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Trends of Age at Menarche and Association with Body Mass Index in Chinese School-Aged Girls, 1985-2010

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Objectives: To estimate the shifts in age at menarche from 1985 to 2010, compare the differences of average age at menarche between urban and rural groups, and determine the association of menarche with body mass index (BMI).

Study design: The data were obtained from 4 cross-sectional Chinese National Surveys on Students' Constitution and Health (1985, 1995, 2005, and 2010). In this representative sample of Chinese school-aged girls, the average age at menarche was determined using probit analysis and compared between urban and rural areas. Logistic regression was used to assess the association of BMI with the likelihood of having reached menarche.

Results: The age at menarche in Chinese girls dropped from 13.41 years to 12.47 years from 1985 to 2010. There was a significant difference in age at menarche between urban and rural girls over time, with urban girls having their menarche earlier than rural girls. Logistic regression showed that a higher BMI was strongly associated with an increased likelihood of having reached menarche, even after controlling for age, urban or rural residence, province, social economic status, and school.

Conclusion: The analysis suggests a drop of about 4.5 months per decade in the average age at menarche over the past 25 years, and a significant inverse association between BMI and having reached menarche. Considering that both early menarche and higher BMI are significant risk factors for chronic diseases, and may act together in later years to the detriment of a woman's health, greater attention should be paid to the health of girls with earlier menarche and higher BMI.

Key words: menarche; China; body mass index; urban-rural; girls

List of Abbreviations:
BMI: body mass index
CNSSCH: Chinese National Survey on Students' Constitution and Health

Introduction

Menarche, the onset of menses, is a strong indicator of puberty in girls. Numerous international studies have shown that puberty is occurring earlier among girls than in previous decades [1-4]. Given the possible associations between early menarche and obesity, cardiovascular disease, and certain cancers [5-7], there is a need for current information on the age at menarche among girls in different countries; however, reports of age at menarche for Chinese girls have been few in number, generally outdated, or limited because of their regional composition [8, 9], and the trend of age at menarche over the past 25 years is unknown.

Questions as to whether age at menarche has decreased among Chinese girls, whether a relationship between age at menarche and body mass index (BMI) exists, and whether such a relationship has changed over the past 25 years remain unanswered. Data on menarche are available from the Chinese National Survey on Students' Constitution and Health (CNSSCH) [10-13], which has been conducted every 5 years since 1985 under the combined auspices of the Ministry of Education, Ministry of Health, Ministry of Science and Technology, State of National Affairs, and State Sports General Administration of the People's Republic of China. The present analysis sought to: (1) estimate the shifts in age at menarche from 1985 to 2010; (2) compare the differences of average age at menarche between urban and rural groups; and (3) determine any possible association between age at menarche and BMI.

Methods

Data were obtained from the 1985, 1995, 2005, and 2010 CNSSCHs [10-13].The sampling procedure has been described in detail previously [8, 14] and was the same at all CNSSCH time points. The participants were primary school and high school girls aged 9-18 years from the same areas in each province. The sample sizes in the CNSSCH for different years ranged from 3764 to 6213 in each sex and age-specific subgroup in urban areas, and from 3737 to 6209 in rural areas, and the urban: rural was approximately 1:1 in each survey (Table I). The sample size in each subgroup was larger in 1985 than in the subsequent years, because the Chinese government consulted relevant experts after the 1985 survey and consequently reduced the sample size. To ensure national representation, the surveys after 1985 proposed to select the same schools as in 1985, but fewer students in each school; thus, more than 85% of the schools sampled were identical in each survey. All subjects were selected by stratified cluster sampling from some classes as clusters selected at random from each grade in the selected school, so that the sample size in sex- and age-specific subgroups varied slightly in each survey after 1985.

Each province had equal sample sizes from 3 socioeconomic groups (“upper”, “moderate”, and “low”) at the regional level. Five factors were taken into consideration when defining socioeconomic status at the regional level: regional gross domestic product, total yearly income per capita, average food consumption per capita, natural growth rate of the population, and regional social welfare index [14].

The time of data collection in survey years 1995, 2005, and 2010 was September-November; in contrast, data for the 1985 CNSSCH were collected from March to June. Our study population included only individuals of Han ethnicity, which represents 92% of the total Chinese population, from 26 mainland provinces and 4 municipalities, excluding Tibet (where Han is the minority ethnic group). All eligible participants had lived in the area for at least 1 year. They received medical examinations before the national survey, to ensure the absence of overt physical or mental disorders. The project was approved by the Medical Research Ethics Committee of the University of Queensland (2011001199).

Individual menarchal data were collected by the status quo method.1 Girls aged $\geqslant$ 9 years in each CNSSCH were interviewed by a female physician or school nurse and asked whether or not menarche had occurred. Because almost all school girls of that age have some knowledge of menstrual periods from school health education, a dichotomous response (yes/no) for menarchal status could be easily obtained. The physicians or school nurses were well trained to explain menstruation to young girls, so that it could be distinguished from other phenomena, such as bleeding in the perineum due to injury. Probit analysis [15] was used to calculate age at menarche. The girls' ages were recorded and calculated as decimal ages (eg, 8.00-8.99 years, 9.00- 9.99 years).

Height (in cm) and weight (in kg) were all measured using similar instruments at all

survey sites [14].The girls were required to wear only light clothing and stand erect, barefoot, and at ease while being measured. Weight was recorded to the nearest 0.1 kg with a standardized scale, and height was recorded to the nearest 0.1 cm with a portable stadiometer. Both the scales and stadiometers were calibrated before use. BMI was calculated as body weight (in kg) divided by height (in m) squared (kg/m^2). BMI-for-age z-score, a quantitative measure of the deviation of a specific BMI value from the mean of that population, was calculated using the World Health Organization 2007 reference data [16]. Measurements at the survey site were conducted by a team of field professionals trained in anthropometric measurements.

Statistical analyses

BMI was calculated for each age group, urban and rural subgroups, and survey year. The distributions of BMI for-age z-scores for the 4 survey years by urban and rural subgroups were represented using kernel densities, which are nonparametric smoothed graphs independent of bin width when compared with histograms. The percentages of menstruating girls of each age by urban and rural subgroups were determined. The age at menarche and the 95% CI in subgroups for different years were calculated using probit regression. Probit models were fit to the proportion of girls of each age who had reached menarche. A cumulative normal curve was fit to the proportion of girls of each age who were menarchal, and the population median age at menarche was the corresponding age at which 50% of girls in the population could be predicted to have reached menarche. ANOVA was used to compare BMI in

premenarchal and postmenarchal girls in different years. A 2-sided *P* value <.05 was considered significant. Logistic regression was used to model the association between the log odds of being menarchal and BMI, age, urban-rural residence, province, socioeconomic status, and school. BMI and age were continuous variables, and urban-rural residence was a categorical variable, with rural as the reference category. The design effect of cluster sampling by school was taken into account in the logistic regression models using Stata 12.1 (Stata Corp, College Station, Texas). All other analyses were conducted with SPSS 20.0 (IBM, Armonk, New York).

Results

Table I presents BMI values of Chinese girls aged 9-18 years from the CNSSCH between 1985 and 2010. During the course of those 25 years, the mean BMI increased continuously in most subgroups. Figure 1 shows a similar trend, in which the curves of BMI-for-age z-score distribution of both urban and rural girls shifted to the right over time at almost every percentile. The M-d plots of BMI by each age group show a similar trend as well (data not shown). Table II presents the percentage of menstruating girls of each age in different years. Both the urban-rural sample and the combined sample show percentages of menstruating girls as S-shaped curves with declining age at menarche over time (Figure 2). The average age at menarche in China was estimated to have decreased by 4.5 months per decade, and the distinction between rural and urban areas was 1.9 months per decade, with a downward shift of 3.6 months per decade in urban areas and 5.5 months per decade in rural areas. The

results were consistent with a significant decline in age at menarche over the past 25 years in the total population, because the 95% CI of age at menarche estimate in 1985 or in 2010 did not overlap in the total sample. In all age groups, the percentage of menstruating girls was higher and the age at menarche was lower in urban residents compared with rural residents at all 4 surveys. However, the decreases in estimated age at menarche over the past 25 years were smaller in urban residents (3.6 months per decade vs 5.5 months per decade) (Figure 2).

Girls of the same age who had reached menarche had a higher mean BMI than girls who had not reached menarche (Table III). For example, menarchal girls aged 12 years in the combined population had a mean BMI 1.72 units higher in the 1985 CNSSCH, 1.81 units higher in the 1995 CNSSCH, 1.75 units higher in the 2005 CNSSCH, and 1.96 units higher in the 2010 CNSSCH ($P < .001$ for each survey) compared with premenarchal girls of the same age.

In each survey period, higher BMI was associated with an increased likelihood of having reached menarche after adjusting for age, urban-rural residence, province, socioeconomic status, and school. The coefficient for BMI in the logistic regression models was highest in the 1985 CNSSCH (OR, 1.74; 95% CI, 1.70-1.78), and was almost identical in the subsequent 3 surveys. Urban-rural residence independently predicted an increased likelihood of having reached menarche in each CNSSCH; however, the magnitude of this association declined over time (Table IV).

Discussion

Over the past 25 years, age at menarche declined from 13.41 to 12.47 years, an average decrease of 4.5 months per decade. In Western Europe, this decrease has been approximately 3-4 months per decade from 1830 to 1980 [1]. Anderson et al [17, 18] found that the average age at menarche in US girls dropped from 12.75 years in 1963-1970 to 12.54 years in 1988-1994, and then to 12.34 years in 1999- 2002. Hosokawa et al [3] concluded that the average age at menarche of Japanese girls has decreased by 1.6 years over the 50 years since 1930, from 13.8 to 12.2 years. Although the tendency of decreasing age at menarche has recently slowed in Japan, The Netherlands, Germany, and Bulgaria [3, 19] and has remained stable in Belgium and Norway, [19] it has continued to decline in China, in both urban and rural areas.

The difference in menarchal age between urban and rural regions is well established, with urban girls reaching menarche earlier than rural girls [19, 20]. It is thought that urbanization influences the evolution of maturational age, likely through increasing BMI [20].Our research also has identified significant differences between urban and rural girls in age at menarche over time; however, we have shown a continuous decrease in the magnitude of the association between age at menarche and urban-rural residence coinciding with the urbanization of China over the last 30 years [21, 22]. According to the official statistics, the rate of urbanization increased from 23.71% in 1985 [23] to 29.04% in 1995 [21] and further to 49.68% in 2010 [24].

Our study found that the downward shift of the average age at menarche has been accompanied by a simultaneous increase in BMI. Others have shown that BMI is an independent predictor for reaching menarche. A plausible explanation for this association is the direct effects of fat on the hypothalamic-pituitary-gonadal axis (eg, aromatization of androgens into estrogens) [6, 25-29]. We found that higher BMI was associated with earlier menarche at each survey point, corroborating earlier findings indicating that girls with a higher BMI are more likely to start menses at a younger age than lean girls. Our cross sectional analyses of premenarchal and postmenarchal girls in each survey year support this conclusion as well; postmenarchal girls had a higher average BMI compared with their premenarchal peers in most age groups in both urban and rural areas.

As for the estimates of OR between menarche and BMI, we found that it was greatest in the 1985 CNSSCH, which was considered the beginning of childhood overweight and obesity epidemic [30],although the entire nutritional status of the population was very low at the time, with 22% of school children and adolescents suffering from malnutrition [31].Since then, estimates have been almost identical in the subsequent 3 surveys conducted between 1995 and 2010, when the nutritional status of entire population of children was improving, suggesting a fairly stable association between menarche and BMI, even though other factors may have changed over the past 15 years.

There is epidemiologic evidence that earlier menarche is associated with adverse health effects. Women who experience earlier menarche are more likely to have estrogen dependent diseases such as breast cancer [7], and also experience earlier mortality [32].Because earlier menarche and higher BMI may act together in later years to the detriment of a woman's health, it may be advisable for school health providers and doctors to pay more attention to pubescent girls with those characteristics.

Our investigation has several limitations. First, it is not a prospective cohort study, because each CNSSCH was a cross-sectional survey conducted with different participants. The average age at menarche might not reflect the exact situation in the population; this can be clarified only by a longitudinal cohort study. Second, although misclassification of menarchal state is possible, the method used is unlikely to be biased, because it relies on the report of whether or not a salient event like menarche has occurred. Third, the time of year of data collection was different in 1985 compared with the other survey years. Considering that there tend to be seasonal differences in physical activity, and that children tend to be heavier in winter and spring, this is a study limitation. Fourth, there was a variation in sample size over time; however, the various sample sizes came from the stratified cluster sampling, and all sample sizes were large, which could ensure the representativeness of the study sample.

Our results suggest that interventions focused on overweight or obesity control in girls before age 9 years may have the effect of delaying early menarche as well. The decrease in the magnitude of the association between menarche and urban-rural residence may be explained to a certain degree by the urbanization of China.

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Table Ⅰ BMI characteristics of sample participants, girls age 9~18 years from 1985 to 2010 (Mean (SE))

Age	1985		1995		2005		2010	
	N	BMI (kg/m^2)	N	BMI (kg/m^2)	N	BMI (kg/m^2)	N	BMI (kg/m^2)
Urban								
9~	5916	14.7(0.02)	4125	15.3(0.03)	4569	16.2(0.04)	3764	16.5(0.04)
10~	6179	15.1(0.02)	4402	15.9(0.03)	4846	16.8(0.04)	4105	17.1(0.04)
11~	6203	15.6(0.02)	4413	16.6(0.04)	4813	17.6(0.04)	4319	17.8(0.05)
12~	6213	16.4(0.02)	4398	17.4(0.04)	4728	18.1(0.04)	4352	18.4(0.05)
13~	6211	17.5(0.02)	4394	18.3(0.04)	4833	18.8(0.04)	4324	19.2(0.05)
14~	6206	18.3(0.03)	4381	18.9(0.04)	4790	19.5(0.04)	4305	19.7(0.04)
15~	6209	18.9(0.03)	4394	19.4(0.04)	4865	20.0(0.04)	4358	20.1(0.04)
16~	6208	19.3(0.02)	4395	19.8(0.04)	4840	20.2(0.04)	4400	20.3(0.04)
17~	6185	19.6(0.03)	4402	19.9(0.03)	4763	20.3(0.04)	4468	20.4(0.04)
18~	5957	19.8(0.03)	4365	20.1(0.03)	4690	20.4(0.04)	4391	20.3(0.04)
Total	61487	17.5(0.01)	43669	18.2(0.01)	47737	18.8(0.01)	42786	19.0(0.02)
Rural								
9~	5970	14.8(0.01)	4066	14.9(0.02)	4428	15.6(0.03)	3737	16.0(0.04)
10~	6112	15.1(0.02)	4356	15.4(0.02)	4370	16.1(0.03)	3979	16.6(0.04)
11~	6105	15.6(0.02)	4251	16.0(0.03)	4490	16.7(0.03)	4176	17.1(0.04)
12~	6099	16.3(0.02)	4201	16.8(0.03)	4407	17.3(0.04)	4309	18.0(0.04)
13~	6209	17.7(0.02)	4160	17.9(0.03)	4503	18.3(0.04)	4412	18.7(0.04)
14~	6201	18.5(0.02)	4194	18.7(0.03)	4484	18.9(0.04)	4419	19.3(0.04)
15~	6199	19.4(0.02)	4190	19.4(0.03)	4599	19.5(0.04)	4428	19.8(0.04)
16~	6209	20.1(0.02)	4122	20.0(0.03)	4545	20.0(0.03)	4423	20.1(0.04)
17~	6203	20.5(0.02)	4128	20.3(0.03)	4577	20.2(0.03)	4398	20.3(0.04)
18~	6109	20.7(0.02)	4092	20.4(0.03)	4627	20.3(0.03)	4446	20.4(0.04)
Total	61416	17.9(0.01)	41760	18.0(0.01)	45030	18.3(0.01)	42727	18.7(0.01)
Combined								
9~	11886	14.7(0.01)	8191	15.1(0.02)	8997	15.9(0.02)	7501	16.2(0.03)
10~	12291	15.1(0.01)	8758	15.6(0.02)	9216	16.5(0.03)	8084	16.8(0.03)
11~	12308	15.6(0.01)	8664	16.3(0.02)	9303	17.1(0.03)	8495	17.5(0.03)
12~	12312	16.3(0.02)	8599	17.1(0.03)	9135	17.7(0.03)	8661	18.2(0.03)
13~	12420	17.6(0.02)	8554	18.1(0.03)	9336	18.6(0.03)	8736	18.9(0.03)
14~	12407	18.4(0.02)	8575	18.8(0.03)	9274	19.2(0.03)	8724	19.5(0.03)
15~	12408	19.1(0.02)	8584	19.4(0.02)	9464	19.8(0.03)	8786	19.9(0.03)
16~	12417	19.7(0.02)	8517	19.9(0.02)	9385	20.1(0.03)	8823	20.2(0.03)
17~	12388	20.0(0.02)	8530	20.1(0.02)	9340	20.3(0.03)	8866	20.4(0.03)
18~	12066	20.3(0.02)	8457	20.2(0.02)	9317	20.3(0.02)	8837	20.4(0.03)
Total	122903	17.7(0.01)	85429	18.1(0.01)	92767	18.6(0.01)	85513	18.9(0.01)

Table Ⅱ Average age at menarche and percentage of girls who had reached menarche from 1985 to 2010

Age	1985		1995		2005		2010	
	N[a]	Percent menarcheal	N[a]	Percent menarcheal	N[a]	Percent menarcheal	N[a]	Percent menarcheal
Urban								
9~	5	0.08	10	0.24	10	0.21	29	0.77
10~	44	0.71	55	1.2	145	3.0	127	3.1
11~	320	5.2	427	9.7	794	16.5	897	20.8
12~	1483	23.9	1719	39.1	1905	40.3	2423	55.7
13~	4302	69.3	3418	77.8	3849	79.6	3659	84.6
14~	5565	89.7	4057	92.6	4594	95.9	4169	96.8
15~	6107	98.4	4276	97.3	4782	98.3	4318	99.1
16~	6189	99.7	4324	98.4	4833	99.9	4369	99.3
17~	6173	99.8	4353	98.9	4756	99.9	4464	99.9
18~	5952	99.9	4323	99.0	4683	99.9	4378	99.7
AAM		13.09(12.86-13.32)[b]		12.82(12.10-13.50)[b]		12.60(12.32-12.88)[b]		12.35(11.62-13.01)[b]
Rural								
9~	0	0	5	0.12	33	0.75	24	0.64
10~	6	0.10	25	0.57	127	2.9	108	2.7
11~	90	1.5	249	5.9	492	11.0	593	14.2
12~	580	9.5	956	22.8	1406	31.9	2000	46.4
13~	2903	46.8	2678	64.4	3127	69.4	3464	78.5
14~	4657	75.1	3710	88.5	3992	89.0	4181	94.6
15~	5702	92.0	4001	95.5	4480	97.4	4372	98.7
16~	6113	98.5	4016	97.4	4521	99.5	4409	99.7
17~	6187	99.7	4033	97.7	4511	98.6	4385	99.7
18~	6106	100.0	4020	98.2	4621	99.9	4441	99.9
AAM		13.73(13.63-13.93)[b]		13.26(12.64-13.84)[b]		12.92(12.63-13.21)[b]		12.59(12.36-12.82)[b]
Combined								
9~	5	0.04	15	0.18	43	0.48	53	0.71
10~	50	0.41	80	0.91	272	3.0	235	2.9
11~	410	3.3	676	7.8	1286	13.8	1490	17.5
12~	2063	16.8	2675	31.1	3311	36.3	4423	51.1
13~	7205	58.0	6096	71.3	6976	74.7	7123	81.5
14~	10222	82.4	7767	90.6	8586	92.6	8350	95.7
15~	11809	95.2	8277	96.4	9262	97.9	8690	98.9
16~	12302	99.1	8340	97.9	9354	99.7	8778	99.5
17~	12360	99.8	8386	98.3	9267	99.2	8849	99.8
18~	12058	99.9	8343	98.7	9304	99.9	8819	99.8
AAM		13.41(13.29-13.53)[b]		13.03(12.40-13.63)[b]		12.76(12.51-13.00)[b]		12.47(12.10-12.83)[b]

a N is the number of girls at that age who had reached menarche.

b Estimates are the age at which 50% girls are menarcheal and 95% confidence interval from probit analysis.

Table Ⅲ Mean BMI in pre-menarcheal and post-menarcheal girls from 1985 to 2010(Mean (SD))

Age	1985			1995			2005			2010		
	Premenarcheal	Postmenarcheal	*P* value	Premenarcheal	Postmenarcheal	*P* value	Premenarcheal	Postmenarcheal	*P* value	Premenarcheal	Postmenarcheal	*P* value
Urban												
9~	14.69(1.36)	15.45(1.38)	0.216	15.29(1.91)	17.45(4.35)	<0.001	16.20(2.46)	16.62(2.95)	0.583	16.45(2.56)	17.25(2.41)	0.0962
10~	15.05(1.45)	16.74(1.63)	<0.001	15.84(2.14)	18.08(3.11)	<0.001	16.77(2.68)	18.43(3.05)	<0.001	16.99(2.70)	19.13(3.05)	<0.001
11~	15.53(1.59)	17.57(1.82)	<0.001	16.41(2.36)	18.61(2.80)	<0.001	17.25(2.80)	19.23(3.20)	<0.001	17.38(2.80)	19.56(2.95)	<0.001
12~	15.93(1.64)	17.76(2.01)	<0.001	16.69(2.34)	18.42(2.54)	<0.001	17.46(2.85)	19.10(2.96)	<0.001	17.26(2.61)	19.34(2.97)	<0.001
13~	16.40(1.60)	17.97(1.86)	<0.001	16.97(2.39)	18.66(2.53)	<0.001	17.12(2.43)	19.22(2.93)	<0.001	17.72(2.85)	19.47(3.01)	<0.001
14~	16.64(1.72)	18.44(1.98)	<0.001	17.94(2.60)	18.95(2.47)	<0.001	17.44(2.51)	19.59(3.00)	<0.001	18.00(2.54)	19.76(2.94)	<0.001
15~	17.11(1.80)	18.89(1.97)	<0.001	19.35(3.10)	19.42(2.44)	0.737	19.43(2.82)	19.99(2.89)	0.082	19.00(3.37)	20.06(2.83)	0.019
16~	17.93(2.03)	19.32(1.94)	0.002	20.44(2.54)	19.81(2.34)	0.025	20.74(4.05)	20.15(2.62)	0.548	19.18(2.84)	20.26(2.63)	0.022
17~	19.02(1.21)	19.60(1.99)	0.313	20.38(2.76)	19.93(2.30)	0.181	19.41(1.91)	20.26(2.74)	0.409	22.18(2.88)	20.38(2.64)	0.173
18~	18.77(0.93)	19.80(1.94)	0.24	20.39(1.90)	20.08(2.26)	0.375	23.20(4.64)	20.37(2.70)	0.006	20.22(2.95)	20.35(2.69)	0.863
Total	15.40(1.63)	19.00(2.06)	<0.001	16.15(2.35)	19.43(22.47)	<0.001	16.89(2.72)	19.87(2.87)	<0.001	17.04(2.72)	19.98(2.83)	<0.001
Rural												
9~	-	-	-	14.91(1.58)	14.18(1.29)	0.304	15.64(2.18)	16.41(2.05)	0.043	15.95(2.25)	17.51(3.23)	0.001
10~	15.10(1.22)	16.85(1.31)	<0.001	15.34(1.62)	17.17(2.26)	<0.001	16.06(2.32)	17.92(3.00)	<0.001	16.54(2.48)	18.59(3.26)	<0.001
11~	15.55(1.33)	17.39(2.25)	<0.001	15.85(1.84)	18.00(2.24)	<0.001	16.48(2.30)	18.39(2.80)	<0.001	16.84(2.51)	18.91(2.80)	<0.001
12~	16.13(1.55)	17.77(1.82)	<0.001	16.37(1.83)	18.15(2.18)	<0.001	16.78(2.34)	18.54(2.60)	<0.001	17.13(2.48)	18.92(2.80)	<0.001
13~	16.94(1.62)	18.51(1.74)	<0.001	16.95(1.80)	18.49(2.03)	<0.001	17.08(2.26)	18.83(2.64)	<0.001	17.21(2.37)	19.06(2.66)	<0.001
14~	17.31(1.60)	18.94(1.80)	<0.001	17.28(2.03)	18.94(2.14)	<0.001	17.29(2.24)	19.12(2.47)	<0.001	17.39(2.35)	19.41(2.60)	<0.001
15~	17.93(1.77)	19.51(1.86)	<0.001	18.55(2.16)	19.47(2.15)	<0.001	17.70(2.45)	19.58(2.49)	<0.001	17.68(2.41)	19.81(2.56)	<0.001
16~	18.28(1.77)	20.13(1.88)	<0.001	19.00(1.92)	20.04(2.14)	<0.001	18.71(2.87)	20.00(2.31)	0.006	18.20(3.21)	20.13(2.41)	0.003

17~	19.38(1.68)	20.49(1.82)	0.015	20.73(2.26)	20.28(2.04)	0.034	20.14(2.34)	20.25(2.27)	0.716	20.24(2.21)	20.33(2.39)	0.886
18~	20.21(1.21)	20.70(1.83)	0.639	20.48(4.55)	20.39(2.12)	0.734	21.44(1.78)	20.30(2.24)	0.211	21.71(3.18)	20.40(2.35)	0.211
Total	15.71(1.62)	19.83(1.99)	<0.001	15.83(1.98)	19.59(2.24)	<0.001	16.32(2.35)	19.64(2.49)	<0.001	16.62(2.47)	19.79(2.58)	<0.001
Combined												
9~	14.74(1.25)	15.45(1.38)	0.206	15.10(1.77)	16.36(3.90)	0.006	15.92(2.34)	16.46(2.25)	0.133	16.20(2.42)	17.37(2.78)	0.001
10~	15.08(1.34)	16.75(1.58)	<0.001	15.59(1.92)	17.79(2.89)	<0.001	16.43(2.54)	18.19(3.04)	<0.001	16.77(2.60)	18.88(3.15)	<0.001
11~	15.54(1.46)	17.53(1.92)	<0.001	16.13(2.13)	18.38(2.62)	<0.001	16.86(2.59)	18.91(3.08)	<0.001	17.10(2.67)	19.30(2.91)	<0.001
12~	16.04(1.60)	17.76(1.96)	<0.001	16.52(2.08)	18.33(2.42)	<0.001	17.11(2.62)	18.86(2.82)	<0.001	17.19(2.54)	19.15(2.90)	<0.001
13~	16.74(1.63)	18.19(1.83)	<0.001	16.96(2.05)	18.59(2.33)	<0.001	17.09(2.33)	19.05(2.81)	<0.001	17.42(2.59)	19.27 (2.85)	<0.001
14~	17.11(1.66)	18.67(1.92)	<0.001	17.55(2.30)	18.94(2.32)	<0.001	17.33(2.32)	19.37(2.77)	<0.001	17.61(2.43)	19.58(2.78)	<0.001
15~	17.79(1.80)	19.19(1.94)	<0.001	18.86(2.59)	19.45(2.31)	<0.001	18.41(2.74)	19.79(2.71)	<0.001	18.23(2.91)	19.94(2.70)	<0.001
16~	18.23(1.81)	19.72(1.95)	<0.001	19.58(2.30)	19.92(2.25)	0.044	19.17(2.22)	20.08(2.48)	<0.041	18.87(2.96)	20.20(2.52)	<0.001
17~	19.23(1.48)	20.05(1.96)	0.027	20.61(2.44)	20.10(2.19)	0.006	20.07(2.30)	20.25(2.52)	0.539	20.69(2.44)	20.36(2.52)	0.579
18~	19.31(1.21)	20.25(1.94)	0.169	20.45(3.79)	20.23(2.20)	0.302	22.39(3.59)	20.33(2.48)	0.003	20.63(3.00)	20.37(2.52)	0.663
Total	15.57(1.63)	19.39(2.07)	<0.001	15.99(2.17)	19.50(2.37)	<0.001	16.60(2.55)	19.76(2.70)	<0.001	16.83(2.60)	19.89(2.71)	<0.001

Table Ⅳ Logistic regression models predicting menarcheal status from BMI, age, and urban-rural for different CNSSCH years [a] (OR(95% CI))

Variable	1985	1995	2005	2010
BMI	1.74(1.70-1.78)	1.35(1.29-1.41)	1.27(1.24-1.30)	1.29(1.26-1.31)
Age (years)	4.13(4.02-4.26)	3.50(2.92-4.18)	4.07(3.69-4.50)	4.54(4.21-4.89)
Urban	3.74(3.46-4.05)	1.69(1.25-2.30)	1.42(1.20-1.68)	1.33(1.13-1.57)

a: adjusted for province, social economic status and school.

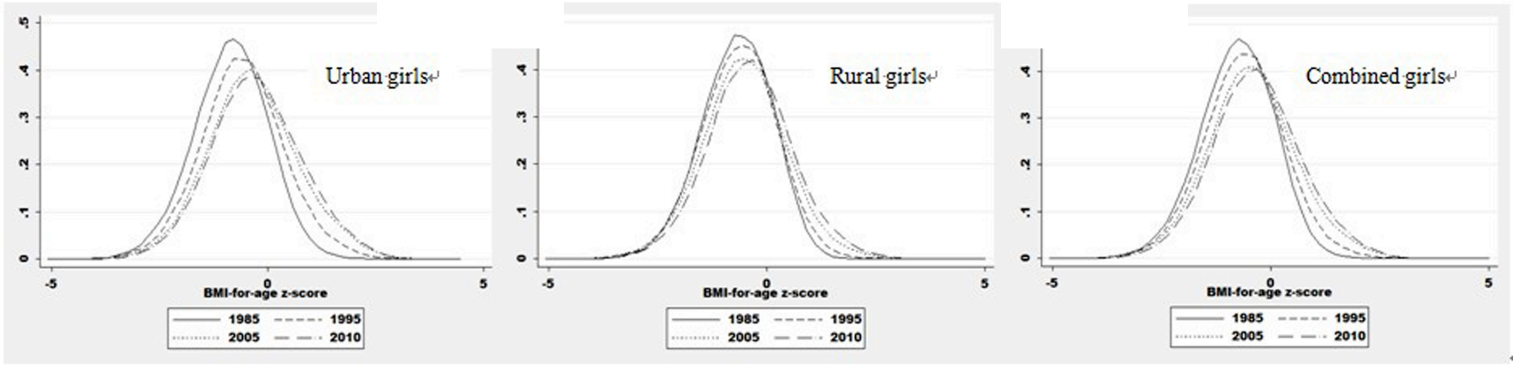

Figure 1 BMI-for-age Z-score distribution shifts among Chinese school-aged girls from 1985 to 2010; online

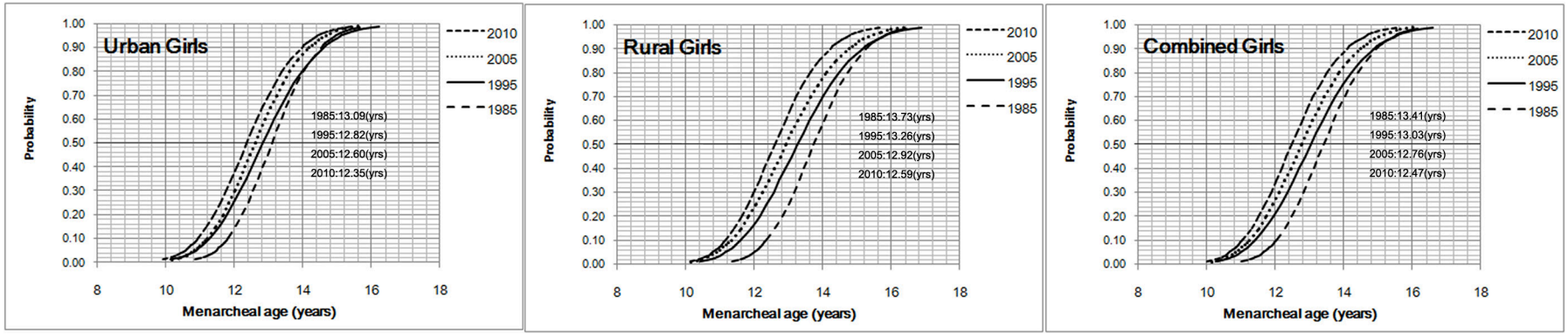

Figure 2 Probit plots for age at menarche for urban, rural and combined girls in China: from 1985 to 2010.