higher prevalence rates of overweight than children from medium- and low-income families, while the income disparity in overweight increased for older children. There was virtually no difference in the age trajectories of overweight for children having different parental years of schooling and this result was robust with different cut-off points for parental years of schooling (e.g., 7 years or 9 years). Net of other effects, individuals with higher parental years of schooling were slightly more likely to be underweight, although the effect of education on underweight was only marginally significant (results available upon request).

With regard to regional disparities in age trajectories of overweight and underweight, the prevalence rates of underweight for children in urban China showed a steady decline from age 6 to age 18, whereas the prevalence of underweight for their peers in rural China dramatically increased from age 6 to age 13 and then decreased. Although urban children had higher prevalence of overweight than their peers in rural China, the age trajectories began to converge around age 13 and a regional crossover happened afterwards. From age 6 to 18, children living in southern China and western China had consistently higher prevalence rates of underweight and lower prevalence rates of overweight than their peers living in northern and middle & eastern China, respectively. However, the gaps in both overweight and underweight prevalence rates among children located at different geographical locations in China (south versus north, west versus middle and east) tended to decrease after age 13. The prevalence rates of overweight and underweight across different socio-demographic groups are shown in Appendix 1.

DISCUSSION

In this research, sex, socioeconomic and regional disparities in age trajectories of BMI across childhood were examined using growth curve models. By tracking changes in BMI of a cohort across several survey waves, this study discusses the overweight and underweight epidemics from a life course perspective and shows the differential effects of socio-economic status at different stages from childhood to adolescence, after adopting a reasonable variance-covariance matrix adjusting for correlated observations tracked over time. Net of other effects, results showed that boys and children from high-income families had significantly higher BMI, whereas children with higher parental education, and living in southern or western China had lower BMI. Moreover, the significant main effects of age and age square on childhood BMI could be explained by their interactions with socio-demographic variables. Based on a polynomial method and logistic growth-curve analyses, the implication of BMI trajectories on underweight and overweight in the transition from childhood to adulthood (age 6-18) was also investigated. For the cohort tracked over the period of study, the underweight epidemic in China remains a significant health burden deserving serious attention, although lots of efforts have been directed to control and prevent the overweight epidemic in recent years. Whereas parental education had little or marginal effect on age trajectories of overweight or underweight, boys and children from high-income families were associated with lower underweight prevalence and higher overweight prevalence. Substantial regional disparities in age trajectories of underweight and overweight were observed. Children from urban areas, northern China or non-western China showed higher prevalence rates of overweight, whereas their counterparts (children from rural areas, southern China or western China) had higher prevalence rates of underweight.

The sex disparities in age trajectories of BMI, underweight and overweight were not surprising given the strong preference of boys over girls in Confucian culture because sons, instead of daughters, are more relevant to the continuation of family lines, intergenerational transfers of property rights and the living arrangements of older parents (Lee & Wang, 2001; Poston Jr., Gu, Liu, & McDaniel, 1997). The income disparity in age trajectories was also expected as high-income families have better access to nutrition than others. Whereas it is worthwhile for future studies to investigate why children of better educated parents are slightly more likely to be underweight, the absence of an educational disparity in age trajectories of overweight is consistent with findings reported elsewhere (Fu & George, 2015) and cannot be explained by the effects of family income (results available upon request). Given that children of better educated parents were not significantly less likely to be overweight, this observation suggests that knowledge of public health, especially that relevant to overweight, had not been incorporated in formal education in China (Kan & Tsai, 2004). Consistent with results from existing studies (Doak, Adair, Monteiro, & Popkin, 2000; Luo & Hu, 2002), the results point to the significance of China’s rural-urban divide in shaping childhood underweight and overweight. Because China adopted Soviet Russia’s model of prioritizing urban industrial growth at the cost of rural development in the early 1950s, the socialist state’s bias towards urbanites and its related ideology that rural persons should be self-reliant deprived rural persons’ entitlements to a variety of social benefits and state resources, such as subsidized food, health care and social welfare (Chan & Zhang, 1999; Wu & Treiman, 2007). As energy intake was not in line with physical growth in the transition from childhood to adolescence, a dramatic increase in the prevalence rates of underweight was observed for rural children from ages 6 to 13, whereas the prevalence of underweight for their urban peers showed a steady decrease over the same age interval. The rural-urban convergence in trajectories of overweight may suggest the synergy of both selection and assimilation effects of massive rural-urban migration in China (J. Chen, 2011; B. Wang, Li, Stanton, & Fang, 2010). On the one hand, rural migrants probably tended to be healthy and normal-weight, leaving overweight or obese peers behind in rural areas and contributing to the rise of overweight prevalence in rural areas. On the other hand, when rural migrants were exposed to an obesogenic environment in urban areas, their body weight was catching up with that of urban residents. Finally, the differences in the prevalence of overweight and underweight between children from western China and non-western China were expected because economic and social development in western China greatly lagged behind other regions (Grogan, 1995). Different dietary patterns also account for the south-north differences in childhood underweight and overweight (Doak et al., 2002; Zhou et al., 1994).

These findings have important implications. For the dual burden of nutritional problems in reform-era China, this research suggests that risk factors for overweight tended to be protective factors for underweight, and vice versa. For example, children who had lower prevalence rates of underweight in the transition from childhood to adulthood (such as boys, children from high-income families, children living in urban China, etc.) also exhibited higher prevalence rates of overweight than their counterparts did. Meanwhile, as demonstrated by the age trajectories of underweight and overweight, children aged 6 to 13 were more vulnerable to underweight, whereas older children who were at the age for secondary education were more vulnerable to overweight. Although these results do not necessarily mean that the focus of intervention programs should be shifted from underweight in primary schools to overweight in secondary schools in China, policy makers, health workers and school teachers should be aware of the critical periods for intervening in childhood underweight and overweight, respectively. Regional disparities also play an important role in driving the distribution of childhood overweight and underweight. This suggests that public health efforts to reduce both underweight and overweight should be targeted at regions where the need is greatest.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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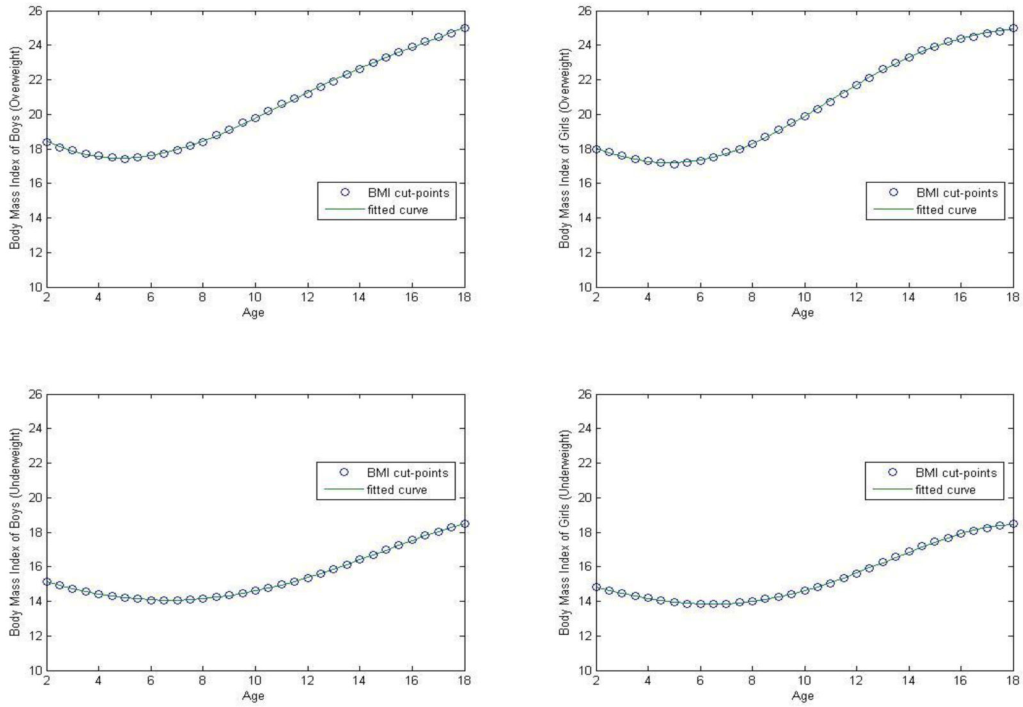

Figure 1.

Fitted age- and sex-specific cut-points for overweight and underweight by a polynomial method

(R^2 > 0.999 and the sum of squared residuals <0.05 for all four figures)

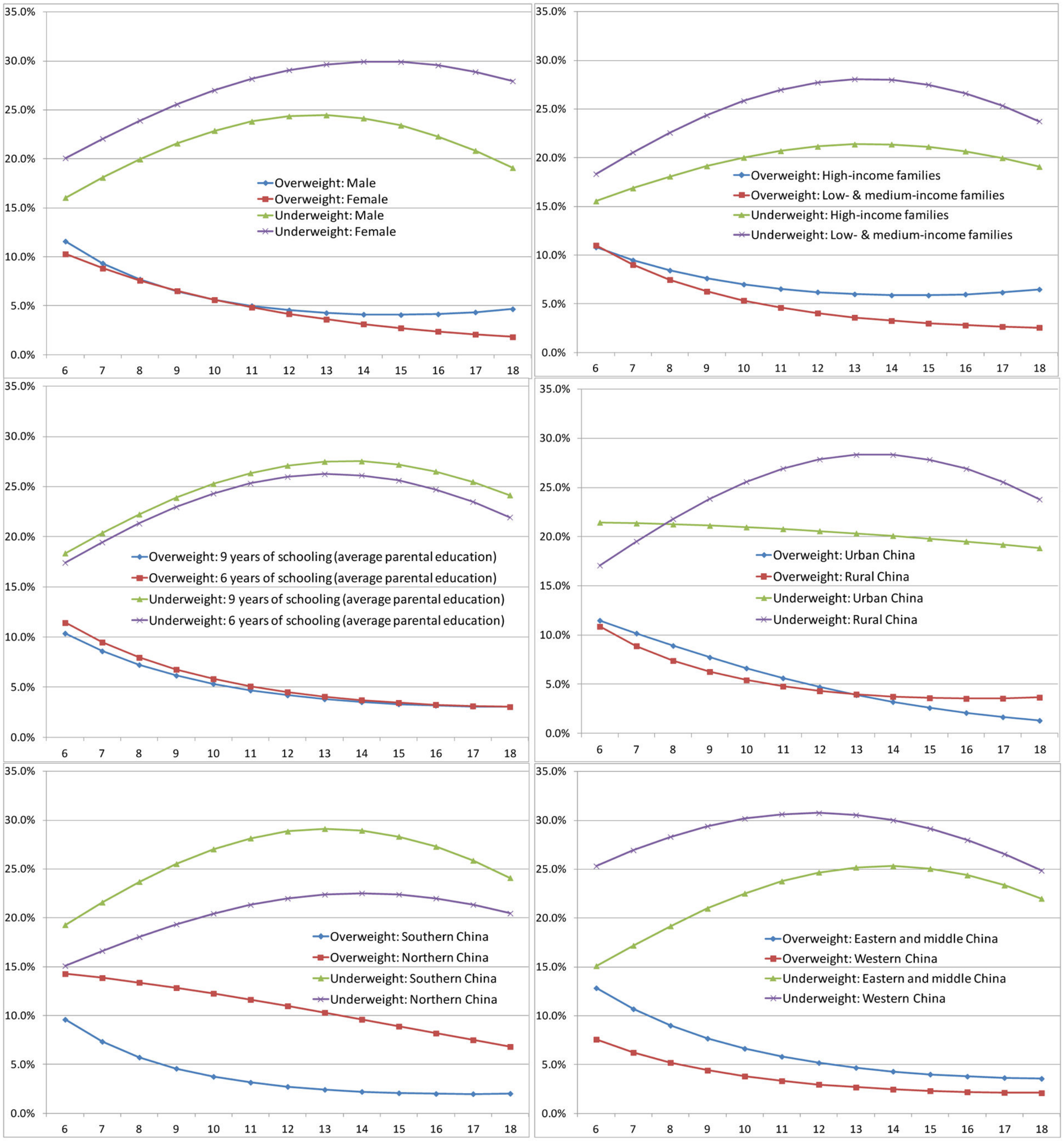

Figure 2.

Age trajectories of the prevalence in overweight and underweight as moderated by sex, socioeconomic status and regional disparity (children and youth aged 6- 18)

Note: The prevalence rates of overweight and underweight are predicted from the estimated partial regression coefficients of the full model of growth-curve analyses.

Table 1

Characteristics of the study sample interviewed in the 1993 wave and tracked in subsequent waves of the CHNS (N=1,694)

	1993 Wave	(N=1,694)	1997 Wave	(N=1,222)	2000 Wave	(N=1,076)	2004 Wave	(N=471)	2006 Wave	(N=278)
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Body Mass Index	15.792	2.220	16.627	2.556	17.927	2.910	19.982	3.232	20.716	3.133
Age	6.856	2.393	10.859	2.361	13.484	2.241	16.957	2.397	19.483	2.555
Male	53.8%		53.6%		54.6%		54.8%		56.8%	
High-income families	18.5%		16.8%		17.4%		20.6%		22.3%	
Parental years of schooling	7.198	3.098	6.967	3.051	7.262	2.997	7.103	2.998	7.214	3.032
Urban China	19.9%		16.9%		16.7%		15.9%		20.5%	
Southern China	64.2%		73.7%		64.5%		65.2%		65.5%	
Eastern & Middle China	70.6%		66.4%		71.7%		68.6%		65.5%	

Table 2

Growth curve models of BMI trajectories of children and youth in China: 1993-2006

	Model 1		Model 2		Model 3	
	Coefficient	**S.E.**	**Coefficient**	**S.E.**	**Coefficient**	**S.E.**
Level-1 intercept						
Age	−0.408	0.043 ***	−0.391	0.043 ***	0.130	0.135
Age square	0.031	0.002 ***	0.031	0.002 ***	0.010	0.006
Waves of survey (the wave of 1993 as the reference group)						
The 1997 wave	0.345	0.104 **	0.342	0.102 **	0.355	0.102 ***
The 2000 wave	0.785	0.154 ***	0.731	0.149 ***	0.727	0.149 ***
The 2004 wave	1.124	0.259 ***	1.063	0.251 ***	1.035	0.251 ***
The 2006 wave	0.340	0.347	0.275	0.338	0.220	0.338
Male			0.204	0.086 *	0.917	0.343 **
High-income families			0.315	0.115 **	−1.413	0.460 **
Parental years of schooling			−0.034	0.015 *	0.108	0.060
Urban China			0.168	0.117	−1.097	0.472 *
Southern China			−0.585	0.102 ***	1.401	0.406 **
Eastern & Middle China			0.577	0.106 ***	1.396	0.429 **
Intercept	16.909	0.201 ***	16.829	0.265 ***	14.118	0.693
Level-1 slope						
Male					−0.124	0.068
High-income families					0.290	0.091 **
Parental years of schooling					−0.031	0.012 **
Urban China					0.269	0.094 **
Southern China					−0.364	0.082 ***
Eastern & Middle China					−0.145	0.085
Level-1 acceleration						
Male					0.004	0.003
High-income families					−0.009	0.004 *
Parental years of schooling					0.001	0.001 **
Urban China					−0.012	0.004 **
Southern China					0.013	0.004 ***
Eastern & Middle China					0.005	0.004 ***
τ_{11} (age)	0.278	0.062 ***	0.284	0.063 ***	0.221	0.060 ***
τ_{22} (age square)	0.001	0.000 ***	0.001	0.000 ***	0.001	0.000 ***
τ_{00} (intercept)	3.944	1.434 ***	4.581	1.472 ***	3.079	1.371 ***
τ_{21} (age, age square)	−0.012	0.003 ***	−0.012	0.003 ***	−0.010	0.003 ***
τ_{10} (age, intercept)	−0.918	0.293 **	−1.025	0.298 ***	−0.723	0.281 *

	Model 1		Model 2		Model 3	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
τ_{20} (age square, intercept)	0.038	0.013**	0.042	0.013**	0.031	0.012*
σ_{ε}^{2} (residual)	3.284	0.116***	3.295	0.117***	3.310	0.117***

Note: Statistical significance:

* $p < 0.05$;

** $p<0.01$;

*** $p<0.001$ (two-tailed tests);

For the Model 1 in Table 1, the unexplained variance σ^2 is 4.394 (.111) in the absence of random effects in slope and acceleration and 6.454 (.133) in the absence of any random effects.