

BMJ Open Secular trends for age at spermarche among Chinese boys from 11 ethnic minorities, 1995–2010: a multiple cross-sectional study

Yi Song,^{1,2} Jun Ma,¹ Liu-Bai Li,¹ Bin Dong,³ Zhiqiang Wang,^{1,3} Anette Agardh²

To cite: Song Y, Ma J, Li L-B, *et al.* Secular trends for age at spermarche among Chinese boys from 11 ethnic minorities, 1995–2010: a multiple cross-sectional study. *BMJ Open* 2016;**6**: e010518. doi:10.1136/bmjopen-2015-010518

► Prepublication history for this paper is available online. To view these files please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2015-010518>).

Received 12 November 2015
Revised 14 January 2016
Accepted 21 January 2016



CrossMark

¹Institute of Child and Adolescent Health, School of Public Health, Peking University, Beijing, China

²Social Medicine and Global Health, Department of Clinical Sciences, Lund University, Malmö, Sweden

³Centre for Chronic Disease, School of Medicine, University of Queensland, Health Sciences Building, Royal Brisbane & Women's Hospital, Herston, Queensland, Australia

Correspondence to

Dr Jun Ma;
majunt@bjmu.edu.cn and
Dr Liu-Bai Li;
liubai@bjmu.edu.cn

ABSTRACT

Objectives: We compared the differences in median age at spermarche among 11 ethnic minorities in 2010, estimated the trends regarding age at spermarche in different ethnic minorities from 1995 to 2010, and explored the association of spermarche with body mass index (BMI).

Methods: We used four cross-sectional Chinese National Surveys on Students' Constitution and Health (CNSSCH, 1995, 2000, 2005 and 2010), and the total sample size was 40 113 children aged 11–18 years. The median age at spermarche of each ethnic minority was determined by using probit analysis. Logistic regression was used to assess the association of spermarche with BMI.

Results: In 2010, the ethnic minorities with earliest age at spermarche were Qiang (12.03 years), Zhuang (12.91 years) and Kirghiz (13.17 years); the three ethnic minorities with latest age at spermarche were Dong (14.73 years), Yao (14.60 years), and Naxi (14.36 years). From 1995 to 2010, age at spermarche showed a decline in almost each minority group except Yao and Dong. A higher BMI was associated with an increased likelihood of having reached spermarche after adjusting for age, regions or ethnic minorities.

Conclusions: A large variation in age at spermarche was observed among different ethnic minorities. The age at spermarche showed a downward shift in almost each of the 11 ethnic minorities with different patterns over time, and the children with higher BMI are more likely to enter puberty early.

INTRODUCTION

Since the timing of onset of puberty in childhood is associated with type 2 diabetes, cardiovascular disease and other adverse outcomes in adulthood,¹ it thus appears to have a profound impact on later health. A better understanding of trends in timing of puberty may improve the planning of health services, and provide the potential target for early preventive interventions of those chronic diseases. Although there are many

Strengths and limitations of this study

- The study population was derived from successive national surveys from 1995 to 2010, and the consistent stratified cluster sampling procedure and methods of measurement contributed to the comparability of the data from different survey years.
- This is the first study to describe the trend in decreasing age at spermarche among Chinese ethnic minority boys.
- It is the first to assess the relationship between spermarche and body mass index (BMI) among Chinese ethnic minority boys, showing that a higher BMI was associated with an increased likelihood of having reached spermarche.
- Previous findings concerning the age at spermarche in ethnic minorities are limited, and thus, comparative studies across different countries or regions are not available.

studies about the trend of age at menarche among girls, the data for evaluating secular trends in male pubertal development are limited and insufficient.² However, some studies have showed that an earlier onset of puberty occurred among boys.^{3–4} Some local surveys in China have also found similar trends.^{5–6} However, reports of age at spermarche among Chinese boys have been sparse, and many are outdated or focus only on boys of Han ethnicity.^{5–7} Data on the timing of spermarche among ethnic minority boys is not available, and the trends in age at spermarche among ethnic minority boys over the past 15 years are unknown.

Previous studies have shown that nutritional status is an important regulator of puberty, that is, underweight could delay onset of puberty and reduce spurt of pubertal growth, whereas, overweight or obese children are more likely to enter puberty early.^{8–11} A study conducted in Chinese Han ethnicity has also found that a

higher BMI is associated with an increased likelihood of having reached spermarche.⁷ However, the question as to whether an association between spermarche and BMI exists among ethnic minorities remains unanswered.

The majority of the population in China belongs to the Han ethnic group, and the other 55 ethnic groups are referred to as *ethnic minorities*. Although they are in the minority, the absolute number of an ethnic minority in China may be larger than in any other country or region.¹² According to the sixth Chinese national census, conducted in 2010, 113 792 211 (8.49%) of the country's total population belonged to ethnic minorities.¹³ For example, there are now more than 3.5 million Yao people in the world, with approximately 2.8 million living in China, 0.8 million in Vietnam, and the remainder in other countries, such as Laos, Thailand and the USA. As a multiethnic country, China provides a good opportunity to describe the diversity in age at spermarche among different ethnic minorities during the same period.

Previous studies have shown that the estimation of spermarche has been performed successfully in China for many years.^{14 15} The age at spermarche in boys can be determined by personal interview, which may be more accurate and convenient than measurement of spermaturia in population-based studies.^{14 16} By using this method, spermarcheal data are collected in the Chinese National Surveys on Students Constitution and Health (CNSSCH),^{17–20} which has been conducted every 5 years using identical methods. As a national sample of school-age children in China, it includes both Han and ethnic minority students, and thus, provides an opportunity to study the trends regarding age at spermarche among ethnic minorities. The present analysis sought to (1) compare the differences of median age at spermarche among 11 ethnic minorities in 2010; (2) estimate the trends of age at spermarche among different ethnic minorities from 1995 to 2010 and (3) determine any possible association between spermarche and BMI.

SUBJECTS AND METHODS

Subjects

Data were obtained from the 1995, 2000, 2005 and 2010 cycles of the CNSSCH.^{17–20} Thus far, it is the largest nationally representative sample of school-aged children in China (more than 200 000 students aged 7–22 years in each survey point). Twenty of the 55 ethnic minorities were investigated in 1995, but only 11 ethnic minorities with spermarcheal data were available in at least three rounds of the survey year. Thus, the present study included only boys aged 11–18 years from the following 11 ethnic minorities: Hui, Zhuang, Yao, Kirghiz, Dong, Hani, Naxi, Dongxiang, Li, Tu and Qiang, who were mainly sampled in the Ethnic Minority Autonomous Region or Ethnic Minority Autonomous Prefecture (figure 1). Because some ethnic minorities did not

participate in the CNSSCH in 2000 or in 2005, information concerning the Hani and Naxi was missing in the 2000 CNSSCH, and information concerning the Yao, Kirghiz, Dongxiang and Qiang was missing in the 2005 CNSSCH. The data from the four cycles of CNSSCH were checked for comparability and reliability according to three indicators: (1) all the participants and their parents were of the same ethnicity origin and had lived in the local areas for at least 1 year; (2) all the participants were uniformly measured in the same year using the same methods and in the same way; (3) all the participants had a thorough medical examination before measurement, and were generally healthy and free from overt disease or physical/mental deformities. The sample sizes of the various ethnic minorities at different survey points ranged from 400 to 2401 (table 1); the sample size of each survey ranged from 8592 to 14 734, and the total sample size (all surveys) was 40 113.

Measures

Individual spermarcheal data were collected by the status quo method. Boys aged ≥ 11 years in each CNSSCH were interviewed face to face by male physicians or professionals, and were asked whether or not they had experienced a first ejaculation. Almost all school boys of that age group have some knowledge about male pubertal events from their school health education; moreover, the interviewers were well trained to create a harmonious atmosphere and not to let the boys answer under stress. The interviewers were also prepared to provide sufficient explanation of sperm emission, if necessary, during the interview. Boys were also encouraged to ask questions freely. A dichotomous response (yes/no) was obtained for spermarcheal status. The boys who did not understand the explanation relating to sperm emission, who could not remember their ejaculation history, or who refused to answer questions, were regarded as invalid cases and excluded from the study. Boys' ages were recorded and calculated as decimal ages (eg, 11.00–11.99, 12.00–12.99 years).

Height (cm) and weight (kg) were all measured using similar instruments at all survey sites.^{17–20} Participants 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 standardised scale and height 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 (kg) divided by height (m) squared (kg/m^2). Measurements at the survey site were conducted by a team of field professionals who had passed a training course in anthropometric measurements. The geographic regions were classified as north China and south China, and north China in the present study included Ningxia Hui Autonomous Region, Xinjiang Uyghur Autonomous Region, Gansu and Qinghai, whereas south China included Guangxi Zhuang Autonomous Region, Guizhou, Yunnan, Hainan and Sichuan.



Figure 1 The locations of 11 ethnic minorities sampled in China.

Statistical analyses

The percentages of boys having reached spermarche in each age group were determined. The median age at spermarche and 95% CIs in subgroups for different years were calculated using probit analysis. We fitted probit models to the proportion of boys within each age group who had reached spermarche. A cumulative normal curve was fitted to the proportion of boys within each age group who were spermarcheal, and the median age at spermarche was the corresponding age at which

50% of boys in the population were predicted to have reached spermarche. Differences in the percentages of spermarcheal boys among different ethnic minorities in 2010 were compared by using the χ^2 test, and differences in age at spermarche between 1995 and 2010 survey points were tested by using the Z test. In order to facilitate the classification of ethnic minorities, age at spermarche among the 11 ethnic minorities was examined by cluster analyses. Stepwise logistic regression was used to assess the association between the log odds of

Table 1 The distribution and sample size of boys aged 11–18 years among 11 ethnic minorities, from 1995 to 2010

Ethnic minorities	Source province/region	Number (millions) ^{21*}	Minority population ranking*	1995	2000	2005	2010
Hui	Ningxia Hui Autonomous Region	10.59	2	2401	1600	1564	1744
Zhuang	Guangxi Zhuang Autonomous Region	16.93	1	2391	1595	1271	1449
Yao	Guangxi Zhuang Autonomous Region	2.8	12	1200	801	484	408
Kirghiz	Xinjiang Uyghur Autonomous Region	0.19	31	1200	400	–	963
Dong	Guizhou	2.88	10	1200	766	708	741
Hani	Yunnan	1.66	15	1200	–	863	806
Naxi (Nakhi)	Yunnan	0.33	26	1189	–	799	673
Dongxiang	Gansu	0.62	21	930	1136	–	768
Li	Hainan	1.46	16	1200	784	645	596
Tu	Qinghai	0.29	28	599	800	557	827
Qiang	Sichuan	0.31	27	1224	710	–	921
Total				14 734	8592	6891	9896

*According to the Sixth National Census in 2010.

being spermarcheal and BMI, geographic regions, age and ethnic minorities in 2010 CNSSCH. A two-sided p value <0.05 was considered significant. All analyses were conducted with SPSS V.20.0 (SPSS, Chicago, Illinois, USA).

RESULTS

Age at spermarche among 11 ethnic minorities in 2010

In 2010, only a few boys (6.54%) were spermarcheal in the 11-year-old group. In the 13-year-old group, almost all ethnic minorities were spermarcheal, and the percentage of spermarche among Yao was the lowest (13.33%), while that among Kirghiz was the highest (91.06%) ($\chi^2=288.80$, $p=0.00$). By the age of 18 years, 98.93% ethnic minority boys were spermarcheal. The median ages at spermarche among the three ethnic minorities with the earliest ages at spermarche in 2010 were as follows: Qiang (12.03 years), Zhuang (12.91 years) and Kirghiz (13.17 years); those with the highest median ages at spermarche were Dong (14.73 years), Yao (14.60 years) and Naxi (14.36 years) (table 2). The cluster analysis indicated that the 11 ethnic minorities in 2010 could be classified as two groups: Zhuang, Kirghiz and Qiang were classified as the earlier age group of age at spermarche, and the other eight ethnic minorities belonged to the later age group of age at spermarche (figure 2).

Secular trends of age at spermarche among 11 ethnic minorities from 1995 to 2010

From 1995 to 2010, the age at spermarche showed a downward shift in almost each of the 11 ethnic minorities, but with different patterns of decline. Some minority groups, such as Hui, Kirghiz, Hani and Qiang showed a clearly declining trend over time, while some minority groups, such as Zhuang, Naxi (Nakhi), Dongxiang, Li and Tu showed a decreasing trend with upward

fluctuations over time, while Yao and Dong showed a relatively flat trend with no statistically significant difference between 1995 and 2010 (figure 3). As a result, Qiang, Zhuang and Kirghiz showed the largest reductions, with age at spermarche found to be 3.53 ($p=0.00$), 2.12 ($p=0.00$) and 1.93 ($p=0.00$) years earlier, respectively, in 2010 than in 1995. By contrast, Yao and Dong showed the smallest differences, with age at spermarche only 0.02 ($p=0.74$) and 0.08 ($p=0.08$) years differences, respectively, between 1995 and 2010 (table 2).

Association of spermarche with BMI

Table 3 shows that there was an association between age at spermarche and BMI: a higher BMI was associated with an increased likelihood of having reached spermarche after adjusting for age, regions or ethnic minorities. The ethnic minorities who lived in the south of China reached spermarche earlier than those who lived in the north of China, after adjusting for BMI and age (OR=1.84).

DISCUSSION

The present study demonstrated large variations in age at spermarche among different ethnic minorities. Zhuang, Kirghiz and Qiang were classified as the earlier age group of age at spermarche, and the other eight ethnic minorities belonged to the later age group of age at spermarche in 2010. More than half among the Zhuang and Qiang boys reached spermarche before 13 years, whereas less than half had spermarche until 14 years among the Hui, Yao, Dong, Naxi (Nakhi) and Tu boys. Currently, the decreasing age of male sexual maturity runs counter to the delay in the social transition to adulthood that has been documented around the world,²² and one of the consequences is that the early developers are at an increased risk of negative reproductive health outcomes in both adolescence and

Table 2 Age at spermarche (95% CI) of boys aged 11–18 years among 11 ethnic minorities from 1995 to 2010 and compared with Han boys

Ethnic minorities	1995	2000	2005	2010	Difference (1995–2010)
Hui	15.93 (15.78 to 16.08)	14.91 (14.48 to 15.31)	14.67 (13.45 to 15.75)	14.31 (13.88 to 14.72)	-1.62*
Zhuang	15.03 (14.84 to 15.21)	15.10 (14.96 to 15.23)	13.34 (11.38 to 14.09)	12.91 (12.56 to 13.22)	-2.12*
Yao	14.58 (14.38 to 14.79)	15.46 (15.03 to 15.90)	–	14.60 (14.29 to 14.84)	0.02
Kirghiz	15.10 (14.86 to 15.34)	14.85 (14.55 to 15.22)	–	13.17 (12.49 to 13.75)	-1.93*
Dong	14.81 (14.66 to 14.96)	15.45 (15.20 to 15.74)	14.74 (14.46 to 15.01)	14.73 (14.02 to 15.41)	-0.08
Hani	14.37 (14.25 to 14.49)	–	14.20 (13.84 to 14.54)	13.76 (13.63 to 13.89)	-0.61*
Naxi (Nakhi)	14.93 (14.72 to 15.14)	–	13.36 (13.19 to 13.53)	14.36 (13.64 to 14.95)	-0.57*
Dongxiang	14.39 (14.12 to 14.65)	15.98 (15.60 to 16.38)	–	13.96 (11.71 to 15.46)	-0.43*
Li	14.11 (13.88 to 14.34)	14.05 (13.00 to 15.07)	13.50 (12.62 to 14.11)	13.66 (13.01 to 14.14)	-0.45*
Tu	15.37 (15.13 to 15.62)	16.23 (15.62 to 16.88)	15.19 (15.02 to 15.37)	14.35 (13.91 to 14.77)	-1.02*
Qiang	15.56 (15.32 to 15.80)	14.65 (14.40 to 14.92)	–	12.03 (11.20 to 12.55)	-3.53*
Han ⁷	14.57 (14.35 to 14.78)	14.33 (14.07 to 14.58)	14.10 (13.79 to 14.39)	14.03 (13.72 to 14.32)	-0.54†

*Significant difference between 1995 and 2010 ($p<0.01$).

†According to reference 7.

Dendrogram using Average Linkage (Between Groups)

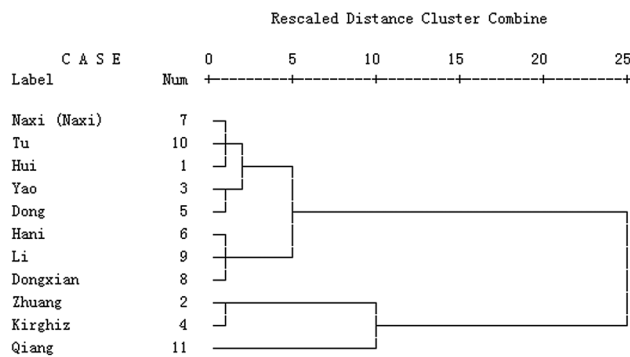


Figure 2 The clustering pattern of age at spermarche among boys aged 11–18 years from 11 ethnic minorities.

adulthood.^{23 24} Therefore, specific health education on male puberty development needs to be developed in order to meet the diverse health requirements among different ethnic minorities in China.

To the best of our knowledge, the present study is the first to describe the trend in decreasing age at spermarche among Chinese ethnic minority boys. We found that the occurrence of a downward secular trend in age at spermarche was evident in almost all the 11 ethnic minorities, but to different degrees. Globally, research on the trend of male puberty development has varied greatly across countries and regions due to different methods of assessment. Some studies used pubarche and testicular enlargement to assess the timing and tempo of puberty.^{3 4 25 26} For example, a study in Poland reported an over 3-month decrease between 2000 and 2010 in the age of initial appearance of pubic hair in boys.³ In Thailand, the age at testicular enlargement Tanner II declined by 0.15 years/decade (1.8 months/decade) from 1975 to 2012.⁴ In the USA, the mean ages of emerging growth of genital and pubic

hair, and early testicular volumes, were 6 months to 2 years earlier than in past studies, that is, HHANES (the Hispanic Health and Examination Survey, 1982–1984) and NHANES III (1988–1992) found attainment of genital stage 2 declined from 12.4 to 10.4 years of age over a 10-year period among Hispanic boys.^{25 26} Some studies used age at spermarche as an indicator.^{6 7} In China, from 1995 to 2010, age at spermarche dropped from 14.57 to 14.03 years, with an average decrease of 4.3 months per decade among Han boys.⁷ On the population level, secular trends in the timing of puberty could influence the health of both genders. Several epidemiological studies in boys showed that the current secular trends in timing of puberty seem to be associated with adverse health implications, such as increased risk for testicular cancer and a greater incidence of conduct and behavioral disorders.^{24 27} However, the mechanisms that determine timing of puberty and the reasons for its alterations are not clear. Thus, periodic surveillances of pubertal development, not only age at spermarche but also indicators of pubarche and testicular enlargement and related health consequences or longitudinal tracking between pubertal development and boys' future health are needed.

When compared with Chinese Han boys, the 11 ethnic minority groups in the present study could be subdivided into three categories: (1) ethnic minority boys whose differences in age at spermarche from 1995 to 2010 were larger than Han boys, that is, Hui, Zhuang, Kirghiz, Hani, Naxi (Nakhi), Tu and Qiang; (2) ethnic minority boys whose differences in age at spermarche from 1995 to 2010 were lesser than Han boys, that is, Dongxian and Li and (3) ethnic minority boys, such as the Yao and Dong, whose differences in age at spermarche from 1995 to 2010 were non-significant. The results are in alignment with many previous studies in China showing that the age of peak of height velocity

Figure 3 The secular trends regarding age at spermarche of boys aged 11–18 years among 11 ethnic minorities from 1995 to 2010.

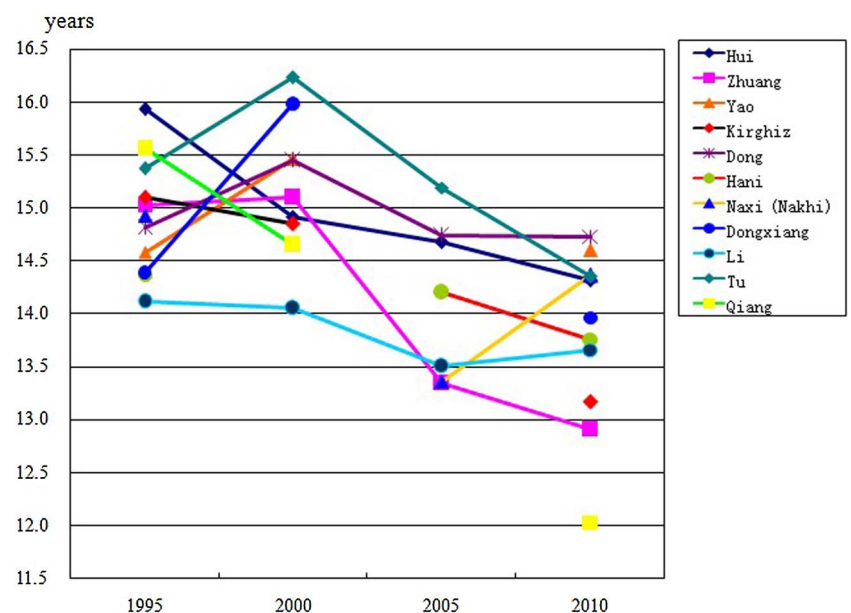


Table 3 Logistic regression models predicting spermarcheal status from BMI, geographic regions, age and ethnic minorities in 2010 CNSSCH (OR (95% CI))

Variable	Model 1	Model 2	Model 3	Model 4
BMI	1.49 (1.45 to 1.52)	1.49 (1.45 to 1.52)	1.09 (1.06 to 1.12)	1.13 (1.10 to 1.16)
Regions				NA
North China		1.00	1.00	
South China		1.68 (1.54 to 1.85)	1.84 (1.63 to 2.08)	
Age (years)			2.85 (2.73 to 2.97)	3.40 (3.23 to 3.58)
Ethnic minorities				
Hui				1.00
Zhuang				7.92 (6.17 to 10.17)
Yao				0.64 (0.49 to 0.85)
Kirghiz				0.92 (0.64 to 1.32)
Dong				2.34 (1.75 to 3.12)
Hani				3.40 (2.51 to 4.61)
Naxi (Nakhi)				1.70 (1.29 to 2.52)
Dongxiang				0.90 (0.68 to 1.20)
Li				6.24 (4.77 to 8.17)
Tu				1.00 (0.76 to 1.31)
Qiang				18.62 (13.92 to 24.91)

Stepwise logistic regression analyses to determine the association between spermarcheal status and BMI in the first step (model 1); regions in the second step (model 2); age in the third step (model 3); and the association between spermarcheal status and BMI, age and ethnic minorities in the model 4. BMI, body mass index; NA, not applicable.

among some ethnic minority boys, such as Hui, Qiang, Zhuang, Kirghiz and Hani, declined over the past years,^{16–19 28–30} and the morphological development level of the Qiang was better than other ethnic minorities.²⁹

The pattern of results thus indicated that some ethnic minorities who lived in the same provinces or regions showed similar trends of age at spermarche; for example, the Hani and Naxi (Nakhi) are both from Yunnan province, and both showed clearly declining trends of age at spermarche. However, not all ethnic minorities showed a significant decline in age at spermarche during the years in question, suggesting that differences in secular trends among ethnic minorities may well be related to specific features of certain ethnic minority groups. Even among ethnic minorities from the same provinces or regions, large variations in age at spermarche were observed. For example, the Zhuang and Yao are both from Guangxi Zhuang Autonomous Region; however, they showed different patterns concerning age at spermarche trends: Zhuang boys had larger differences regarding average age at spermarche than Han boys, whereas the Yao had no significant differences over the past 15 years.

Considering that growth is a product of a continuous and complex interaction between heredity and the environment, our findings of difference in age at spermarche of minority boys can be attributed to the effects of both hereditary and environmental factors. Environmental factors can be generally divided into two dimensions: socioeconomic (nutrition, disease, income, occupation, family size, social mobility, urbanisation, etc) and ecological (altitude, season, climate, etc).^{14 31} In the present study, we observed that higher BMI was

associated with an earlier spermarche, which is consistent with previous studies showing that earlier maturing boys were heavier than their peers, whereas, underweight boys developed puberty later.^{7 9 32} Moreover, a cohort study also showed that a significant effect of BMI at 7 years on age at sexual maturation in boys; the heavier at age 7 years, the earlier was puberty.³³ This suggests that nutritional strategies and interventions, such as the programme on improving student nutrition among rural compulsory school students, initiated by the State Council in 2011,³⁴ may have effects on both children's nutritional status and puberty development. Although ethnic minority children would benefit from this programme to a certain extent, long-term nutritional strategies targeting the ethnic minorities should be considered, and health education focused on the secular trend of male puberty should also be correspondingly developed.

The primary limitation of this study was that only association but not causality can be inferred, given the cross-sectional design of the CNSSCH. Since the enlargement of testicular volume to 4 mL is considered as the best clinical marker for detecting the onset of puberty in boys, the average age at spermarche might not reflect the exact timing of puberty onset in this sample. In addition, the actual spermarche dates of boys are unavailable. The status quo method—when used in a large study population such as the current sample—is considered to be even more reliable than the recall method for obtaining spermarche dates. Moreover, the same method was used to evaluate the puberty timing across the survey years and the different ethnicities in this study, and these limitations are not likely to affect our conclusions concerning the trends of puberty timing.

Further, information concerning environmental factors was not collected in these surveys, and adjustment for such factors may potentially modify our results. The sample size of some ethnic minorities in the present study, such as Yao, may not have been adequate for obtaining reliable estimates. Surveys with large samples, and data on important environmental factors, are needed to confirm our findings.

CONCLUSION

Age at spermathe varied widely among different ethnic minorities. From 1995 to 2010, the age at spermathe among Chinese ethnic minority boys declined significantly among 9 of the 11 ethnic minorities included in the current study. During that period, seven ethnic minorities showed clearly declining rates, with a decrease of over 4.3 months per decade, which is a larger decrease than that shown among Han boys. Two ethnic minorities showed decreasing trends, and two ethnic minorities showed no significant differences. Among Han boys, increasing BMI was associated with an increased likelihood of being spermatheal when adjusted for age, regions or ethnic minorities. This suggests that nutritional interventions may also have an effect on children's pubertal development.

Acknowledgements The authors thank WK Liao, WH Xing and X Zhang for their permission concerning accessing the 1995, 2000, 2005 and 2010 Chinese National Survey on Student's Constitution and Health data. They also thank the students who participated in the surveys for their cooperation.

Contributors YS conceived and designed the study, carried out the initial analyses, and prepared the first draft of the manuscript. JM, L-BL, BD and ZW critically reviewed and revised the manuscript. YS and JM conducted the research and collected the data. AA, ZW and BD interpreted data, developed materials analysis tools and revised the manuscript. All authors read and approved the final manuscript.

Funding The present study was supported by a grant from the National Natural Science Foundation of China (81302442) and Research special fund of the Ministry of Health public service sectors funded projects (201202010).

Competing interests None declared.

Patient consent Obtained.

Ethics approval The project was approved by the Medical Research Ethics Committee of Peking University Health Science Center (IRB00001052-13082).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

Open Access This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

REFERENCES

- Day FR, Elks CE, Murray A, *et al.* Puberty timing associated with diabetes, cardiovascular disease and also diverse health outcomes in men and women: the UK Biobank study. *Sci Rep* 2015;5:11208.
- Euling SY, Herman-Giddens ME, Lee PA, *et al.* Examination of US puberty-timing data from 1940 to 1994 for secular trends: panel findings. *Pediatrics* 2008;121(Suppl 3):S172-91.
- Kryst L, Kowal M, Woronkiewicz A, *et al.* Secular changes in height, body weight, body mass index and pubertal development in male children and adolescents in Krakow, Poland. *J Biosoc Sci* 2012;44:495-507.
- Jaruratanasirikul S, Sriplung H. Secular trends of growth and pubertal maturation of school children in Southern Thailand. *Ann Hum Biol* 2014;18:1-8.
- Sun Y, Tao F, Su PY; China Puberty Research Collaboration. National estimates of pubertal milestones among urban and rural Chinese boys. *Ann Hum Biol* 2012;39:461-7.
- Ma HM, Chen SK, Chen RM, *et al.* Pubertal development timing in urban Chinese boys. *Int J Androl* 2011;34:e435-45.
- Song Y, Ma J, Wang HJ, *et al.* Age at spermathe: 15-year trend and its association with Body Mass Index in Chinese school-aged boys. *Pediatr Obes* 2015. doi:10.1111/jipo.12073
- Wagner IV, Sabin MA, Pfäffle RW, *et al.* Effects of obesity on human sexual development. *Nat Rev Endocrinol* 2012;8:246-54.
- Tomova A, Robeva R, Kumanov P. Influence of the body weight on the onset and progression of puberty in boys. *J Pediatr Endocrinol Metab* 2015;28:859-65.
- Soliman A, De Sanctis V, Elalaily R. Nutrition and pubertal development. *Indian J Endocrinol Metab* 2014;18(Suppl 1):S39-47.
- Marcovecchio ML, Chiarelli F. Obesity and growth during childhood and puberty. *World Rev Nutr Diet* 2013;106:135-41.
- Song Y, Ma J, Agardh A, *et al.* Secular trends in age at menarche among Chinese girls from 24 ethnic minorities, 1985 to 2010. *Glob Health Action* 2015;8:26929.
- National Bureau of Statistics of China. Communiqué of the National Bureau of Statistics of the People's Republic of China on Major Figures of the 2010 Population Census(No.1).[WWW document]. 2011. http://www.stats.gov.cn/tjsj/tjgb/rkpcgb/qgrkpcgb/201104/t20110428_30327.html
- Ji CY, Ohsawa S. Onset of the release of spermatozoa (spermathe) in Chinese Male youth. *Am J Hum Biol* 2000;12:577-87.
- Ji CY. Age at spermathe and comparison of growth and performance of pre- and post-spermatheal Chinese boys. *Am J Hum Biol* 2001;13:35-43.
- Tinggaard J, Mieritz MG, Sørensen K, *et al.* The physiology and timing of male puberty. *Curr Opin Endocrinol Diabetes Obes* 2012;19:197-203.
- CNSSCH Association. *Report on the 1995th National Survey on students' constitution and health*. Changchun: Jilin Technical and Science Publication, 1997:3-38 [in Chinese].
- CNSSCH Association. *Report on the 2000th National Survey on students' constitution and health*. Beijing: People's Educational Publication, 2002:3-46 [in Chinese].
- CNSSCH Association. *Report on the 2005th National Survey on students' constitution and health*. Beijing: China College & University Press, 2007:3-52 [in Chinese].
- CNSSCH Association. *Report on the 2010th National Survey on students' constitution and health*. Beijing: China College & University Press, 2012:4-71 [in Chinese].
- National Bureau of Statistics of China. The population of each ethnic minority.[WWW document]. 2011. <http://data.stats.gov.cn/search/keywordlist2?keyword=2010%E5%B9%B4%E4%BA%BA%E5%8F%A3>
- Goldstein JR. A secular trend toward earlier male sexual maturity: evidence from shifting ages of male young adult mortality. *PLoS ONE* 2011;6:e14826.
- Sabageh AO, Sabageh D, Adeoye OA, *et al.* Pubertal timing and demographic predictors of adolescents in southwest Nigeria. *J Clin Diagn Res* 2015;9:LC11-13.
- Campbell BC, Prossinger H, Mbzivo M. Timing of pubertal maturation and the onset of sexual behavior among Zimbabwe school boys. *Arch Sex Behav* 2005;34:505-16.
- Herman-Giddens ME, Steffes J, Harris D, *et al.* Secondary sexual characteristics in boys: data from the pediatric research in office settings network. *Pediatrics* 2012;130:e1058-68.
- Karpati AM, Rubin CH, Kieszak SM, *et al.* Stature and pubertal stage assessment in American boys: the 1988-1994 Third National Health and Nutrition Examination Survey. *J Adolesc Health* 2002;30:205-12.
- Golub MS, Collman GW, Foster PM, *et al.* Public health implications of altered puberty timing. *Pediatrics* 2008;121(Suppl 3):S218-30.
- Zhang TC. Dynamic analysis of the development of students of minority nationalities in plateau areas between 1985 and 2005. *J Phys Educ* 2008;15:79-83 [in Chinese].



29. Ma J, Li SS, Song Y, *et al.* Study on the changing status of morphological development among minority students in China from 1985 to 2005. *Chin J Epidemiol* 2009;30:1304–8. [in Chinese]
30. Wang YH, Deng ZH, Zhou GX, *et al.* Dynamic analysis of body shape variation of southwest minority adolescents from 1995 to 2010 in the view of social changes. *J Guangzhou Sport Univ* 2014;34:52–8.[in Chinese]
31. Malina RM, Bouchard C. *Growth, maturation, and physical activity*. Champaign, IL: Human Kinetics, 1991:229–49, 329–52.
32. De Leonibus C, Marcovecchio ML, Chiavaroli de Giorgis T, *et al.* Timing of puberty and physical growth in obese children: a longitudinal study in boys and girls. *Pediatr Obes* 2014;9: 292–9.
33. Aksglaede L, Juul A, Olsen LW, *et al.* Age at puberty and the emerging obesity epidemic. *PLoS ONE* 2009;4: e8450.
34. The central People's Government of the People's Republic of China. The inform of Interim Measures on management of special funds targeted on rural compulsory schools to improve student nutrition program issued by Ministry of Finance and Ministry of Education. (WWW document). http://www.gov.cn/gongbao/content/2012/content_2256575.htm