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Research article

Traditional Chinese Medicine constitution types of high-normal blood pressure: A meta-analysis

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ABSTRACT

Objective: We determined the distribution of constitutional types of high-normal blood pressure in Traditional Chinese Medicine (TCM) and provided evidence for the prevention of high-normal blood pressure and hypertension.

Methods: Eight digital databases were searched from January 2011 to November 2022, including PubMed, EMBASE, Web of Science, EBSCOhost, CNKI, CBM, Wangfang, and CQVIP. We performed a meta-analysis with the random-effects model or fixed-effects model to describe the distribution of constitutional types of high-normal blood pressure in TCM. The studies were assessed based on heterogeneity testing and the potential for publication bias. The meta-analysis was performed on Stata software 15.0.

Results: A total of 17 studies with 8118 participants were included in this meta-analysis. The proportion of the biased constitution (82.3%; 95% CI: 75.6%–89.1%, $p < 0.001$) was higher than the balanced constitution (17.3%; 95% CI: 10.7–23.8%, $p < 0.001$). Phlegm-dampness constitution, *Yin*-deficiency constitution, and damp-heat constitution accounted for 16.0% (95%CI: 10.5–21.5%, $p < 0.001$), 14.8% (95% CI: 11.0–18.6%, $p < 0.001$), 11.3% (95% CI: 8.0–14.5%, $p < 0.001$) of the total high-normal blood pressure cases, respectively. The subgroup analyses performed that region, age and gender were positively associated with the distribution of constitution types of high-normal blood pressure in TCM. Compared with the general population, the risk of high-normal blood pressure in people with the phlegm-dampness constitution, *Yin*-deficiency constitution, and blood-stasis constitution was 2.665 (95%CI: 2.286–3.106, $p < 0.001$), 2.378 (95%CI: 1.197–4.724, $p = 0.013$), 1.965 (95%CI: 1.634–2.363, $p < 0.001$) times of the general population, respectively. Meanwhile, the risk of high-normal blood pressure was lower in people with a balanced constitution (0.248, 95%CI: 0.165–0.372, $p < 0.001$).

Conclusions: Phlegm-dampness constitution, *Yin*-deficiency constitution, and damp-heat constitution were the common constitution types of high-normal blood pressure. There might also be differences in the distribution characteristics of TCM constitution among people with high-normal

List of abbreviations: High-normal BP, High-normal blood pressure; TCM, Traditional Chinese Medicine; CCMQ, Constitution in the Chinese Medicine Questionnaire; CNKI, China National Knowledge Infrastructure; CBM, China Biology Medicine.

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blood pressure in different regions, ages, and genders. Finally, a balanced constitution might be a protective factor for hypertensive people.

1. Background

High-normal blood pressure (high-normal BP) is an intermediate state between hypertension and normal blood pressure and is common in the general population. In some areas, the prevalence of high-normal BP is even higher than hypertension [1]. Globally, the prevalence of high-normal BP in healthy adults is 36.3% [2], and in some developing countries, the number is around 30.7–47.3% [3–7]. According to Xu T [8], the prevalence of high-normal BP in China is 36.4%, with an average age of 44.0 ± 16.0 years. Except for the high incidence rate, high-normal BP is a known risk factor for cardiovascular disease. Studies have also suggested that high-normal BP is an independent risk factor for hypertension. Moreover, a 15-year follow-up study showed that, compared to people with blood pressure <120/80 mmHg, those with high-normal BP presented a risk of cardiovascular disease, coronary heart disease, and stroke increased by 78%, 77%, 79%, respectively, and the risk of cardiovascular death increased by 1.50 times [9].

Furthermore, high-normal BP is common and closely related to cardiovascular and cerebrovascular diseases. Consequently, people with high-normal BP should receive increased attention. Recently, Traditional Chinese Medicine (TCM) has drawn attention to clinical trials and its significant effects on disease prevention have been demonstrated [10]. Additionally, the identification of the TCM constitution is an effective approach to "treat disease before onset" [11]. Ye PH [12] showed that combining the identification of the TCM constitution with modern medical laboratory technology can offer support for personalized intervention plans for high-normal BP. The identification of the TCM constitution depends on the intrinsic characteristics of the human body and is affected by the environment, integrating the morphological structure and physiological function with the psychological state [13]. Balanced constitution, *Qi*-deficiency constitution, *Yang*-deficiency constitution, *Yin*-deficiency constitution, phlegm-dampness constitution, damp-heat constitution, blood-stasis constitution, *Qi*-stagnation constitution, and inherited-special constitution types are nine classifications of TCM constitution [14–16]. Except for the balanced constitution, the other eight types are known as the biased constitution. Previously, Liang [16] analyzed the correlations between TCM constitution types and diseases published from 2009 to 2019, to determine the relationship between specific diseases with different constitution types. Moreover, a cross-sectional study with 2660 participants performed by Zhu [13] explored the association of five chronic diseases (hypertension, hyperlipidemia, diabetes mellitus, heart disease, and obesity) with nine TCM constitution types. People with hypertension present changes in the TCM constitution [16]. High-normal BP is a transitional stage for the development of hypertension, we also need to pay attention to the characteristics of TCM constitution types of people with high-normal BP. In the present meta-analysis, we evaluated the distribution of TCM constitution types of high-normal BP, to determine the types of TCM constitution prone to high-normal BP, and provide evidence for the early prevention of high-normal BP and hypertension for "preventive treatment of disease".

2. Methods

This meta-analysis was a systematic reviews and meta-analyses based on PRISMA guidelines (2020) [17,18].

2.1. Registration

The protocol was registered and published at PROSPERO, the registration number was CRD42022376371.

2.2. Search strategy

A pre-specified search strategy was used to identify publications regarding on TCM constitution of high-normal BP in PubMed, EMBASE, Web of Science, EBSCOhost, China Biology Medicine (CBM), China National Knowledge Infrastructure (CNKI), Wangfang Database, and CQVIP databases. Medical Subject Headings (MeSH) and keywords were used to search in eight databases from January 1, 2011, to November 16, 2022. The search strategies for the English databases are shown in Supplementary Table 1.

2.3. Inclusion criteria

The inclusion criteria were: (1) Research type: cross-sectional, longitudinal, case-control, and cohort. (2) Participants: Chinese, diagnosed with high-normal BP, and their TCM constitutions were diagnosed according to the "Classification and Determination of Constitution in TCM" [19] released by the Chinese Association of Chinese Medicine in 2009. (4) Outcomes: the sample size of the study was clear and available, and the data on the TCM constitution composition was sufficient and complete. The Constitution in Chinese Medicine Questionnaire (CCMQ) is shown in Supplementary Table 2.

2.4. Exclusion criteria

The exclusion criteria were: (1) Lack of basic information or without statistics on the constitution composition; (2) Participants suffered from diseases that might affect the TCM constitution types; (3) Repeatedly published studies and conference papers.

2.5. Data extraction

Two investigators independently conducted the literature screening and data extraction, checked the information extracted, and objections were auxiliary judged by a third experienced reviewer. Researchers read the title and abstract for initial screening and excluded ineligible studies. After removing duplicate references using the NoteExpress Software, the full text was evaluated based on the inclusion criteria. Only studies that met the inclusion criteria were finally extracted. For each eligible study, extracted information includes the first author, publication year, study type, total sample size, the number of people in the constitution region, gender, and the mean and standard deviation of age.

2.6. Quality assessment

The assessment tool recommended by the Agency for Healthcare Research and Quality (AHRQ) [20] was used to evaluate cross-sectional studies. This tool includes 11 items with the highest score of 11: 0–3 represent low quality, 4–7 represent medium quality, and 8–11 represent high quality. The Newcastle-Ottawa Scale (NOS) [21] was used to evaluate case-control and cohort studies. This scale includes study population selection, comparability, exposure, and outcome with a total score of 9. Two investigators independently performed the quality assessment. In the case of disagreement, a third investigator was consulted.

2.7. Data analyses

Stata 15.0 software was used to perform this meta-analysis. The mean percentage of constitution types of high-normal BP people was calculated as the effect size (ES), and the 95% confidence intervals (95% CI) were described using a forest plot. The heterogeneity of eligible studies was determined by the Q statistic [22] and *I*-squared (I^2) [23]. A fixed-effects model was used when the heterogeneity was not statistically significant ($I^2 < 50\%$); otherwise, a random-effects model was used ($I^2 > 50\%$). The significance of the pooled ES was determined by a χ^2 test with a $p < 0.05$. Publication bias was assessed by funnel plots and the asymmetry of funnel plots was measured by Egger's test.

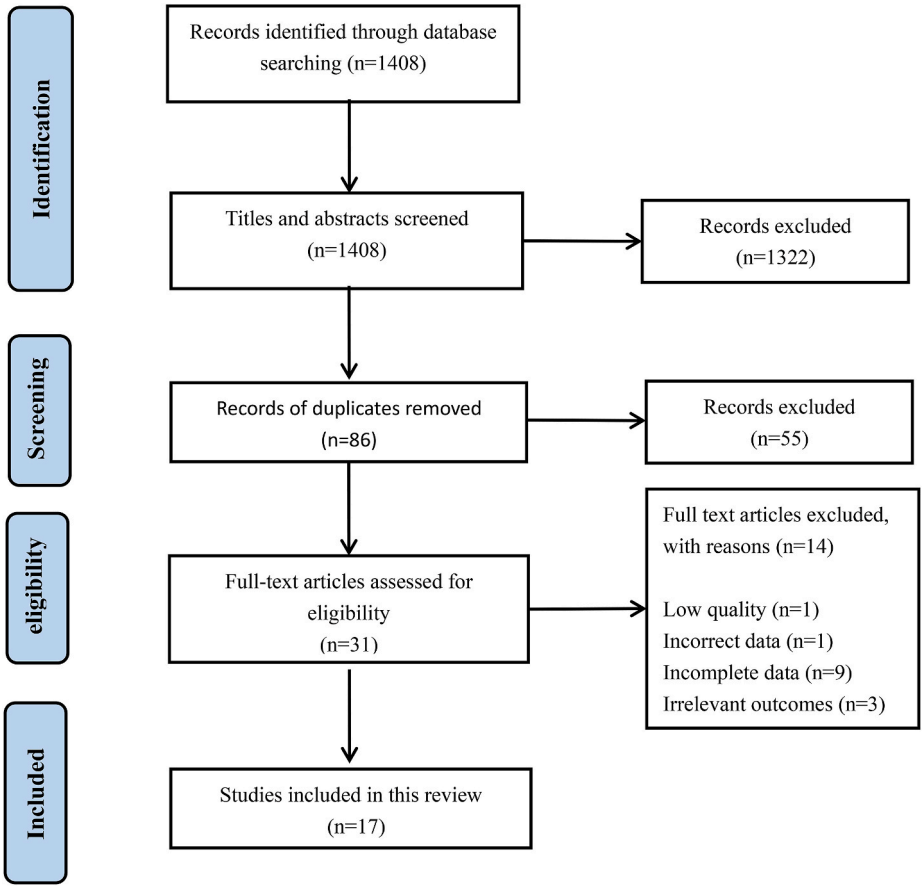

Fig. 1. PRISMA flow diagram of study selection and identification.

3. Result

3.1. Study characteristics

A total of 1408 studies were included during the database search. After reading the titles and abstracts, 86 articles were included. Then, 55 duplicate studies were removed using the NoteExpress Software. After retrieving and screening the full texts of the remaining studies, 17 eligible studies [24–40] with 8118 participants were finally included. Fig. 1 shows the specific screening process and results. All 11 cross-sectional and 6 case-control studies, were Chinese articles. The major characteristics of included studies are summarized in Table 1. The composite constitution type was ineligible for meta-analysis. The quality assessment results according to the AHRQ and NOS of included studies are listed in Table 1. Overall, the scores ranged from 5 to 8.

3.2. Meta-analysis of the distribution of TCM constitutions

A total of 17 studies reported the distribution of TCM constitutions, comprehending 8118 participants. The proportion of the biased constitution (82.3%; 95%CI: 75.6–89.1%) (Fig. 2B) was higher than the balanced constitution (17.3%; 95% CI: 10.7–23.8%) (Fig. 2A). In the biased constitution, the phlegm-dampness constitution, the *Yin*-deficiency constitution, and the damp-heat constitution presented the highest proportions.

3.2.1. Phlegm-dampness constitution

Considerable heterogeneity was detected for studies with the phlegm-dampness constitution ($I^2 = 98.9\%$, $p < 0.001$). Hence, a random-effects model was used. The meta-analysis revealed that the proportion of phlegm-dampness constitution was 16.0% (95%CI: 10.5–21.5%). The forest plot is shown in Fig. 3.

Table 1
Major characteristics of included studies.

Author, year	Region	Study design	Sample size	Gender ratio (M/F)	Age range (years)	Average age (years)	The calculation method of TCM constitution	Quality evaluation
Huo R 2012	South China	CCS	200	106/84	NA	53.1 ± 14.6	Clear[a]	7
Jiao YF 2013	East China	CCS	242	136/106	20–70	NA	Clear	7
Du XL 2015	East China	CSS	196	130/66	18–75	50.67 ± 13.74	Not clear	7
Huang CY 2015	South China	CSS	200	89/111	NA	Male: 45.81 ± 9.75; Female: 45.35 ± 11.36	Not clear	7
Li HB 2015	South China	CCS	200	71/129	NA	49.89 ± 12.91	Clear	6
Yin LH 2015	East China	CSS	300	136/164	40–60	44.93 ± 2.66	Not clear	8
Wang ZY 2017	Northeast China	CSS	100	52/48	NA	57.74 ± 10.68	Clear	6
Yuan SH 2017	North China	CSS	616	233/383	18–60	NA	Not clear	8
Jiang HX 2018	East China	CSS	300	NA	≥20	NA	Not clear	7
Sun QC 2018	North China	CSS	453	236/217	≥18 and ≤ 89	NA	Not clear	7
Xu JX 2019	South China	CCS	94	52/42	18–80	44.66 ± 9.573	Clear	6
Zhang GH 2019	South China	CCS	2019	1548/471	16–82	41.94 ± 11.89	Not clear	6
Zhou ZY 2019	East China	CSS	150	97/53	19–74	49.88 ± 8.31	Not clear	6
Chen ZP 2020	East China	CCS	128	NA	40–60	NA	Not clear	6
Wang P 2020	East China	CSS	828	390/438	17–23	18.54 ± 0.966	Clear	8
Wu FJ 2021	South China	CSS	292	NA	> 18	NA	Not clear	6
Yang JY 2021	Northwest China	CSS	1800	1064/736	> 50	NA	Not clear	5

CSS: cross-sectional study; CCS: case-control study; M: man; F: female; NA: not available; TCM, traditional Chinese medicine.

[a] The Constitution in Chinese Medicine Questionnaire (CCMQ) was used to identify the TCM constitution which consists of 9 subscales. Each subscale represent a specific constitution, the original score of the subscale is equal to the sum of the scores for each item, and the transformed score is calculated as follows: [(original score - number of items)/(number of items × 4)] × 100. If the transformed score for the balanced constitution ≥60 and all the remaining eight biased constitutions transformed score <30, then a balanced constitution was defined. Otherwise, if the transformed score for balanced constitution <60 and *Qi*-deficiency scores ≥40, then *Qi*-deficiency constitution was defined, and the determination for the other seven biased constitutions was similarly defined.

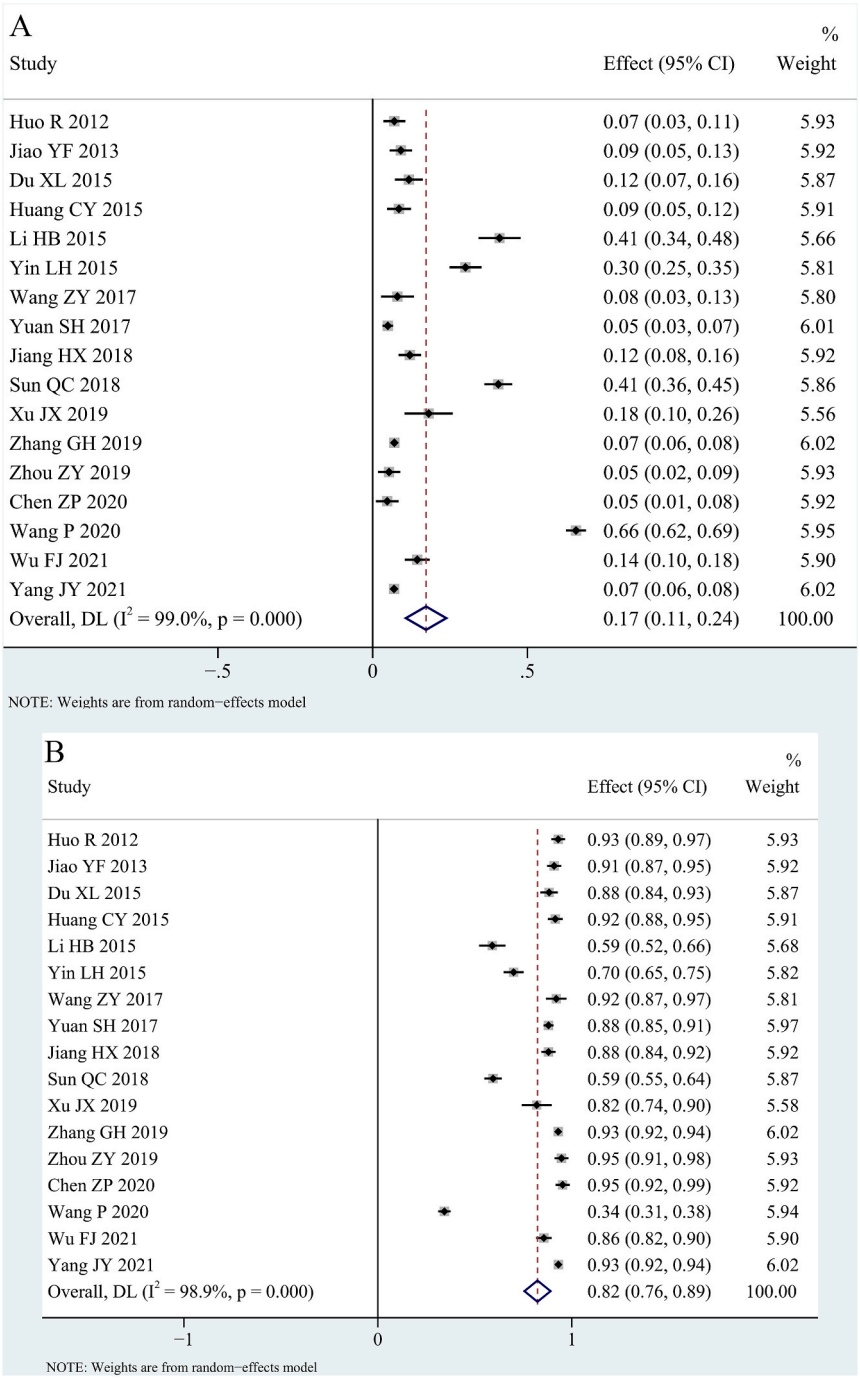

Fig. 2. Meta-analysis of the proportion of biased constitution and balanced constitution in high-normal BP. (A: balanced constitution/B: biased constitution).

3.2.2. Yin-deficiency constitution

Heterogeneity was also tested among the studies with the *Yin*-deficiency constitution ($I^2 = 96.7\%$, $p < 0.001$), and a random-effects model was used. The proportion of the *Yin*-deficiency constitution was 14.8% (95% CI: 11.0–18.6%). The forest plot is shown in Fig. 4.

3.2.3. Damp-heat constitution

A random-effects model was used for the damp-heat constitution due to the high heterogeneity ($I^2 = 96.0\%$, $p < 0.001$). The proportion of damp-heat constitution was 11.3% (95% CI: 8.0–14.5%). The forest plot is shown in Fig. 5.

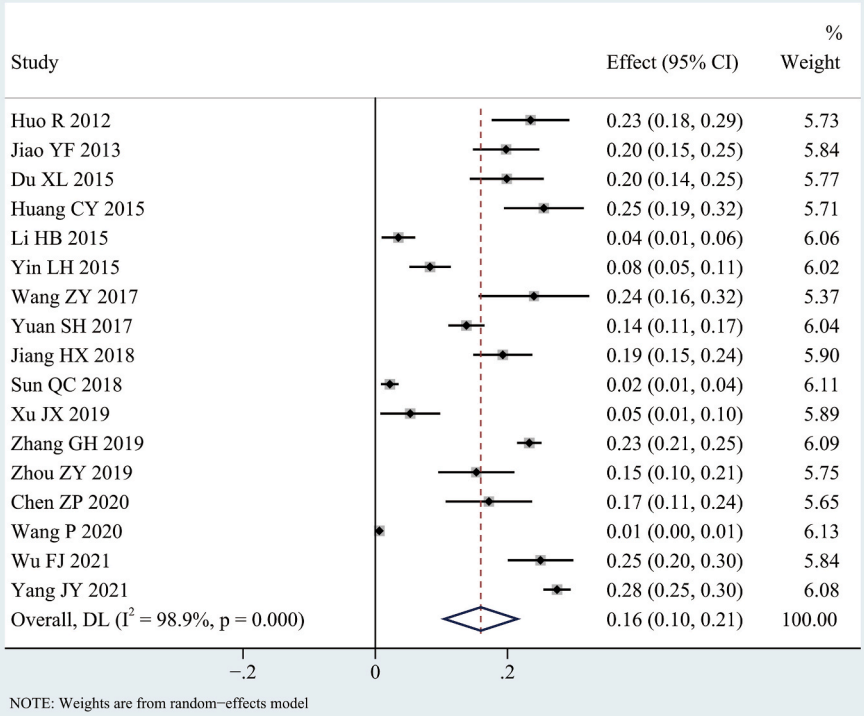

Fig. 3. Meta-analysis of the proportion of phlegm-dampness constitution in high-normal BP.

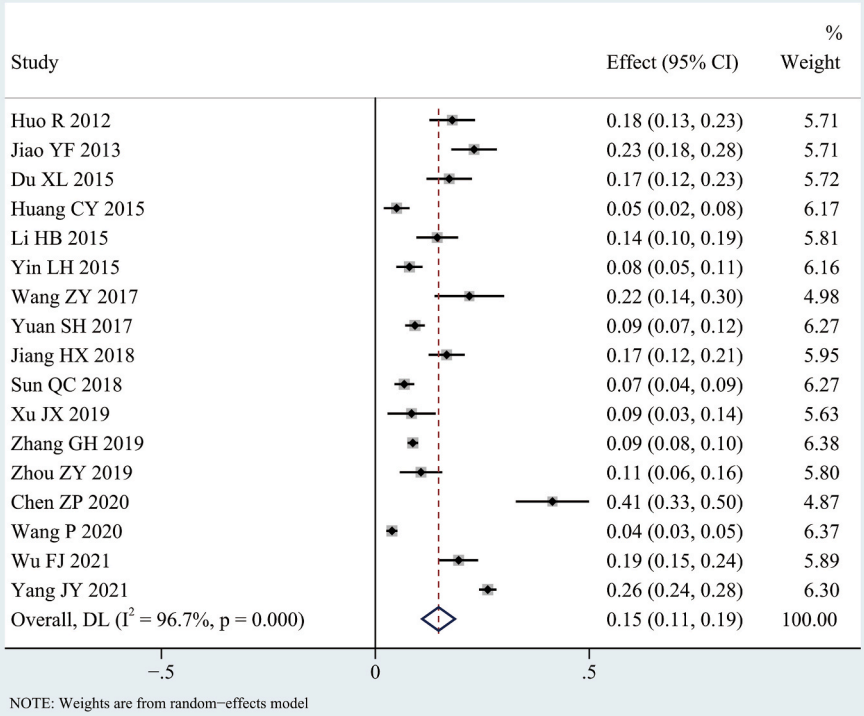

Fig. 4. Meta-analysis of the proportion of yin-deficiency constitution in high-normal BP.

3.3. Subgroup analyses

People with a balanced constitution often feel energetic, have strong adaptability to circumstances, and are less likely to be vulnerable to disease. Meanwhile, people with a biased constitution are easily exposed to the disease. Thus, we further performed subgroup analyses to explore the distribution of the biased constitution in different high-normal BP populations according to the region (East China, South China, North China, Northeast China, and Northwest China), age (>40 years, <40 years and whole age subgroup), gender (male and female). The results of the proportion of high-normal BP in different subgroups are shown in Table 2.

3.3.1. Region

The studies included five regions, but only East China, South China, and North China were eligible for the meta-analysis. In East China, the first three of the eight biased constitutions were the *Yin*-deficiency constitution (16.7%; 95%CI: 9.6–23.8%), phlegm-dampness constitution (14.2%; 95%CI: 6.3–22.1%), damp-heat constitution (10.6%; 95%CI: 5.8–15.3%). Phlegm-dampness constitution (17.6%; 95%CI: 8.3–26.8%) was the major type in South China, *Qi*-deficiency constitution (14.1%; 95% CI, 8.4–19.7%) was the second, *Yin*-deficiency constitution (12.1%; 95%CI: 7.9–16.3%) and damp-heat constitution (12.1%; 95% CI: 6.5–17.8%) were tied for the third place. In North China, the *Yang*-deficiency constitution (17.9%; 95%CI: 14.5–21.3%), damp-heat constitution (14.6%; 95% CI: 12.4–16.7%), and *Qi*-deficiency constitution (9.4%; 95% CI: 5.4–13.3%) were ranked in the top three.

3.3.2. Age

All eligible studies were divided into 3 subgroups (>40 years, <40 years, and whole age subgroup) based on the age range of participants reported in studies. In the >40 years subgroup, the *Yin*-deficiency constitution (24.8%; 95%CI: 9.4–40.1%) took first place, phlegm-dampness constitution (17.7%; 95%CI: 3.7–31.7%) was ranked.

Second, *Yang*-deficiency constitution (9.7%; 95%CI: 3.7–15.7%) and *Qi*-deficiency constitution (9.7%; 95%CI: 8.4–10.9%) were tied for the third place. In the Whole age subgroup, the top three constitutions were the phlegm-dampness constitution (15.9%; 95%CI: 8.7–23.2%), damp-heat constitution (14.9%; 95%CI: 12.0–17.8%), and *Yin*-deficiency constitution (13.0%; 95%CI: 9.9–16.1%).

3.3.3. Gender

Four studies reported the distribution of TCM constitutions for different genders. In the male subgroup, the damp-heat constitution (17.6%; 95%CI: 2.3–32.9%) was the highest followed by the phlegm-dampness constitution (17.2%; 95%CI: 2.4–32.0%) and *Yin*-deficiency constitution (9.4%; 95%CI: 3.2–15.6%). The top three constitutions in the female subgroup were the *Yang*-deficiency constitution (12.8%; 95%CI: 2.5–23.1%), *Qi*-stagnation constitution (12.0%; 95%CI: 2.7–21.4%), and phlegm-dampness constitution

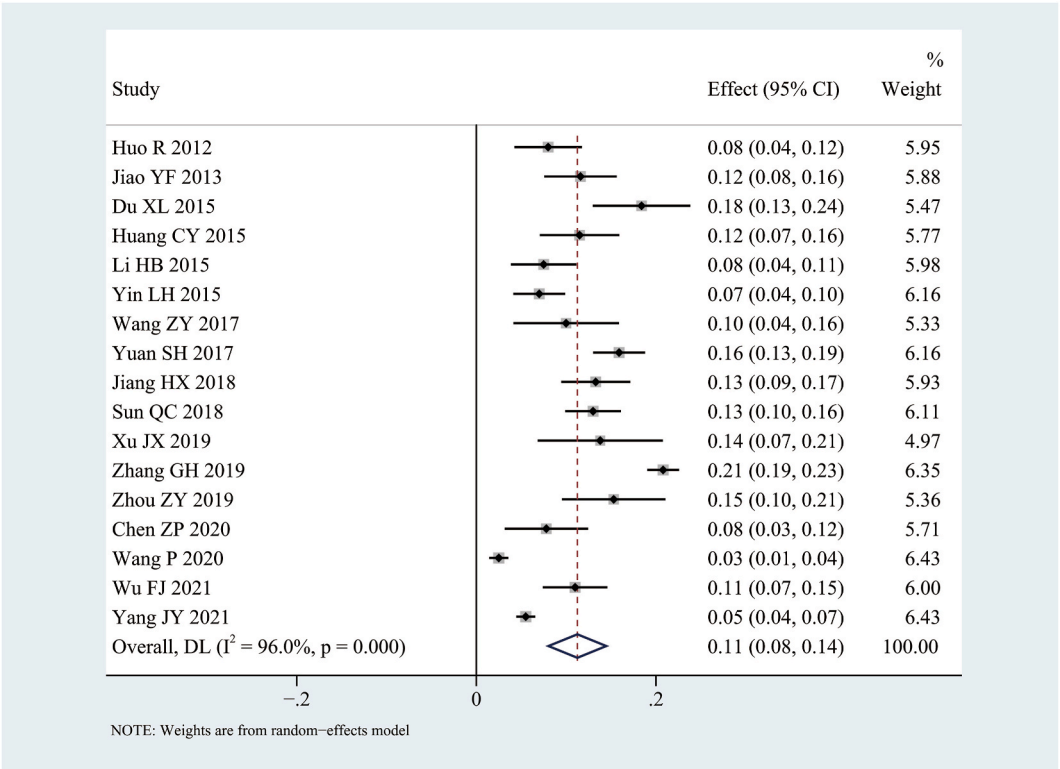

Fig. 5. Meta-analysis of the proportion of dampness-heat constitution in high-normal BP.

Table 2
Subgroup analysis of the biased constitution according to region, age, gender.

Subgroup	Studies(*N*)	Sample size	Constitution	ES[1] (95% CI)	*P*	Heterogeneity test		
						Q	I^2 (%)	P
			phlegm-dampness	0.160 (0.105–0.215)	<0.001	1455.98	98.9	<0.001
Total	17	8118	*Yin*-deficiency	0.148 (0.110–0.186)	<0.001	481.26	96.7	<0.001
			damp-heat	0.113 (0.080–0.145)	<0.001	403.36	96.0	<0.001
Region								
East China	7	2144	*Yin*-deficiency	0.167 (0.096–0.238)	<0.001	155.54	96.1	<0.001
			phlegm-dampness	0.142 (0.063–0.221)	<0.001	227.18	97.4	<0.001
			damp-heat	0.106 (0.058–0.153)	<0.001	88.36	93.2	<0.001
South China	6	3005	phlegm-dampness	0.176 (0.083–0.268)	<0.001	200.65	97.5	<0.001
			Qi-deficiency	0.141 (0.084–0.197)	<0.001	81.50	93.9	<0.001
			Yin-deficiency	0.121 (0.079–0.163)	<0.001	42.30	88.2	<0.001
			damp-heat	0.121 (0.065–0.178)	<0.001	77.57	93.6	<0.001
North China	2	1069	*Yang*-deficiency	0.179 (0.145–0.213)	<0.001	2.21	54.8	0.137
			damp-heat	0.146 (0.124–0.167)	<0.001	1.80	44.5	0.179
			Qi-deficiency	0.094 (0.054–0.133)	<0.001	4.74	78.9	0.029
Northeast China	1	100	phlegm-dampness	0.240 (0.156–0.324)	/	/	/	/
			Yin-deficiency	0.220 (0.139–0.301)	/	/	/	/
			blood-stasis	0.190 (0.113–0.267)	/	/	/	/
Northwest China	1	1800	phlegm-dampness	0.275 (0.254–0.296)	/	/	/	/
			Yin-deficiency	0.263 (0.243–0.283)	/	/	/	/
			Qi-deficiency	0.097 (0.083–0.111)	/	/	/	/
Age								
>40	3	2228	*Yin*-deficiency	0.248 (0.094–0.401)	0.002	116.58	98.3	<0.001
			phlegm-dampness	0.177 (0.037–0.317)	0.013	102.82	98.1	<0.001
			Yang-deficiency	0.097 (0.037–0.157)	0.002	29.12	93.1	<0.001
			Qi-deficiency	0.097 (0.084–0.109)	<0.001	2.82	29.0	0.245
Whole age	9	4362	phlegm-dampness	0.159 (0.087–0.232)	<0.001	410.29	98.1	<0.001
			damp-heat	0.149 (0.120–0.178)	<0.001	46.29	82.7	<0.001
			Yin-deficiency	0.130 (0.099–0.161)	<0.001	68.79	88.4	<0.001
<40	1	828	*Yang*-deficiency	0.045 (0.031–0.059)	/	/	/	/
			Yin-deficiency	0.039 (0.026–0.052)	/	/	/	/
			Qi-deficiency	0.030 (0.018–0.042)	/	/	/	/
Gender								
Male	4	827	damp-heat	0.176 (0.023–0.329)	0.024	114.64	97.4	<0.001
			phlegm-dampness	0.172 (0.024–0.320)	0.023	115.97	97.4	<0.001
			Yin-deficiency	0.094 (0.032–0.156)	0.003	32.84	90.9	<0.001
Female	4	1015	*Yang*-deficiency	0.128 (0.025–0.231)	0.015	76.78	96.1	<0.001
			Qi- stagnation	0.120 (0.027–0.214)	0.011	86.88	96.5	<0.001
			phlegm-dampness	0.119 (0.020–0.219)	0.018	91.32	96.7	<0.001

ES: effect size, represents the prevalence of biased constitution.

(11.9%; 95%CI: 2.0–21.9%).

3.3.4. Distribution of TCM constitution in high-normal BP and the general population

Based on the six case-control studies included, we further compared the distribution of TCM constitution types between the high-normal BP population and the general population. A total of 5817 participants (experimental:2883/control:2934) were included in the analysis, the results of the meta-analysis showed that the risk of high-normal BP in people with the phlegm-dampness constitution, *Yin*-deficiency constitution, and blood-stasis constitution was 2.665 (95%CI: 2.286–3.106), 2.378 (95%CI: 1.197–4.724), 1.965 (95%CI: 1.634–2.363) times of the general population, respectively (Fig. 6B–D). The risk of high-normal blood pressure was lower in people with a balanced constitution (0.248; 95%CI: 0.165–0.372) (Fig. 6A). The results are shown in Table 3.

3.4. Publication bias

Egger's linear regression test was applied to assess the asymmetry of the funnel plot and evaluate the publication bias significance, the results of the funnel plot indicate publication bias. The results indicated that no obvious publication bias was present based on Egger's test ($p = 0.090$) (Fig. 7).

4. Discussion

In the current meta-analysis, people with high-normal BP tended to have a higher proportion of biased constitutions, the most common biased constitutions in people with high-normal BP were the phlegm-dampness constitution, *Yin*-deficiency constitution, and damp-heat constitution. Meanwhile, compared to the general population, people with the phlegm-dampness constitution, *Yin*-deficiency constitution, or damp-heat constitution tended to have a higher risk of high-normal BP, and people with a balanced constitution

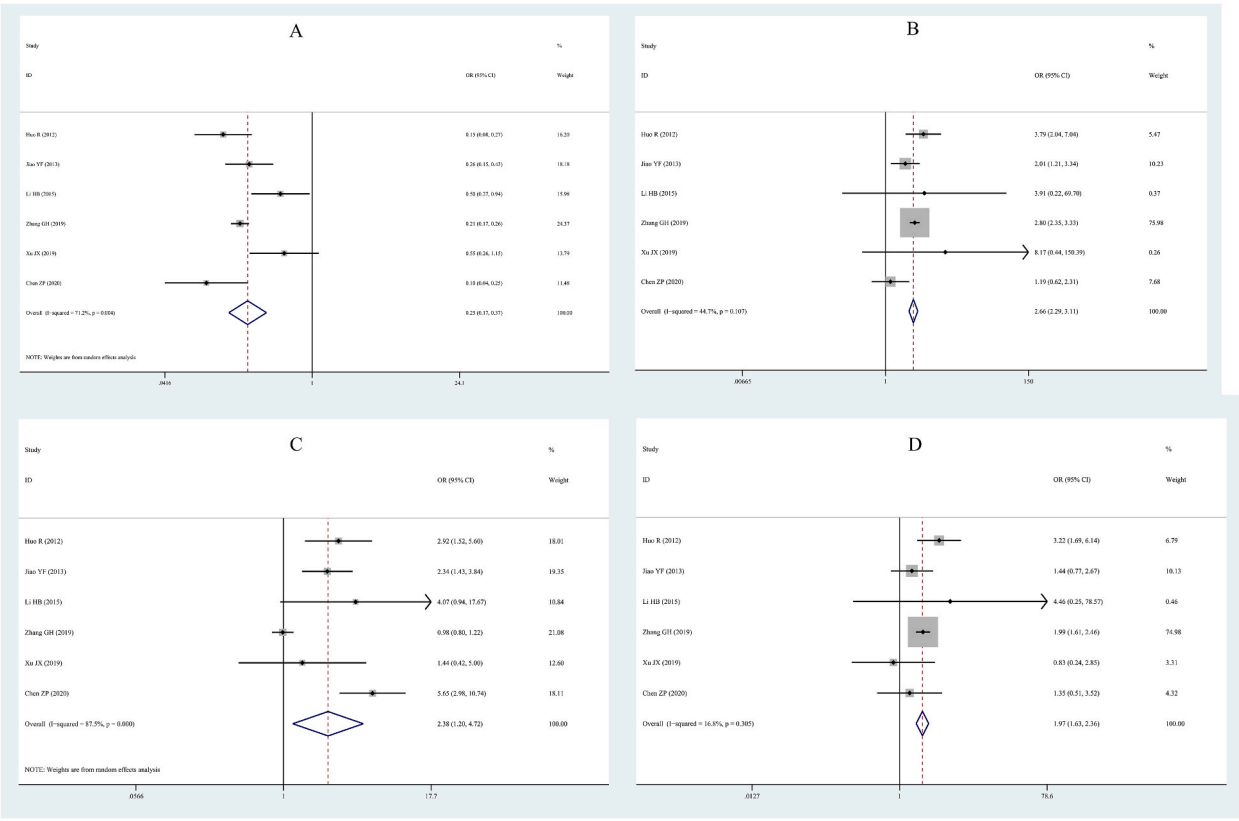

Fig. 6. Comparison of distribution of TCM constitutions between High-normal BP population and general population. (A: balanced constitution/B: phlegm-dampness constitution/C: *Yin*-deficiency constitution/D: blood-stasis constitution).

Table 3
Comparison of distribution of traditional Chinese medicine constitutions between High-normal BP population and general population (N = 6).

Constitution	Sample size		Event		*OR* (95%CI)	Z	P	Heterogeneity test		
	Experimental	Control	Experimental	Control				Q	I^2 (%)	P
Balanced	2883	2934	283	821	0.248 (0.165–0.372)	6.72	<0.001	17.37	71.2	0.004
Qi-deficiency	2883	2934	456	489	0.904 (0.784–1.042)	1.39	0.164	8.86	43.6	0.115
Yang-deficiency	2883	2934	200	233	0.908 (0.746–1.106)	0.96	0.338	3.31	0.0	0.652
Yin-deficiency	2883	2934	360	263	2.378 (1.197–4.724)	2.47	0.013	40.02	87.5	<0.001
phlegm-dampness	2883	2934	599	281	2.665 (2.286–3.106)	12.54	<0.001	9.04	44.7	0.107
damp-heat	2883	2934	501	399	1.161 (0.661–2.040)	0.52	0.604	22.49	77.8	<0.001
Qi-stagnation	2883	2934	109	190	0.577 (0.452–0.737)	4.42	<0.001	4.66	0.0	0.458
blood-stasis	2883	2934	342	196	1.965 (1.634–2.363)	7.18	<0.001	6.01	16.8	0.305
inherited-special	2883	2934	33	62	0.582 (0.249–1.359)	1.25	0.211	12.77	60.8	0.026

tended to have a lower risk of high-normal BP. Bai et al. [41] found that among 108,015 Chinese people over the age of 15, the proportion of a balanced constitution was less than one-third, while the proportion of biased constitution increased. *Yang*-deficiency constitution, *Qi*-deficiency constitution, and damp-heat constitution were commonly biased constitutions [41]. At the same time, according to the results of this study, the balanced constitution may be a protective factor of high-normal BP, and attention should be paid to the conditioning of the TCM constitution in people with high-normal BP.

This study found that the distribution of TCM constitution in people with high-normal BP was different from other diseases, such as diabetes mellitus, and dyslipidemia. *Yin*-deficiency constitution, phlegm-dampness constitution, and *Qi*-deficiency constitution were the common constitution types of diabetic people [42], the top three TCM constitutions of dyslipidemia were phlegm-dampness constitution, *Qi*-deficiency constitution, and *Yang*-deficiency constitution [43], these indicated that there were differences in the distribution of TCM constitutions among different diseases. Professor Sun pointed out that from health to pro-disease, the fundamental reason lies in constitution changes, and that the biased constitution was the internal basis of pre-disease [44]. According to the results of this study, the distribution of TCM constitutions in the high-normal BP population has already changed, and the TCM constitutions measurement has positive significance in the identification and prevention of high-normal BP populations. Therefore, it is necessary to

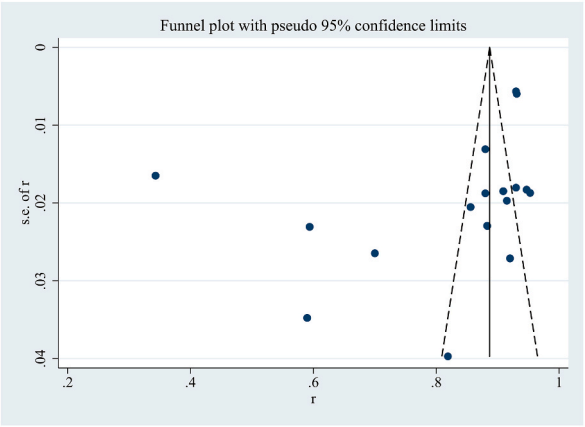

Fig. 7. Funnel plot analysis of the distribution of biased constitution.

pay more attention to the evaluation of the constitution and take preventive measures in the early stages, we recommend that the identification of TCM constitutions should be extended to the evaluation of pro-disease people.

Professor Wang believed that TCM constitutions were affected by different regions, gender, and age [45]. We found that the distribution of the biased constitution in high-normal BP populations varied differently in regions. The most common constitution of people with high-normal BP in South China was the phlegm-dampness constitution, while the most common constitution in North China was the *Yang*-deficiency constitution, which may be related to the climatic characteristics of different regions. The climate in South China is warm and humid, and residents are easy to generate phlegm, and dampness, which may lead to more people with phlegm-dampness [42]. However, the climate in North China is cool and dry, which may not easily generate phlegm or dampness, thus having less influence on the health of residents [43]. These results indicated that the constitution of the high-normal BP population varied between different climatic regions, suggesting that the TCM constitution distribution will vary in countries with different latitudes. Due to the differences in physiological function, material metabolism, and heredity between males and females, different TCM constitutions were formed [45]. Males are extroverted and have a stronger constitution and a higher basal metabolic rate. Meanwhile, female have a lower basal metabolic rate and an excess of *Yin in vivo* which lead to *Yang*-deficiency [41], which would explain the prevalence of *Yang*-deficiency constitution in this subgroup, consistent with Liang's findings [16]. Furthermore, with the change in visceral functional activities and the metabolism of *Qi-blood-body fluid*, the constitution characteristics of each age are continuously changing [45]. This study found that the *Yin*-deficiency constitution, phlegm-dampness constitution, *Yang*-deficiency constitution, and *Qi* -deficiency constitution accounted for a relatively high proportion of people over 40 years old with high normal BP. Wang Q et al. [46] found that with aging, *Qi*-deficiency constitution, *Yang*-deficiency constitution, and blood stasis constitution gradually increase, and the phlegm-dampness constitution is more common in middle-aged and elderly people, which may be because, with aging, *Qi-blood-body fluid* and internal organs from prosperity to decline, the function of organs is weakened, *Qi-blood* movement is slow, thus forming the TCM constitutions of *Qi*-deficiency constitution, *Yang*-deficiency constitution, blood stasis constitution and phlegm-dampness constitution.

Only six studies reported the calculation method of the TCM constitution they applied. But studies included in this meta-analysis mainly used CCMQ [47] as a standard for constitution measurement. Notably, this questionnaire only has one calculation method to determine the TCM constitution. Therefore, the identification of constitutions may be similar in all included studies. In addition, since these measurements are self-reported, bias is inevitable. Only one study [27] used tongue, facial, pulse information acquisition, and constitution identification systems (Model: DS01-A, No: A20111209) combined with CCMQ for diagnosis. Nowadays, more researchers believe that objectification methods are important for TCM constitution diagnosis. For example, Fan et al. applied a personalized body constitution inquiry method that used the recognition results of the tongue-coating image of patients by a machine [48]. Additionally, a constitution classification algorithm based on a convolutional neural network was also proposed [49]. The two methods significantly improved the accuracy of constitution measurement. Therefore, objective and subjective factors need to be comprehensively considered during constitution identification, requiring more objectification methods for TCM constitution diagnosis.

4.1. Limitation

This study still has some limitations. First, the quality of the original studies included in this meta-analysis was mediocre. Second, all the original studies included were written in Chinese, and none of the retrieved English articles met the inclusion criteria, presenting a certain selection bias. Third, the meta-analysis was a retrospective study and cannot prove causation, making this approach limited by any methodological deficiencies of the pooled studies. Fourth, not all studies explicitly reported the calculation methods of the TCM constitution. Although CCMQ is a standard constitution measurement, the research results are likely to be biased due to the different study methodologies.

5. Conclusion

In summary, most people with high-normal BP have a biased constitution. This implies that the constitution of the population has changed when it is not diagnosed as prehypertension. The current meta-analysis included 17 studies and showed that phlegm-dampness constitution, *Yin*-deficiency constitution, and damp-heat constitution were the main constitution types in high-normal BP people. The distribution characteristics of TCM constitution among people with high-normal BP varied in different regions, ages, and genders. The balanced constitution may be a protective factor of high-normal BP, and the phlegm-dampness constitution, *Yin*-deficiency constitution, and blood stasis constitution may be the risk factors of high-normal BP. TCM constitution measurement has a positive significance in the identification and prevention of high-normal BP. We recommend that the identification of the TCM constitution should be extended to the evaluation of high-normal BP or other pro-disease people. Finally, more high-quality observational studies were needed to provide a more scientific evidence-based basis for the application of individualized diagnosis and treatment of TCM constitution in the prevention and treatment of hypertension.

Author contribution statement

Tingyu Mu: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Qianyin Zhu: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Lingshan Chen, Die Dong, Jiayi Xu: Performed the experiments.

Rixiang Xu: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Cuizhen Shen: Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data included in article/supp. material/referenced in article.

Declaration of interest's statement

The authors declare no competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e13438.

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