Epidemiological characteristics of elevated blood pressure among middle and high school students aged 12–17 years: a cross-sectional study in Jiangsu Province, China, 2017–2018

Xiyan Zhang,1 Jie Yang,1 Yan Wang,1 Weina Liu,1 Wenyi Yang,1 Liuwei Gao,1,2 Rainer Schwertz,3 Andreas Welker,3 Fengyun Zhang,1 Yonglin Zhou1

ABSTRACT

Objective In this study, we aimed to present the epidemiological characteristics of elevated blood pressure among middle and high school students aged 12–17 years in Jiangsu Province.

Setting Hypertension, which is considered a rare disease in children, is an important early predictor to long-term cardiovascular damage, and elevated blood pressure in childhood is a strong predictor of hypertension in adulthood.

Participants Physical examination and questionnaire investigation among children aged 12–17 years in Jiangsu Province were conducted from 2017 to 2018.

Main outcome measures Physical measurements included height, weight, blood pressure and history of menarche/first spermatorrhoea. Questionnaire investigation included family type, delivery mode, lifestyle habits and psychological test.

Results In our study we investigated 17 791 middle and high school students, consisting of 8701 female students and 9090 male students. The prevalence of screening elevated blood pressure among students aged 12–17 years was 20.0% (95% CI 19.2% to 20.9%) for female students and 22.3% (95% CI 21.5% to 23.2%) for male students. The prevalence of screening elevated blood pressure for urban male middle and high school students was higher than that of elevated blood pressure for rural male middle and high school students. However, similar phenomenon cannot be observed among female students. For both male and female students, body mass index (BMI), obesity/overweight and menarche/first spermatorrhoea can be a risk factor contributing to elevated blood pressure, and sleep time and regional distribution might be important factors that need to be investigated in depth.

Conclusion We found a relatively high prevalence of screening elevated blood pressure among students aged 12–17 years for both female and male students in Jiangsu Province. The risk factors can be BMI, obesity/overweight and menarche/first spermatorrhoea.

INTRODUCTION

Hypertension or elevated blood pressure (BP) is an important risk factor for cardiovascular disease, causing more than seven million deaths worldwide each year. It contributes to an increase in the lifetime risk of stroke or coronary heart disease death in Asian population. Childhood hypertension, which is closely correlated with adulthood hypertension, does damage to the arteries of target organs such as the heart, brain and kidney.

In China, a national survey indicated that the prevalence of hypertension was high, and that awareness, treatment and control rates did not match the fast economic development. We found that the increased trend in the prevalence of hypertension is striking in young people and rural populations. In the USA, hypertension and its unawareness are common in young adult population, and most participants with hypertension were unaware of their elevated BP. However, these studies did not reveal detailed information on people younger than 18 years of age, and a lot of reasons may contribute to this phenomenon. In this study we will describe the epidemiological characteristics of elevated BP.

Strengths and limitations of this study

- This is the first study to present the prevalence of elevated blood pressure among middle and high students in Jiangsu Province using the National Blood Pressure Reference for Chinese Han Children and Adolescents, and this study covers all 13 cities of Jiangsu Province.
- There is a relatively high prevalence of screening elevated blood pressure among students aged 12–17 years in Jiangsu Province.
- Body mass index, obesity/overweight, menarche/first spermatorrhoea, sleep time and regional distribution might have an impact on this phenomenon.
among middle and high school students aged 12–17 years in China.

China is one of the world’s largest developing countries with a population of 1.37 billion, and while the prevalence of elevated BP has been stable among Chinese children, this has become more and more concerning recently.\(^3\)\(^6\) Located in eastern China, Jiangsu Province is one of the developed regions in the country. We have previously reported that the prevalence of overweight and obesity among primary school children was 15.2% (18.7% for male students and 11.0% for female students) and 11.7% (14.5% for male students and 8.2% for female students), respectively, and we found that obesity in children was closely associated with elevated BP.\(^1\)\(^1\) Therefore, in this study we intend to show more detailed information about the epidemiological characteristics of elevated BP among children and adolescents in Jiangsu Province.

| Characteristics of female students (8701) \(n\) (%)/mean±SD | Characteristics of male students (9090) \(n\) (%)/mean±SD |
|----------------------------------------------------------|----------------------------------------------------------|
| **Age**                                                   |                                                          |
| 12–                                                      | 1133 (13.0)                                              |
|                                                          | 1104 (12.0)                                              |
| 13–                                                      | 1567 (18.0)                                              |
|                                                          | 1660 (18.3)                                              |
| 14–                                                      | 1539 (17.7)                                              |
|                                                          | 1536 (16.9)                                              |
| 15–                                                      | 1561 (17.9)                                              |
|                                                          | 1634 (18.0)                                              |
| 16–                                                      | 1539 (17.7)                                              |
|                                                          | 1596 (17.6)                                              |
| 17–                                                      | 1362 (15.7)                                              |
|                                                          | 1560 (17.2)                                              |
| **Mean±SD**                                              | 14.6±1.6                                                 |
|                                                          | 14.6±1.6                                                 |
| **Region**                                               |                                                          |
| Rural                                                    | 3555 (40.9)                                              |
|                                                          | 3448 (37.9)                                              |
| Urban                                                    | 5146 (59.1)                                              |
|                                                          | 5642 (62.1)                                              |
| **Physical examination**                                 |                                                          |
| Height (cm)                                              | 159.3±5.8                                                |
|                                                          | 168.1±8.5                                                |
| Weight (kg)                                              | 54.4±9.8                                                 |
|                                                          | 62.0±14.2                                                |
| BMI                                                      | 21.4±3.4                                                 |
|                                                          | 21.8±4.1                                                 |
| SBP                                                      | 114.5±10.3                                               |
|                                                          | 121.6±12.1                                               |
| DBP                                                      | 66.9±7.4                                                 |
|                                                          | 66.6±8.1                                                 |
| Menarche                                                 | 8159 (93.8)                                              |
|                                                          | First spermatorrhoea 4804 (52.8)                         |
| **Family type**                                          |                                                          |
| Nuclear family*                                          | 3886 (44.7)                                              |
|                                                          | 4042 (44.5)                                              |
| Extended family†                                         | 3177 (36.5)                                              |
|                                                          | 3399 (37.4)                                              |
| Single-parent family                                     | 889 (10.2)                                               |
|                                                          | 892 (9.8)                                                |
| Others                                                   | 749 (8.6)                                                |
|                                                          | 757 (8.3)                                                |
| **Delivery mode**                                        |                                                          |
| Natural delivery                                         | 4452 (51.2)                                              |
|                                                          | 3710 (40.8)                                              |
| Caesarean delivery                                       | 2838 (32.6)                                              |
|                                                          | 2878 (31.7)                                              |
| Unknown                                                  | 1411 (16.2)                                              |
|                                                          | 2502 (27.5)                                              |
| **Lifestyle habits**                                     |                                                          |
| Ever passive smoking                                     | 2454 (28.2)                                              |
|                                                          | 2470 (27.2)                                              |
| Ever active smoking                                      | 535 (6.1)                                                |
|                                                          | 1218 (13.4)                                              |
| Alcohol consumption                                      | 2050 (23.6)                                              |
|                                                          | 3372 (37.1)                                              |
| Sleep time (hours)                                       | 7.1±1.3                                                  |
|                                                          | 7.3±1.7                                                  |
| Exposure to sunlight (less than 3 hours)                | 6461 (74.3)                                              |
|                                                          | 6316 (69.5)                                              |
| **Psychological test**                                   |                                                          |
| CES-D scale                                              | 13.4±8.5                                                 |
|                                                          | 13.2±8.7                                                 |

*Nuclear family: a family unit consisting only of a father, mother and children.
†Extended family: a network of relatives that include grandparents, cousins, uncles, aunts and foster children.
BMI, body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure.
Table 2  Age-specific prevalence of screening elevated blood pressure among middle and high school students aged 12–17 years in Jiangsu Province, 2017–2018

| Sex/Age | Prevalence of elevated blood pressure (95% CI) | Blood pressure |
|---------|-----------------------------------------------|----------------|
|         |                                               | SBP            | DBP            |
| Female  |                                               |                |                |
| 12–     | 16.3 (14.2 to 18.5)                           | 112.7±10.3     | 65.6±7.7       |
| 13–     | 18.9 (17.0 to 20.8)                           | 113.8±10.1     | 66.3±7.3       |
| 14–     | 21.9 (19.8 to 24.0)                           | 114.9±10.0     | 67.1±7.2       |
| 15–     | 22.2 (20.2 to 24.3)                           | 115.4±10.3     | 67.3±7.4       |
| 16–     | 19.4 (17.5 to 21.4)                           | 114.6±10.3     | 67.1±7.5       |
| 17–     | 20.4 (18.3 to 22.6)                           | 115.5±10.5     | 68.0±7.5       |
| 12–17   | 20.0 (19.2 to 20.9)                           | 114.5±10.3     | 66.9±7.4       |
| Male    |                                               |                |                |
| 12–     | 14.6 (12.5 to 16.7)                           | 114.8±11.4     | 64.0±7.8       |
| 13–     | 18.0 (16.1 to 19.8)                           | 117.6±11.4     | 64.6±7.9       |
| 14–     | 23.4 (21.3 to 25.5)                           | 121.8±11.7     | 66.0±8.0       |
| 15–     | 24.1 (22.0 to 26.1)                           | 123.4±11.5     | 67.0±8.0       |
| 16–     | 23.2 (21.1 to 25.3)                           | 124.0±11.3     | 68.0±7.9       |
| 17–     | 28.8 (26.6 to 31.1)                           | 126.4±11.4     | 68.9±8.1       |
| 12–17   | 22.3 (21.5 to 23.2)                           | 121.6±12.1     | 66.6±8.1       |

DBP, diastolic blood pressure; SBP, systolic blood pressure.

METHODS
Setting and participants
This study was based on the project ‘Surveillance for common disease and health risk factors among students’ in Jiangsu Province, which was conducted during the 2017–2018 academic year. We selected students aged 12–17 years from all 13 cities in Jiangsu Province, with each city having two types of middle and high schools: one from the urban area and another from the rural area.

Measurements
Studies were conducted in 13 cities, including 13 urban districts and 13 rural counties. In every county or district we had at least one observer measuring height, at least one observer measuring weight, two to three observers measuring BP, two observers (one for boys and one for girls separately and secretly) investigating questions about first spermatorrhoea or menarche, and at least one observer responsible for receiving questionnaires and reviewing the quality of questionnaires. After physical examination students filled in a questionnaire, providing basic demographic information including name, sex, region, identification number, and habits of 1 week including smoking, alcohol consumption, sleep time, exposure to sunlight, and other health risk factors-related information such as family type, delivery mode, lifestyle habits and psychological test (Center for Epidemiological Studies-Depression, CES-D).

Anthropometric variables were measured by trained project members, skilled nurses and doctors. BP was measured using an upper arm automated BP device (Omron HBP-1300). Each participant was seated with the back supported, legs uncrossed and feet on the floor. The observers measured the circumference at the midpoint of the arm and selected an appropriate cuff, the width of which was as close as possible to 40% of the arm circumference. After each subject had rested for at least 15 min, BP was measured on the left upper arm at the level of the heart.
Figure 2 Regional distribution of obesity-related elevated blood pressure among middle and high school students aged 12–17 years in Jiangsu Province, 2017–2018.

with the lower arm passively supported. The interfacing two measurements were separated by at least 1 min intervals. Heart rate was recorded in beats/min at each visit. The start button was pressed and the measurements started automatically. Two observers were responsible for two measurements, and the average of the two BP measurements was recorded for each child.

Weight and height were measured after students had removed their shoes and clothes. Height (measured to the nearest 0.1 cm) and weight (measured to the nearest 0.1 kg) were measured using standardised equipment and procedures according to the health checklist for primary and junior school students (GB 16 134–2011; Chinese standard for physical examination records for elementary and middle school students). Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared.

All students filled in a questionnaire, providing basic demographic information including name, sex, region, identification number and so on. We reviewed students’ habits of 1 week, including smoking, alcohol consumption, sleep time, exposure to sunlight, and health risk factors-related information such as family type, delivery mode and psychological test (CES-D). Definitions of elevated BP

We used the National Blood Pressure Reference for Chinese Han Children and Adolescents (CCBP) thresholds: ≥95th percentile as elevated BP (WS/T 610–2018; reference of screening for elevated BP among children and adolescents aged 7 ~ 18 years; online supplementary table S1-S4).

Bias

In this study, if our quality control observers found that the difference between systolic/diastolic BP is more than 10 mm Hg, the student will be required to go back to measure a third BP. The observers responsible for BP measurement were blinded when the students received the third measurement. In addition, studies were stopped or rejected if subjects had arrhythmia and could not sit still for the study. Quality control methods and validation of Omron HBP-1300 can be found in Meng et al.

Statistical analysis

Descriptive statistics were used to summarise the variables concerning the characteristics of middle and high school students, and the prevalence was presented as the prevalence and 95% CI of the prevalence. Continuous variables such as BP were presented as mean with SD of the mean. Student’s t-tests were used for comparisons of two groups with continuous variables, and χ² tests were performed for comparing two proportions. Poisson regression analysis was performed and adjusted risk ratio values were computed to assess the relationship between hypertension and other risk factors. Data were analysed using SPSS V.20.0 software, and figures were drawn using ArcGIS V.10.0 software.

Patient and public involvement (participants)

Studies were conducted in 13 cities, including 13 urban districts and 13 rural counties. We randomly selected schools in each district or rural county, and then randomly sampled the students from each school. In each of the schools selected, teachers, students and doctors were included in this study. No patients were involved in this study.

Table 3 Age-specific obesity-related elevated blood pressure prevalence among middle and high school students aged 12–17 years in Jiangsu Province, 2017–2018

| Sex/Age | Obesity prevalence (95% CI) | Obesity-related hypertension* prevalence (95% CI) |
|---------|-----------------------------|-----------------------------------------------|
| Female  |                             |                                               |
| 12–     | 11.5 (9.6 to 13.3)          | 4.3 (3.1 to 5.5)                              |
| 13–     | 9.8 (8.3 to 11.2)           | 4.0 (3.0 to 4.9)                              |
| 14–     | 9.6 (8.1 to 11.1)           | 4.6 (3.6 to 5.7)                              |
| 15–     | 9.9 (8.4 to 11.3)           | 5.2 (4.1 to 6.3)                              |
| 16–     | 6.0 (4.8 to 7.2)            | 3.2 (2.4 to 4.1)                              |
| 17–     | 5.4 (4.2 to 6.6)            | 2.8 (1.9 to 3.7)                              |
| 12–17   | 8.6 (8.0 to 9.2)            | 4.0 (3.6 to 4.4)                              |
| Male    |                             |                                               |
| 12–     | 17.9 (15.7 to 20.2)         | 5.1 (3.8 to 6.4)                              |
| 13–     | 15.5 (13.7 to 17.2)         | 6.9 (5.7 to 8.1)                              |
| 14–     | 14.0 (12.3 to 15.7)         | 6.9 (5.7 to 8.1)                              |
| 15–     | 15.2 (13.4 to 16.9)         | 7.3 (6.1 to 8.6)                              |
| 16–     | 12.7 (11.1 to 14.4)         | 6.3 (5.1 to 7.5)                              |
| 17–     | 12.8 (11.1 to 14.4)         | 7.4 (6.1 to 8.7)                              |
| 12–17   | 14.5 (13.8 to 15.2)         | 6.7 (6.2 to 7.2)                              |

*Denotes the student is both obese and has elevated blood pressure.
Table 4  Associations between risk factors and elevated blood pressure among middle and high school students aged 12–17 years

| Risk factors          | Adolescents with elevated BP | Adolescents without elevated BP | P value |
|-----------------------|------------------------------|---------------------------------|---------|
| **Female**            |                              |                                 |         |
| Age                   | 14.6±1.6                     | 14.5±1.7                        | 0.000   |
| BMI                   | 23.1±4.1                     | 20.9±3.1                        | 0.000   |
| Height                | 159.1±6.0                    | 159.4±5.7                       | 0.094   |
| Obesity/Overweight    | 20.1%/24.2%                  | 5.7%/15.0%                      | 0.000   |
| Urban or not          | 58.6%                        | 59.3%                           | 0.614   |
| Natural delivery      | 51.5%                        | 51.1%                           | 0.616   |
| Menarche              | 95.9%                        | 93.2%                           | 0.000   |
| Sleep time            | 7.1±1.3                      | 7.1±1.3                         | 0.197   |
| Active smoking        | 6.4%                         | 6.1%                            | 0.586   |
| Passive smoking       | 71.4%                        | 71.9%                           | 0.690   |
| Alcohol consumption   | 22.8%                        | 23.7%                           | 0.433   |
| Exposure to sunlight  | 74.4%                        | 74.2%                           | 0.880   |
| CES-D                 | 13.3±8.5                     | 13.5±8.5                        | 0.228   |
| **Male**              |                              |                                 |         |
| Age                   | 14.9±1.6                     | 14.5±1.7                        | 0.000   |
| BMI                   | 24.3±4.6                     | 21.1±3.7                        | 0.000   |
| Height                | 168.9±7.8                    | 167.9±8.7                       | 0.000   |
| Obesity/Overweight    | 30.1%/26.3%                  | 10.0%/18.2%                     | 0.000   |
| Urban or not          | 64.4%                        | 61.4%                           | 0.016   |
| Natural delivery      | 42.0%                        | 40.5%                           | 0.135   |
| First spermatorrhoea  | 58.3%                        | 51.3%                           | 0.000   |
| Sleep time            | 7.2±1.9                      | 7.3±1.7                         | 0.007   |
| Active smoking        | 14.2%                        | 13.2%                           | 0.241   |
| Passive smoking       | 73.6%                        | 72.6%                           | 0.400   |
| Alcohol consumption   | 38.8%                        | 36.6%                           | 0.071   |
| Exposure to sunlight  | 70.9%                        | 69.1%                           | 0.128   |
| CES-D                 | 13.2±8.6                     | 13.1±8.7                        | 0.813   |

BMI, body mass index; BP, blood pressure; CES-D, Center for Epidemiological Studies-Depression.

Ethics issues
Reasons can be listed as follows: first, our study had no patients, did not involve extraction of biological materials such as blood, pleural effusion and cerebrospinal fluid (CSF) sampling, and had no experimental design. Second, this is our daily monitoring task to ensure students’ health. The students and their parents were informed about the aim of the survey, and participants’ and their parents’ oral and written consent were obtained by teachers. Detailed information can be found in our previous study.11

RESULTS
Participants
The baseline characteristics of middle and high school students are shown in table 1. The total number of students was 17 791, consisting of 8701 female students and 9090 male students, and the male to female ratio was 1.04. More than half of students were from urban regions: 59.1% of female students and 62.1% of male students. The results of physical examinations reveal that the values of BMI and diastolic blood pressure (DBP) are similar between male and female students. Height, weight and systolic BP (SBP) of male students are higher than female students. The proportion of menarche among female middle and high school students was 93.8%, which is higher than that of the first spermatorrhoea among male middle and high school students (52.8%). Nuclear family and extended family take up the major part of family type among middle and high school students. Self-reported survey showed that the proportion of natural delivery
among female and male students is 51.2% and 40.8%, respectively, but 16.2% of female students and 27.5% of male students reported unknown delivery mode. The proportion of active smoking and passive smoking was 6.1% and 28.2% for female students and 13.4% and 27.2% for male students. The proportion of alcohol consumption for male students is higher than that of alcohol consumption for female students, but the proportion of exposure to sunlight less than 3 hours for female students is higher than that of exposure to sunlight less than 3 hours for male students. Sleep time for both male and female students is similar. The CES-D test score was also similar (table 1).

Prevalence of screening elevated BP among students aged 12–17 years
The prevalence of screening elevated BP for urban male middle and high school students was higher than that of elevated BP for rural male middle and high school students (p < 0.05). However, the prevalence of screening elevated BP for female students was similar between rural students and urban students (p > 0.05). Obesity-related elevated BP was similar for both female and male students between the rural region and urban region (figures 1 and 2).

The prevalence of screening elevated BP among students aged 12–17 years was 20.0% (95% CI 19.2% to 20.9%) for female students and 22.3% (95% CI 21.5% to 23.2%) for male students. The average value for both SBP and DBP was within the normal reference range, and the prevalence of obesity-related elevated BP was 4.0% (95% CI 3.6% to 4.4%) for female students and 6.7% (95% CI 6.2% to 7.2%) for male students (tables 2 and 3).

For female students, BMI, obesity/overweight and menarche can be risk factors contributing to elevated BP, and for male students BMI, obesity/overweight, first spermatorrhoea, sleep time and regional distribution can be risk factors contributing to elevated BP (table 4). In the Poisson regression analysis, BMI and menarche/first spermatorrhoea could be risk factors for elevated BP for both boys and girls (table 5).

DISCUSSION
In our study we investigated 17 791 middle and high school students, consisting of 8701 female students and 9090 male students. Of the female students, 59.1% were from urban cities, while 62.1% of male students came from the urban region. The prevalence of elevated BP among students aged 12–17 years was 20.0% (95% CI 19.2% to 20.9%) for female students and 22.3% (95% CI 21.5% to 23.2%) for male students. The prevalence of screening elevated BP for urban male middle and high school students was higher than that of elevated BP for rural male middle and high school students. However, similar phenomenon cannot be observed among female students. For both male and
female students, BMI, obesity/overweight and menarche/first spermatorrhoea can be risk factors contributing to elevated BP, and sleep time and regional distribution might be important factors that need to be investigated in depth.

The high prevalence of hypertension and poor hypertension control are serious problems in low-income and middle-income countries, and it has been reported that almost 2 million cardiovascular deaths and 1.2 million premature cardiovascular deaths were attributable to hypertension every year in China. The definition of hypertension in adults, which is based on the approximate level of BP that marks an increase in cardiovascular events and death, is not to be applied to children and adolescents. In this study, we used the CCBP reference based on a large-scale representative population amounting to 0.2 million Han Chinese students. For national Chinese boys and girls aged 12–17, the prevalence of hypertension ranged from 7.8% to 18.5% based on the CCBP reference, which was far lower than that in Jiangsu Province which ranged from 14.6% to 28.8%. The average height and proportion of obesity/overweight were higher than national levels, and CCBP reference values excluded obese/overweight children. We consider that CCBP reference values might not be appropriate for for children in Jiangsu Province. Also, we found that CCBP reference values are generally lower than the US reference values for older adolescents. The prevalence of hypertension in our study cannot be confirmed, but initial screening elevated BP shows results that are higher than the national results.

Generally, overweight and obese adolescents have higher than normal weights, and a strong relationship was observed between BMI and BP. In our study we also found this phenomenon. We found that the prevalence of obesity-related hypertension was high: 4.0% (3.6%–4.4%) for female students and 6.7% (6.2%–7.2%) for male students. An interesting phenomenon is that the prevalence of elevated BP in Jiangsu Province is similar to the rates of elevated BP seen in the USA, where we have nearly doubled the prevalence of overweight/obese (online supplementary figure S1). First, it is well worth noting that CCBP reference values are generally lower than the US reference values for older adolescents. The prevalence of hypertension in our study cannot be confirmed, but initial screening elevated BP shows results that are higher than the national results.

Second, we used automated devices and initial measurements, which would also contribute to a higher prevalence of elevated BP. Song et al found that both boys and girls who enter puberty earlier with menarche/first spermatorrhoea were more likely to have high BP, and combined with our results we also suggested that interventions focused on prepuberty students may be beneficial to reduce the prevalence of high BP. Dong et al’s study revealed that short sleep duration may be one of the influential factors of high BP during puberty. In the USA, Sabanayagam and Shankar found that compared with a sleep duration of 7 hours, there was a positive association between both shorter and longer sleep durations, and they suggested that sleep duration may be an important marker of cardiovascular disease. While in our study we found a weak association between sleep duration and elevated BP among boys, we still put sleep factor as an indispensable factor, and this problem should be explored in depth. In addition, the prevalence of hypertension varied geographically and economic status might play an important role. Also, we observe the phenomenon that urban male middle and high school students had higher prevalence of elevated BP than rural male students, while the urban–rural gap in Jiangsu Province is narrowing.

Our study had some limitations. First, the US reference in 2004 recommended that hypertension should be defined using the results of elevated BP on at least three occasions in children and adolescents. In our study, we only had one BP measurement with two to three readings, and our results show increased prevalence of elevated BP on initial screening. Second, in this study we used self-reported questionnaire, and the results may not be entirely true. Completing questionnaires with the assistance of parents may improve accuracy, and this will be our next study. Third, the CCBP is based on an auscultatory method, while this study is done by automated devices. Even though some studies had been conducted to prove that the professional Omron HBP-1300 BP monitor meets the Association for the Advancement of Medical Instrumentation (AAMI) accuracy standards in Chinese children, consistency of measurement methods was not achieved. Also, it is known as referred before that regional distribution is an important factor, and it may have an impact on the definition of childhood hypertension reference. Therefore, a new BP reference suitable for children from Eastern China is essential, and this will also be our next study.

CONCLUSION

We found that the burden of elevated BP for both female and male students aged 12–17 years in Jiangsu Province was substantially heavy (above the average level among Chinese adolescents). Potential risk factors can be BMI, obesity/overweight, menarche/first spermatorrhoea and sleep duration.

Contributors Data curation: XZ. Investigation: JY, WY. Methodology: YW. Project administration: WL. Software: LG. Article modification: RS, AW. Supervision: FZ, YZ. Writing the original draft: XZ, JY.

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Competing interests None declared.

Patient consent for publication Obtained.

Ethics approval The study protocol was approved by the Institutional Review Board of Jiangsu Provincial Center for Disease Prevention and Control, while we were informed that approval by an ethical committee was not necessary.
