

ORIGINAL ARTICLE

Association of reproductive history with hypertension and prehypertension in Chinese postmenopausal women: a population-based cross-sectional study

Qian Yang^{1,2}, Chunhua Song^{1,2}, Jicheng Jiang^{1,2}, Yi Chen^{1,2}, Shuying Liang³, Nan Ma³, Kaiyan Dong^{1,2}, Wei Nie³ and Kaijuan Wang^{1,2}

Hypertension and prehypertension may have important roles in the etiology of cardiovascular disease. However, the risk factors of hypertension and prehypertension have not been thoroughly elucidated to date. This study intended to explore the relative effects between reproductive history and the prevalence of hypertension and prehypertension. A population-based cross-sectional survey of postmenopausal women ($n = 6252$), aged 41–93 years, was conducted from August 2013 to August 2015. All subjects, selected by the multistage random sampling method in Henan province, were categorized as normotension, prehypertension and hypertension according to blood pressure (BP) levels. Ordinal logistic regression models were used to estimate the risks of prehypertension and hypertension with three categories of BP as dependent variables. Hypertension was associated with a positive history of induced abortion (adjusted odds ratio (OR) = 1.190, 95% confidence interval (CI): 1.020, 1.388), but there was no association between hypertension and a positive history of spontaneous abortion (adjusted OR = 1.126, 95% CI: 0.973, 1.303) after adjusting for age, alcohol consumption, education status, smoking, body mass index, physical activity and occupation. Compared with women with one or no children, those with two or three children were at a lower risk of hypertension (adjusted OR = 0.605, 95% CI: 0.434, 0.845). In addition, individuals with an age of menopause between 46 and 51 years may have a decreased risk of both prehypertension and hypertension, especially in terms of systolic BP. In conclusion, a positive history of induced abortion may be a predictive risk factor for hypertension and prehypertension. However, a menopausal age of 46–51 years or having two children may be protective factors against hypertension and prehypertension.

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INTRODUCTION

Hypertension accounts for a significant proportion of the global health-care burden.¹ Prehypertension could independently increase the risk of hypertension and cardiovascular disease (CVD).^{2–4} Over the past decade, the risk factors of hypertension have been identified.^{5,6} In addition to excess salt intake and alcohol consumption, overweight and obesity, less physical activity, a positive family history of hypertension, lower education levels^{7,8} and other risk factors are also concerning, namely, reproductive history.^{9,10} A limited number of studies have shown that an early age at menarche and a late age at menopause could increase the risk of hypertension and CVD.^{11–13} The association between the number of live births and hypertension yielded inconsistent results in both postmenopausal women and premenopausal women.^{13,14} Abortion history could affect the risk of maternal hypertension.¹⁵ Overall, reproductive history is not only associated with maternal hypertension but also with the incidence of

hypertension later in life.¹⁶ The number of live births, age at menarche, age at menopause and the duration of breast feeding were associated with the incidence of hypertension later in life. However, these studies showed inconsistent results.^{9,17,18}

In addition, the prevalence of prehypertension among adults was 30% over the past decade and prehypertension is treated as a risk factor for hypertension and other CVD.^{19,20} Furthermore, a high prevalence rate of hypertension and prehypertension in postmenopausal women has been confirmed.³ Therefore, in this study we aimed to investigate the relationship between reproductive history and hypertension and prehypertension.

METHODS

Study design and populations

Postmenopausal women from one part of a Chinese national survey on the prevalence of CVD in Henan province, China supported by the National Key

¹Department of Epidemiology and Health Statistics, College of Public Health, Zhengzhou University, Zhengzhou, China; ²Key Laboratory of Tumor Epidemiology of Henan Province, Zhengzhou City, China and ³The Henan Academy of Medical Sciences, Zhengzhou, China
Correspondence: Dr K Wang, Department of Epidemiology and Health Statistics, College of Public Health, Zhengzhou University, No. 100 Science Avenue, Zhengzhou City 450001, China.

E-mail: kjwang@163.com

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R&D Program in the Twelfth Five-year Plan (No. 2011BAI11B01) from the Chinese Ministry of Science and Technology, including 31 provinces and 262 counties, were enrolled. The detailed design and the methods of this study have been introduced by Wang *et al.*²¹ The participants included women aged >15 years from 11 districts sampled in urban and rural regions. A stratified multistage random sampling method was used to select the participants from the general population. The first stage of the study used the probability proportional to size method to sample four rural areas and four urban areas. Using simple random sampling in the second stage, two townships or two districts were selected within each region. Simple random sampling was used in the third stage to sample three communities or villages. Finally, a given number of populations was selected from the chosen villages or communities by simple random sampling. Then this study selected all postmenopausal women to analyze the relationship between reproductive history and blood pressure (BP). Therefore, all the participants were postmenopausal women. Among 19 000 subjects, 6252 were postmenopausal women, including those with normotension (19.61%), prehypertension (24.47%) and hypertension (55.92%).

Written informed consent was obtained from each participant prior to data collection. This survey was approved by the Ethical Committee of the Chinese Ministry of Science and Technology.

Data collection

All of the participants were interviewed by trained research staff with a structured questionnaire. The questionnaire collected detailed data on demographic characteristics, lifestyle and behavior, self-reported individual and family history of CVD (including hypertension, diabetes, hyperlipidemia, stroke and coronary heart disease) and menstrual and reproductive history (total number of abortions, history of spontaneous abortion and induced abortion, total pregnancies, the number of live births and the ages of menarche and menopause). A pilot survey was first conducted with a small group of the general population to test the validity of the questionnaire. After verifying its enforceability, the complete survey was conducted and substantiated with the face-to-face questionnaire.

Quality control was performed by a special supervisor and staff training programs that mainly addressed the standardized techniques for interviews and measurements. The apparatuses were regularly examined for accuracy and reproducibility at each site.²²

Assessment of anthropometric and bioelectrical variables

Height, weight, waist circumference, body fat percentage, visceral fat index, systolic BP (SBP), diastolic BP (DBP) and heart rate were examined by certified and trained surveyors in accordance with the standard method. Height and waist circumference were both measured to the nearest 0.5 cm and were gauged using standardized protocols. BP was measured by a mercury sphygmomanometer (Yutu Brand, Yutu, Shanghai Medical Instruments Co., Ltd., Shanghai, China) and oscillometric BP monitors (Omron HBP-1300, Kyoto, Japan). After a minimum 5-min rest in the sitting position, BP was measured at least three times in the right arm when the participant was in the sitting position, with 30 s between each measurement. The average value of the three measurements was used for the analysis in this study. Body weight was measured with light clothing and height was measured without shoes and hats in the standing position. Body composition was measured by the multi-frequency bioelectrical impedance method.^{22,23}

Definitions

Participants were separated into three categories (normotension, prehypertension and hypertension) based on SBP and DBP values and history of hypertension. Hypertension was defined as SBP \geq 140 mm Hg and/or DBP \geq 90 mm Hg and/or a diagnosis of hypertension. Prehypertension was defined as 120 mm Hg \leq SBP < 140 mm Hg and/or the 80 mm Hg \leq DBP < 90 mm Hg and without current antihypertensive therapy. Normotension was defined as SBP < 120 mm Hg and DBP < 80 mm Hg, without antihypertensive therapy.²⁴

According to the international medical community, non-smokers were participants who had ever smoked <100 cigarettes from birth to the survey

date. Relative to non-smokers, smokers had smoked >100 cigarettes from birth to the investigation date.

The standard calculation of physical activity level was conducted according to the Chinese guidelines for analysis concerning the International Physical Activity Questionnaire.²⁵ According to the standard, the participants were divided into three groups (low, medium and high).

The definition of drinkers was >100 g of alcohol consumption once and more than once a week for at least 6 months.²⁶

Statistical analysis

A total of 6252 participants were included in the current analysis after excluding those who were not postmenopausal after interview or had incomplete information on BP.

For continuous data, the mean and s.d. were used to describe basic characteristics and analysis of variance or Wilcoxon test was performed to compare differences among groups. The frequencies and percentages were used to report the basic characteristics for the categorical data and comparisons among groups were performed using Chi-square test or the Cochran–Armitage test for trends.

SBP and DBP were categorized as normotension, prehypertension and hypertension according to the definition. Ordinal logistic regression adjusted for age, smoking, drinking, body mass index, physical activity, education status and family history of CVD were conducted to evaluate the association of reproductive history with BP categories.

The 95% confidence intervals (CIs) are calculated for each odds ratio (OR). The statistical tests are all two-sided. A significant value of *P* is 0.05. All statistical analyses were carried out by SPSS 21.0 (SPSS Inc., Shanghai, co., LTD, 6761805c6989326cbf14, Shanghai, China).

RESULTS

Baseline characteristics of the participants

Of the 19 000 participants, there were 6252 postmenopausal women. Table 1 shows the basic characteristics of the postmenopausal women. There were 1226 women (19.61%) with normotension, 1530 (24.47%) with prehypertension and 3496 (55.92%) with hypertension. The proportions of smoking, education below primary school and primary school, increasing age and a positive family history of CVD significantly increased from normotension to hypertension through prehypertension.

The characteristics of the 6252 postmenopausal women's reproductive histories are summarized in Table 2. Statistically significant differences were observed between the age of menarche and the age of menopause, history of induced abortion, the duration of breastfeeding, the number of living births and prehypertension or hypertension, but the correlations were not the same (analysis of variance or Cochran–Armitage trend test, *P* < 0.05).

Association of hypertension and prehypertension with reproductive history

The ordinal logistic regression analyses for all reproductive histories after adjusting for age, smoking, alcohol consumption, body mass index, physical activity and education status (Table 3) illustrated a negative association between age at menopause between 46 and 49 years and both prehypertension (adjusted OR = 0.742, 95% CI: 0.590, 0.933, *P* = 0.011) and hypertension (adjusted OR = 0.717, 95% CI: 0.584, 0.879, *P* < 0.001). An age between 50 and 51 years at natural menopause also showed the same result as hypertension (adjusted OR = 0.813, 95% CI: 0.665, 0.993, *P* = 0.043). This age did not show a significant association with the incidence of prehypertension. There was no significant difference between hypertension or prehypertension and an age at natural menopause >51 years compared with a natural menopause age <45 years. In addition, the number of live births and having two children were found to be protective factors for the

Table 1 Characteristics of the menopausal women

Characteristics	Total (n = 6252)	NTN (n = 1226)	PHT (n = 1530)	HTN (n = 3496)
Age (years, months)*	63.75 (9.1)	60.11 (8.5)	62.61 (8.8)	65.52 (8.9)
<i>Drinking, n (%)</i>				
No	5936 (95.0)	1154 (94.1)	1454 (95.1)	3328 (95.2)
Yes	314 (5.0)	72 (5.9)	75 (4.9)	167 (4.8)
<i>Smoking*, n (%)</i>				
Never smoker	4592 (73.5)	856 (69.8)	1095 (71.6)	2641 (75.5)
Current smoker	101 (1.6)	26 (2.1)	31 (2.0)	44 (1.3)
Former smoker	35 (0.6)	5 (0.4)	3 (0.2)	27 (0.8)
Passive smoker	1521 (24.3)	339 (27.7)	400 (26.2)	782 (22.4)
<i>BMI (kg m⁻²)**, n (%)</i>				
< 18.5	132 (2.1)	23 (1.9)	34 (2.3)	75 (2.2)
18.5–23.9	1976 (32.1)	418 (34.6)	488 (32.6)	1070 (31.0)
24–27.9	2443 (39.7)	477 (39.5)	602 (40.1)	1364 (39.5)
28–	1605 (26.1)	290 (24.0)	374 (25.0)	941 (27.3)
<i>Family history**, n (%)</i>				
Negative	3941 (63.0)	872 (72.1)	1051 (70.2)	2018 (59.4)
Positive	2163 (34.6)	337 (27.9)	446 (29.8)	1380 (40.6)
Not clear	148 (2.4)			
<i>Occupation**, n (%)</i>				
Farmer	3786 (60.6)	668 (54.5)	952 (62.2)	2166 (62.0)
Non-farmer	2466 (39.4)	558 (45.5)	578 (37.8)	1330 (38.0)
<i>Physical activity, n (%)</i>				
Low	2485 (39.8)	481 (39.2)	603 (39.5)	1401 (40.1)
Medium	2090 (33.5)	434 (35.4)	512 (33.5)	1144 (32.8)
High	1670 (26.7)	311 (25.4)	412 (27.0)	947 (27.1)
<i>Education status**, n (%)</i>				
Below primary school	2779 (44.4)	444 (36.2)	649 (42.4)	1686 (48.2)
Primary school	1667 (26.7)	312 (25.4)	383 (25.0)	972 (27.8)
Middle school or above	1806 (28.9)	470 (38.4)	498 (32.5)	838 (24.0)
Height (cm)**	153.1 (6.1)	153.9 (6.0)	153.6 (6.0)	152.5 (6.2)
Weight (kg)**	60.9 (19.7)	57.9 (9.4)	59.7 (9.9)	62.5 (24.9)
Waist circumference (cm)**	88.1 (19.2)	83.8 (9.6)	87.3 (25.4)	89.9 (18.4)
Percentage of body fat**	36.2 (4.7)	34.2 (4.4)	35.6 (4.4)	37.1 (4.7)
Visceral fat index**	36.2 (4.7)	7.8 (3.6)	9.0 (4.0)	10.7 (4.8)

Abbreviations: BMI, body mass index; HTN, hypertension; NTN, normotension; PHT, prehypertension. Data are presented as the number (percentage), other than age, which is the mean value (s.d.). * $P < 0.05$; ** $P < 0.01$.

incidence of hypertension compared with having less than two children among the postmenopausal women (adjusted OR = 0.605, 95% CI: 0.434, 0.845, $P = 0.003$). Furthermore, there was no significant association between having more than three children and hypertension or prehypertension. A positive history of induced abortion demonstrated a significant positive trend with an increasing probability of having hypertension in the postmenopausal women (adjusted OR = 1.190, 95% CI: 0.434, 0.845, $P = 0.027$), but a history of spontaneous abortion did not show a significant result (adjusted OR = 0.967, 95% CI: 0.769, 1.216, $P = 0.774$).

Association between SBP and reproductive history

The adjusted ORs and 95% CIs for SBP associated with reproductive history in the postmenopausal women from the ordinal logistic

regression analysis are shown in Table 4. Ordinal logistic regression analyses revealed that the age at menarche, age at natural menopause, the duration of breast feeding, live birth history, induced abortion history and spontaneous abortion history all had statistical associations with prehypertension or hypertension in terms of SBP. A significant difference was not observed between spontaneous abortion history and BP in terms of SBP. An age at menarche of 14 or 15 years showed a significant inverse association with the risk of hypertension compared with an age at menarche of < 13 years (adjusted OR = 0.736, 95% CI: 0.585, 0.927, $P = 0.009$). An age at natural menopause between 46 and 49 years can not only decrease the risk of hypertension (adjusted OR = 0.788, 95% CI: 0.647, 0.090, $P = 0.018$) but can also decrease the risk of prehypertension (adjusted OR = 0.703, 95% CI: 0.574, 0.860, $P = 0.001$) compared with an age at natural menopause of ≤ 45 years.

Table 2 Reproductive characteristics of the study participants

	Total (n = 6252)	NTN (n = 1226)	PHT (n = 1530)	HTN (n = 3496)
Age at menarche (years)*	16.15 (3.46)	15.97 (3.31)	16.17 (3.13)	16.20 (3.64)
Age at menopause (years)**	48.64 (4.20)	48.18 (4.44)	48.71 (4.00)	48.77 (4.19)
<i>Live birth history, n (%)**</i>				
0 or 1	870 (13.9)	135 (11.0)	135 (8.8)	600 (17.2)
2	1775 (28.4)	356 (29.0)	499 (32.6)	920 (26.3)
3	1742 (27.9)	354 (28.9)	435 (28.4)	953 (27.3)
4	1055 (16.9)	200 (16.3)	239 (15.6)	616 (17.6)
≥ 5	742 (11.9)	171 (13.9)	211 (13.8)	360 (10.3)
Absent	68 (1.1)	10 (0.8)	11 (0.7)	47 (1.3)
χ^2_{trend}		102.776		
P for trend		0.001		
<i>Duration of breast-feeding (months)**</i>				
0	144 (2.3)	35 (2.9)	37 (2.4)	72 (2.1)
1–18	1943 (31.1)	424 (34.6)	487 (31.8)	1032 (29.5)
> 19	3799 (60.8)	692 (56.4)	917 (60.0)	2190 (62.6)
Not clear	366 (5.9)	75 (6.1)	89 (5.8)	202 (5.8)
χ^2_{trend}		16.623		
P for trend		0.011		
<i>Spontaneous abortion</i>				
Never	5236 (83.7)	1022 (83.4)	1290 (84.3)	2924 (83.6)
One and more	636 (10.2)	121 (9.9)	149 (9.7)	366 (10.5)
Absent	206 (6.1)	83 (6.8)	91 (5.9)	206 (5.9)
χ^2_{trend}		0.703		
P for trend		0.507		
<i>Induced abortion**</i>				
Never	3942 (63.1)	833 (67.9)	981 (64.1)	2128 (60.9)
One and more	1943 (31.1)	315 (25.7)	460 (30.1)	1168 (33.4)
Absent	367 (5.9)	78 (6.4)	89 (5.8)	200 (5.7)
χ^2_{trend}		26.275		
P for trend		0.001		
<i>Abortion times**</i>				
Never	3401 (54.4)	649 (52.9)	850 (55.6)	1902 (54.4)
One and more	2435 (38.9)	457 (37.3)	589 (38.5)	1389 (39.7)
Absent	416 (6.7)	120 (9.8)	91 (5.9)	205 (5.9)
χ^2_{trend}		24.893		
P for trend		0.001		

Abbreviations: HTN, hypertension; NTN, normotension; PHT, prehypertension.
Data are presented as the number (percentage), other than age at menarche and menopause, which is the mean year (s.d.). * $P < 0.05$; ** $P < 0.01$.

A duration of breast feeding for > 18 months was strongly and inversely associated with prehypertension (adjusted OR = 0.811, 95% CI: 0.698, 0.934, $P = 0.007$) and hypertension (adjusted OR = 0.825, 95% CI: 0.712, 0.958, $P = 0.011$) when considering only SBP. Additionally, live births of two, three or four children could decrease the prevalence of systolic hypertension and systolic prehypertension. People with a history of induced abortion had an increased risk of hypertension (adjusted OR = 1.446, $P < 0.001$). Interestingly, SBP not show a positive correlation with a history of spontaneous abortion.

Association between reproductive history and DBP

The adjusted ORs and 95% CIs for prehypertension or hypertension between reproductive history and DBP are shown in Table 5. We

found that reproductive history showed almost no difference with DBP. In this study, the postmenopausal women with three children showed a negative association with the prevalence of prehypertension compared with having five or more children (adjusted OR = 0.729, 95% CI: 0.548, 0.970, $P = 0.030$). However, no other factors were associated with the risk of hypertension or prehypertension.

DISCUSSION

This study, conducted in a large population-based sample of postmenopausal Chinese women, evaluated the relative contributions of reproductive history to hypertension and prehypertension. The results indicated that having two children, a positive history of induced abortion and an age between 46 and 49 years at natural menopause had significant associations with the prevalence of hypertension and

Table 3 Adjusted OR (95% CIs) for prehypertension and hypertension in relation to reproductive history among the menopausal women in Henan, China

Reproductive characteristic	Prehypertension			Hypertension		
	β	OR _{adj} (95% CIs)	P-value	β	OR _{adj} (95% CIs)	P-value
<i>Age at menarche (years)</i>						
≤ 13	Reference			Reference		
14–15	–0.103	0.902 (0.696, 1.167)	0.902	0.089	1.093 (0.866, 1.379)	0.455
16–17	–0.170	0.844 (0.682, 1.043)	0.844	0.070	1.073 (0.888, 1.297)	0.467
≥ 18	–0.068	0.934 (0.761, 1.148)	0.934	0.049	1.050 (0.872, 1.264)	0.607
<i>Age at natural menopause (years)</i>						
≤ 45	Reference			Reference		
46–49	0.299	0.742 (0.590, 0.933)	0.011*	–0.140	0.717 (0.584, 0.879)	0.001**
50–51	0.116	0.890 (0.712, 1.114)	0.309	–0.207	0.813 (0.665, 0.993)	0.043*
≥ 52	0.086	0.918 (0.728, 1.157)	0.467	–0.333	0.869 (0.706, 1.070)	0.186
<i>Live birth history</i>						
≤ 1	Reference			Reference		
2	0.247	0.781 (0.538, 1.134)	0.194	–0.502	0.605 (0.434, 0.845)	0.003**
3	0.098	1.102 (0.819, 1.484)	0.520	–0.080	0.983 (0.758, 1.276)	0.983
4	0.035	1.036 (0.755, 1.420)	0.828	0.080	1.083 (0.822, 1.426)	0.570
≥ 5	0.002	1.102 (0.819, 1.484)	0.992	–0.179	0.836 (0.639, 1.094)	0.193
<i>Duration of breast-feeding (months)</i>						
0	Reference			Reference		
1–18	–0.172	0.842 (0.522, 1.359)	0.481	–0.268	0.765 (0.495, 1.183)	0.229
> 19	–0.106	0.899 (0.759, 1.064)	0.217	–0.053	0.949 (0.816, 1.103)	0.491
<i>Spontaneous abortions</i>						
No	Reference			Reference		
Yes	0.021	1.022 (0.789, 1.322)	0.871	–0.033	0.967 (0.769, 1.216)	0.774
<i>Induced abortion</i>						
No	Reference			Reference		
Yes	0.063	1.065 (0.898, 1.264)	0.469	0.174	1.190 (1.020, 1.388)	0.027*
<i>Abortion times</i>						
No	Reference			Reference		
Yes	0.063	1.065 (0.905, 1.253)	0.450	0.119	1.126 (0.973, 1.303)	0.111

Abbreviations: CI, confidence interval; OR, odds ratio.

All the ORs and 95% CIs are adjusted for age, smoking, alcohol consumption, body mass index, physical activity, education status and family history of cardiovascular disease and the ordinal logistic regression was used. The normotension group was the reference group. * $P < 0.05$, ** $P < 0.01$.

prehypertension after adjusting for body mass index, age, physical activity, smoking, alcohol consumption, education status and a family history of CVD in the postmenopausal population in China. Further analysis demonstrated that having two children and an age between 46 and 49 years at natural menopause were not only significantly associated with systolic hypertension but also with the incidence of hypertension or prehypertension and showed an inverse association with the prevalence of hypertension or prehypertension. Having a positive history of induced abortion was positively associated with the risk of hypertension. A strong, positive correlation was observed between SBP and a positive history of induced abortion.

An age between 46 and 49 years at natural menopause is associated with the prevalence of hypertension and prehypertension as a protective factor. However, the age of menarche did not show a significant difference with hypertension or prehypertension, warranting further clarification. Menarche and menopause are two milestones

in a women's reproductive life. Increasing evidence has shown that different ages at menarche could lead to a significant association with CVD²⁷ and metabolic syndrome.²⁸ Some researchers have shown that an earlier age of menarche could lead to an earlier age of hypertension,²⁹ but the association between the age of menarche and hypertension in postmenopausal women is still uncertain. This study did not show a difference between the age at menarche and hypertension in postmenopausal women. However, an age between 46 and 49 years at natural menopause was a protective factor for the prevalence of hypertension, which is similar to the association between age at natural menopause and hypertension in terms of the activation of central adiposity and increased body fatness.^{30,31} In addition, obesity is one of the risk factors in the prevalence of hypertension and prehypertension.^{32–34}

As notably shown, a strong positive association was observed between a positive history of induced abortion and the prevalence of

Table 4 Adjusted OR (95% CIs) for prehypertension and hypertension in the aspect of systolic blood pressure (SBP) in relation to reproductive history among the menopausal women in Henan, China

Reproductive history	Prehypertension			Hypertension		
	β	OR _{adj} (95% CIs)	P-value	β	OR _{adj} (95% CIs)	P-value
<i>Age at menarche (years)</i>						
≤ 13	Reference			Reference		
14–15	–0.163	0.850 (0.675, 1.069)	0.164	–0.306	0.736 (0.585, 0.927)	0.009**
16–17	–0.163	0.850 (0.701, 1.029)	0.096	–0.121	0.886 (0.735, 1.068)	0.204
≥ 18	–0.098	0.907 (0.752, 1.093)	0.304	–0.122	0.885 (0.737, 1.063)	0.192
<i>Age at natural menopause (years)</i>						
≤ 45	Reference			Reference		
46–49	–0.353	0.703 (0.574, 0.860)	0.001**	–0.238	0.788 (0.647, 0.909)	0.018*
50–51	–0.086	0.917 (0.746, 1.128)	0.412	–0.107	0.899 (0.732, 1.103)	0.306
≥ 52	–0.090	0.914 (0.748, 1.117)	0.381	–0.052	0.949 (0.779, 1.157)	0.607
<i>Duration of breast-feeding (months)</i>						
0	Reference			Reference		
1–18	–0.384	0.681 (0.446, 1.039)	0.075	–0.627	0.534 (0.345, 0.828)	0.005**
≥ 19	–0.209	0.811 (0.698, 0.943)	0.007**	–0.192	0.825 (0.712, 0.958)	0.011*
<i>Live birth history</i>						
≤ 1	Reference			Reference		
2	–0.790	0.454 (0.334, 0.618)	0.001**	–1.491	0.225 (0.165, 0.308)	0.001**
3	–0.386	0.680 (0.534, 0.866)	0.002**	–1.019	0.361 (0.286, 0.456)	0.001**
4	–0.160	0.852 (0.667, 1.090)	0.203	–0.519	0.595 (0.471, 0.752)	0.001**
≥ 5	–0.048	0.953 (0.723, 1.256)	0.731	–0.155	0.856 (0.660, 1.111)	0.243
<i>Spontaneous abortion</i>						
No	Reference			Reference		
Yes	0.016	1.016 (0.807, 1.280)	0.890	–0.021	0.979 (0.781, 1.227)	0.855
<i>Induced abortion</i>						
No	Reference			Reference		
Yes	0.102	1.107 (0.949, 1.291)	0.195	0.369	1.446 (1.239, 1.688)	<0.001
<i>Abortion times</i>						
No	Reference			Reference		
Yes	0.085	1.089 (0.941, 1.261)	0.253	0.292	1.339 (1.158, 1.549)	<0.001

Abbreviations: CI, confidence interval; OR, odds ratio.

The parameter is the normotension. All the ORs and 95% CIs are adjusted for age, smoking, drinking, body mass index, physical activity, education status and family history of cardiovascular disease and the ordinal logistic regression was used. Prehypertension: 120 mm Hg ≤ SBP < 140 mm Hg. Hypertension: SBP ≥ 140 mm Hg. The SBP < 120 mm Hg was the reference group.

*P < 0.05, **P < 0.01.

hypertension for the first time. However, when adjusting for a history of spontaneous abortion, a history of abortion did not show a significant association with prehypertension or hypertension. These comparisons suggested that a history of induced abortion rather than spontaneous abortion significantly affects the risk of prehypertension or hypertension. For example, having a history of induced abortion would lead to 1.190-fold increased risk of developing hypertension among normotension for women. Furthermore, the ORs for hypertension or prehypertension by a history of induced abortion were estimated from the ordinal logistic regression after adjusting for common confounding factors. Given the high prevalence of hypertension and prehypertension,^{35–37} we would like to emphasize disease prevention because hypertension must be treated to avoid serious clinical consequences, such as chronic kidney disease and hematencephalon. However, the long-term results of preventing the transition from prehypertension to hypertension by treatment are still

inconsistent.^{38–40} Moreover, increasing evidence has shown that hypertension and prehypertension increase the risk of CVD.^{41,42} In this study, a history of induced abortion is a predictive risk factor for hypertension, though some studies considered an induced abortion as a short-term pregnancy. However, some other studies have shown that induced abortions could lead to long-term consequences.^{43,44} The positive history of induced abortion could lead to obesity and metabolic syndrome, and then obesity and metabolic disturbance could lead to hypertension.^{44,45}

Having two live births is significantly associated with reducing the risk of hypertension in our study, possibly because the number of live births is associated with key physiological changes in left ventricular structural and functional measures in middle-to older-aged women.⁴⁶ The results are consistent with a study that investigated the association between the number of live births and subsequent CVD with participants from the Framingham Heart Study.^{8,47}

Table 5 Adjusted ORs and 95% CIs for prehypertension and hypertension in the aspect of diastolic blood pressure (DBP) in relation to reproductive history among the menopausal women in Henan, China

Reproductive history	Prehypertension			Hypertension		
	β	OR _{adj} (95% CIs)	P-value	β	OR _{adj} (95% CIs)	P-value
<i>Age at menarche (years)</i>						
≤ 13	Reference			Reference		
14–15	0.063	0.939 (0.742, 1.187)	0.597	0.001	0.999 (0.768, 1.301)	0.996
16–17	0.028	1.028 (0.815, 1.297)	0.814	0.075	1.078 (0.832, 1.398)	0.570
≥ 18	0.028	1.028 (0.763, 1.385)	0.855	0.108	1.114 (0.799, 1.552)	0.526
<i>Age at natural menopause (years)</i>						
≤ 45	Reference			Reference		
46–49	0.086	1.089 (0.848, 1.399)	0.503	0.093	0.912 (0.687, 1.209)	0.520
50–51	0.097	1.101 (0.863, 1.405)	0.437	0.099	1.104 (0.842, 1.448)	0.473
≥ 52	0.182	1.199 (0.930, 1.547)	0.161	0.127	1.136 (0.856, 1.508)	0.378
<i>Duration of breast-feeding (months)</i>						
0	Reference			Reference		
1–18	–0.144	0.866 (0.717, 1.045)	0.134	–0.147	0.864 (0.699, 1.067)	0.175
≥ 19	0.200	1.221 (0.646, 2.308)	0.539	0.048	1.049 (0.515, 2.138)	0.895
<i>Live birth history</i>						
≤ 1	Reference			Reference		
2	–0.169	0.844 (0.559, 1.274)	0.420	0.172	1.188 (0.753, 1.875)	0.460
3	–0.228	0.796 (0.595, 1.065)	0.124	0.004	1.004 (0.724, 1.393)	0.979
4	–0.316	0.729 (0.548, 0.970)	0.030*	0.065	0.937 (0.679, 1.293)	0.693
≥ 5	–0.101	0.904 (0.657, 1.244)	0.536	0.081	1.084 (0.758, 1.550)	0.657
<i>Spontaneous abortion</i>						
No	Reference			Reference		
Yes	0.098	1.103 (0.828, 1.467)	0.503	–0.141	0.869 (0.635, 1.188)	0.379
<i>Induced abortion</i>						
No	Reference			Reference		
Yes	–0.089	0.915 (0.748, 1.118)	0.384	–0.102	0.903 (0.722, 1.130)	0.375
<i>Abortion times</i>						
No	Reference			Reference		
Yes	–0.11	0.989 (0.821, 1.191)	0.905	–0.099	0.905 (0.736, 1.115)	0.349

Abbreviations: CI, confidence interval; OR, odds ratio.

All the OR and 95% CI are adjusted for age, smoking, drinking, body mass index, physical activity, education status and the family history of cardiovascular disease and the ordinal logistic regression was conducted. Prehypertension: 80 mm Hg ≤ DBP < 90 mm Hg. Hypertension: DBP ≥ 90 mm Hg. The DBP < 80 mm Hg was the reference group. **P* < 0.05, ***P* < 0.01.

Strengths and limitations

This study has several advantages. A particular strength is that this study assessed the association between reproductive history and BP, including comprehensively related information, with a sufficient sample size. Another important strength of this research is that anthropometric values and BP were measured according to the recommended standard methods.^{8,48} All investigators were trained by the same supervisor and all participants were evaluated by the same well-trained investigators in a Chinese central province, which ensured consistency and accuracy in the data.

As a population-based cross-sectional study, this study also has several limitations. Cause–effect conclusions cannot be established, reducing the power to clarify the association between reproductive history and hypertension or prehypertension. Furthermore, the participants were all Chinese Han and this study was a sampling

survey, implying the presence of sampling errors. Further investigations should be conducted in other ethnicities.

CONCLUSIONS

The present study showed that having two children, rather than having fewer than two children, significantly reduces the risk of hypertension or prehypertension among women, and a menopausal age between 46 and 49 years may be a protective risk factor against hypertension or prehypertension. Conversely, women with a history of induced abortion may have an increased risk of hypertension or prehypertension.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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