Influencing factors analysis of dynamic change of TCM constitution based on multiple methods

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ABSTRACT

Objective This study aimed to explore the influencing factors of dynamic changes in traditional Chinese medicine (TCM) constitution based on general statistics, Apriori-DEMATEL algorithm, and DoWhy causal inference framework methods.

Methods Dynamic collection of TCM constitution identification data was conducted from the population aged 18 – 60, containing collection time and constitution type, and 11 constitution influencing factors including dietary habit, sleeping habit, sleeping duration, exercise habit, emotion state, stress level, living environment, work/life calamity, family atmosphere, business trip frequency, and overtime situation. General statistical analysis was used to analyze the relative percentage of corresponding influencing factors of different types of constitution changes, the Apriori-DEMATEL algorithm was used to analyze the correlation between 11 constitution influencing factors such as dietary habit and constitution changes, and the DoWhy causal inference framework was used to analyze the causality between dietary habit, sleeping habit, sleeping duration, exercise habit, emotion state, and stress level, explore the frequency of constitution type transformation-change factors, and determine the key influencing factors causing dynamic changes in constitution type.

Results After preprocessing, 13 536 valid data points were obtained. Based on the Apriori-DEMATEL algorithm, the factors were divided into six original factors including dietary habit, sleeping habit, sleeping duration, exercise habit, emotion state, and stress level, and five result factors including living environment, work/life calamity, family atmosphere, business trip frequency, and overtime situation. Combining with general statistics, we found that among the original factors, changes in dietary habit, sleeping habit, sleeping duration, and stress level had a greater impact on other factors. In the process of constitution conditioning, attention should be paid to these four factors to maintain constitution balance. Among the five result factors, the absolute values of work/life calamity and family atmosphere were relatively large, indicating that these two factors were easily influenced by other factors. The dietary habit, sleeping habit, sleeping duration, exercise habit, emotion state, and stress level have higher centrality in changes, indicating that these six factors had important in constitution changes. According to the statistical frequency of constitution changes corresponding to each factor, we found that the changes of these six factors accounted for a large proportion of the constitution transformation frequency among Qi deficiency constitution, balanced constitution, and allergic constitution, indicating that the changes of these six factors played an important role in the changes of the three constitution types. Combined with the results of the Apriori-

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DEMATEL algorithm, and DoWhy causal inference framework analysis, it was inferred that dietary habit and sleeping duration indirectly lead to constitution changes by affecting the changes of other factors.

Conclusion This study explored the influencing factors of dynamic changes in TCM constitution from the perspective of dynamic data and multiple analysis methods, and the results showed that the changes of dietary habit, sleeping habit, sleeping duration, exercise habit, emotion state, and stress level had a great impact on the changes of Qi deficiency constitution, balanced constitution and allergic constitution. Attention should be paid to the changes of these six factors in daily life, and corresponding improvement plans should be formulated to reduce the probability of transforming into biased constitution. Our study also provided data support and objective analysis reference for the analysis of influencing factors of dynamic changes in TCM constitution types.

1 Introduction

Traditional Chinese medicine (TCM) constitution is an inherent trait of the human body in morphological structure, physiological function and psychological status on the basis of innate inheritance and acquired acquisition, which determines the susceptibility of individuals to certain diseases and similarities in pathological processes [1]. The difference in body constitution is the result of a combination of innate factors and multiple acquired factors, such as dietary habit and emotion state [2]. Considering the existing studies on the influencing factors of TCM constitution, the related influencing factors of constitution in disease states or static analysis of data at a moment in time [3-5], or the influencing factors of a certain constitution type [6, 7], are mostly explored. However, there are few studies on the influencing factors of the transformation between body constitution types. The law of body constitution transformation is the ruler of body constitution diagnosis and the basis of body constitution conditioning [8]. Through a certain grasp of the change rule of body constitution, we can speculate the factors affecting constitution changes, and then according to some specific factors, make an improvement plan, for example, poor sleeping quality leads to constitution conversion to biased constitution, so sleeping quality should be improved. The study of this rule can provide a reference value for the population who is biased or prone to disease, helps them improve the biased constitution, and reduces the probability of related diseases. Based on this, this paper explores the reasons for the transformation of individual constitution types, aiming to provide accurate data support for the adjustment of individual types of constitution.

2 Data and methods

2.1 Data

Using the TCM constitution identification platform in the project group (the constitution identification function in the official WeChat account "Palm Xingyun"), dynamic TCM constitution identification data were collected following the 24 solar terms from February 1, 2020 to April 30, 2022 in Chengdu City and Yilong County, with 27 084 original data entries. All data were obtained with ethical approval from the Affiliated Hospital of Chengdu University of Traditional Chinese Medicine (2022KL-024). The data include collection time, individual constitution type, and 11 influencing factors (dietary habit, sleeping habit, sleeping duration, exercise habit, emotion state, stress level, living environment, work/life calamity, family atmosphere, business trip frequency, and overtime situation).

2.2 Inclusion and exclusion criteria

2.2.1 Inclusion criteria　Participants were eligible for the study if they: (i) aged from 18 to 60 (without gender restriction); (ii) provided informed consent forms; (iii) were classified according to the standards of "TCM constitution Classification and determination" issued by China Association of Chinese Medicine [9]. The identified constitution types include normal constitution, Qi deficiency constitution, Yin deficiency constitution, Yang deficiency constitution, phlegm-dampness constitution, damp-heat constitution, blood stasis constitution, Qi stagnation constitution, and allergic constitution.

2.2.2 Exclusion criteria　Participants were ineligible for the study if they: (i) were under treatment for major diseases such as cardiovascular diseases, diabetes, and tumors; (ii) had been receiving medication to maintain non-major diseases; (iii) were pregnant or lactating; (iv) had mental or neurological disorders.

2.3 Data preprocessing for samples

The "drop_duplicates ()" method in the Python pandas library was used to remove duplicate data entries, and only the first data in each group of duplicates was retained. The k nearest neighbor imputation method was used to

impute missing data, where the imputated value closest to the actual data entry was found in the dataset. Abnormal data entries were identified and deleted.

2.4 General statistical analysis

C was set as {normal constitution, Qi deficiency constitution, Yin deficiency constitution, Yang deficiency constitution, phlegm-dampness constitution, damp-heat constitution, blood stasis constitution, Qi stagnation constitution, allergic constitution}. Individual constitution types change over time were set as $R_n = \{r_1 => r_2, r_5 => r_3, \ldots r_n\}$, where r_n represents the constitution type, and R_n, a specific item in the set of changing constitution types, for example: $R_1 = r_1 => r_2$.

The 11 influencing factors were established as set E = {dietary habit, sleeping habit, sleeping duration, exercise habit, emotion state, stress level, living environment, work/life calamity, family atmosphere, business trip frequency, overtime situation}, and encode them as $E = \{E_1, E_2, E_3, E_4, E_5, E_6, E_7, E_8, E_9, E_{10}, E_{11}\}$. Changes in internal and external factors lead to changes in constitution types, where m represents a certain influencing factor causing changes in constitution types, n, the types of changes in constitution types, and the $Result_{nm}$, the number of cases where a certain constitution type changes to another constitution type (e.g., blood stasis constitution => damp-heat constitution), and a certain influencing factor also changes (e.g., blood stasis constitution => damp-heat constitution, and emotion state changes) is called the frequency, $P(Result_{nm})$, the ratio of the frequency of a certain influencing factor changing when a certain constitution type transitions to another constitution type to the total number of cases of constitution type changes. As:

$$Result_{nm} = Count\,(R_n, E_m) \tag{1}$$

$$P(Result_{nm}) = \frac{Result_{nm}}{\sum_{i=1}^{m} Result_{nm}} \tag{2}$$

Formula (1) was adopted to calculate the frequency of each influencing factor and the type of synchronized constitution changes, and Formula (2) was adopted to calculate the relative percentage of each influencing factor under a certain type of constitution changes, and synchronized changes. Finally, the obtained data tables were imported into Origin 2017 software for graph drawing.

2.5 Correlation analysis of influencing factors based on the Apriori algorithm

To further determine the influencing factors causing the transformation among constitution types, this study first employed the Apriori algorithm to conduct association analyses on the constitution types undergoing transformation and their influencing factors. The Apriori algorithm iteratively generates frequent item sets to discover the association relationships between item sets in the dataset. The generated association rules are in the form of $A => B$, where A is the antecedent of the association rule and B is the consequent. In this study, both A and B represent influencing factors of constitution changes.

$$Support\,(A, B) = P(A, B) \tag{3}$$

$$Confidence\,(A => B) = P(B|A) = \frac{P(A, B)}{P(A)} \tag{4}$$

To facilitate analysis, the types of constitution changes are encoded as $T = \{T_1, T_2, T_3, T_4 \ldots\ldots T_n\}$. In the data analyzed in this paper, there are 60 types of constitution transformation relationships (n = 60, Supplementary Table S1). The influencing factors causing constitution type transformations are encoded according to the encoding rules in section 2.4. The combination of influencing factors can cause transformations among n constitution types (Supplementary Table S2).

Based on the combination of body constitution type transformation and the influencing factor item sets, and the frequency $Result_{nm}$, if there was a change in a certain influencing factor in the body constitution type transformation, it was marked as 1; if there was no change, it was marked as 0. This process resulted in a 60 rows 11 columns Boolean matrix A.

$$A = \begin{Bmatrix} 1\,1\,1\,1\,1\,1\,1\,0\,0\,1\,1 \\ 1\,1\,1\,1\,1\,1\,1\,1\,1\,1\,1 \\ 1\,1\,1\,1\,1\,1\,1\,1\,0\,0\,1 \\ 1\,1\,1\,1\,1\,1\,1\,1\,1\,1\,1 \\ \cdots\cdots \\ 0\,0\,0\,0\,0\,0\,0\,0\,0\,0\,0 \\ 1\,0\,1\,0\,1\,0\,0\,0\,0\,0\,1 \end{Bmatrix}$$

Apriori association rules mining was performed on Boolean matrices, setting a minimum support of 45% and a minimum confidence of 50%, and 110 association rules were finally selected (Supplementary Table S3), and the top 15 rules are shown in Table 1.

2.6 Influencing factors ranking based on DEMATEL

DEMATEL is a systematic analysis method that utilizes graph theory and matrix tools. By using matrix operations and linear algebra, it calculates four attributes for each factor including degree of influence, degree of being influenced, degree of centrality, and degree of causality. Based on the calculation results, factors were classified into result factors and cause factors, and then the key factors were evaluated and ranked. DEMATEL has been applied in various industries such as healthcare, government, and construction for analyzing influencing factors [10-12]. Based on the selected 110 association rules and using the four-level scale [Formula (5)] to transform them into matrices, the DEMATEL algorithm was utilized to

Table 1 The top 15 association rules output

Posterior-B	Previous-A	Support (%)	Confidence (%)
Stress level	Dietary habit	82.812 5	83.018 9
Dietary habit	Stress level	76.562 5	89.795 9
Sleeping duration	Stress level	76.562 5	91.836 7
Stress level	Sleeping duration	82.812 5	84.905 7
Emotion state	Dietary habit	82.812 5	86.792 5
Dietary habit	Emotion state	78.125 0	92.000 0
Sleeping duration	Sleeping habit	81.250 0	92.307 7
Sleeping habit	Dietary habit	82.812 5	90.566 0
Sleeping habit	Sleeping duration	82.812 5	90.566 0
Dietary habit	Sleeping habit	81.250 0	92.307 7
Sleeping duration	Dietary habit	82.812 5	92.452 8
Dietary habit	Sleeping duration	82.812 5	92.452 8
Emotion state	Exercise habit	78.125 0	88.000 0
Exercise habit	emotion state	78.125 0	88.000 0
Emotion state	Sleeping duration	82.812 5	88.679 2

evaluate and identify the influencing factors of dynamic changes in body constitution.

$$
Z_{ij} = \begin{cases} 3, & 0.8 \leqslant conf(S_i \to S_j) \leqslant 1 \\ 2, & 0.5 \leqslant conf(S_i \to S_j) < 0.8 \\ 1, & 0.2 \leqslant conf(S_i \to S_j) < 0.5 \\ 0, & conf(S_i \to S_j) < 0.2 \end{cases} \tag{5}
$$

The specific steps are as follows.

(i) The direct impact matrix Z was calculated based on the association rules. According to the association rules obtained from the Apriori algorithm, the confidence of the posterior factors to the anterior factors was divided into four parts following the four-level scale method including no impact, weak impact, moderate impact, and strong impact, which were identified as 0, 1, 2, 3, respectively, constructing a matrix with rows and columns representing the constitution influencing factors, forming an 11×11 direct impact matrix Z.

$$
Z = \begin{Bmatrix}
0\,3\,3\,3\,3\,3\,3\,3\,3\,3\,3 \\
3\,0\,3\,3\,3\,3\,3\,3\,3\,3\,3 \\
3\,3\,0\,3\,3\,3\,3\,3\,3\,3\,3 \\
3\,3\,3\,0\,3\,3\,3\,3\,3\,3\,3 \\
3\,3\,3\,3\,0\,3\,3\,3\,3\,3\,3 \\
3\,3\,3\,3\,3\,0\,3\,3\,3\,3\,3 \\
2\,2\,2\,3\,2\,2\,0\,3\,3\,3\,3 \\
2\,2\,2\,2\,2\,2\,2\,0\,2\,2\,2 \\
2\,2\,2\,2\,2\,2\,2\,2\,0\,2\,2 \\
2\,2\,2\,2\,2\,2\,2\,3\,3\,0\,2 \\
2\,2\,2\,3\,3\,2\,3\,3\,3\,3\,0
\end{Bmatrix}
$$

(ii) Normalization directly impacts the matrix. By using Formula (6), the direct influence matrix Z was normalized to obtain the normalized direct influence matrix

X, where n represented the number of influencing factors, that is, $n = 11$, i and j denoted the rows and columns of matrix Z.

$$
X = \frac{Z}{\max\limits_{1 \leqslant i \leqslant n} \sum_{j=1}^{n} Z_{ij}} \tag{6}
$$

(iii) A composite impact matrix and four attribute values for each factor were calculated. According to Formula (7), the comprehensive influence matrix was calculated, which reflected the cumulative effects of direct and indirect effects of various influencing factors of constitution changes. The comprehensive influence matrix was set as the identity matrix. The degree of influence (A), degree of being influenced (B), degree of centrality (C), and degree of causality (D) for each influencing factor were determined according to Formulas (8) – (11).

$$
T = X(E - X)^{-1} \tag{7}
$$

$$
A_i = \sum_{j=1}^{n} t_{ij} \ (i = 1, 2, 3, ..., n) \tag{8}
$$

$$
B_i = \sum_{j=1}^{n} t_{ji} \ (i = 1, 2, 3, ..., n) \tag{9}
$$

$$
C_i = A_i + B_i \ (i = 1, 2, 3, ..., n) \tag{10}
$$

$$
D_i = A_i - B_i \ (i = 1, 2, 3, ..., n) \tag{11}
$$

2.7 Analysis based on the DoWhy causal inference framework algorithm

To further analyze the causal relationship between constitution and factors, this paper employed the DoWhy causal inference framework to analyze the causality between factors and constitution. The framework is based on graphical models and potential outcome models, using graph-based criteria to model hypotheses and identify non-parametric causal effects. The steps are as follows (Figure 1).

(i) Variable setting. Since the study investigated the relationship between multiple influencing factors and constitution, each factor was analyzed independently. The constitution outcome was set as the outcome variable. One factor was set as the treatment variable, and other factors were set as control variables.

(ii) Hypothesis extraction. There are 11 influencing factors in this study. By analyzing the frequency ratio of factor and constitution both changed and both unchanged, the significance level of simultaneous change between factors and constitution was assumed to be 20%. Factors with strong causal relationships with constitution changes were selected based on reasonable hypotheses.
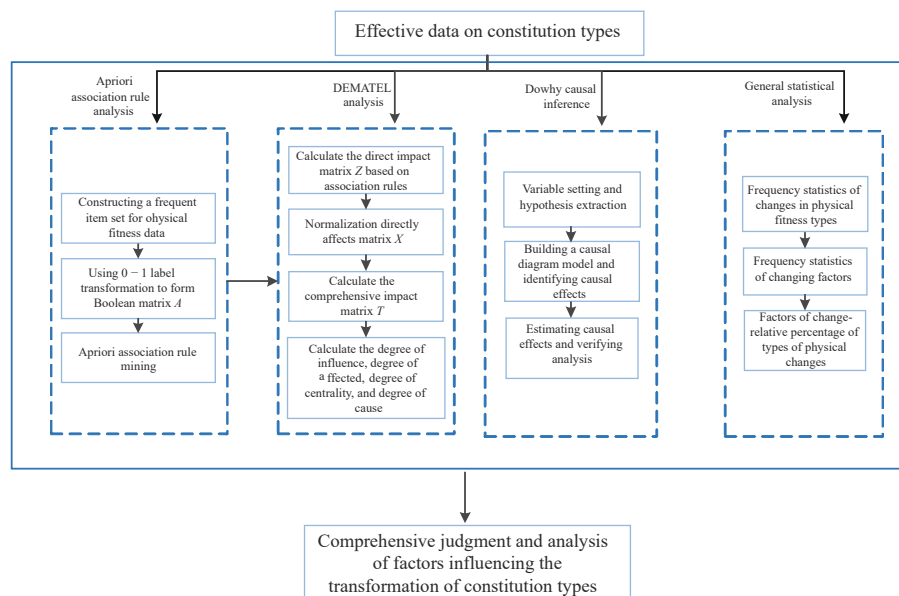
Figure 1 Algorithm flow chart of this study

(iii) Causal diagram model construction. When using the DoWhy framework, it is necessary to first construct a causal graph model, excluding the influence between control variables and only considering the causal relationship between treatment variables and outcome variables to ensure the clarity of causal hypotheses. Based on the above hypotheses, we described the causal graph using the GML format and constructed a directed acyclic causal diagram model.

(iv) Identifying causal effects. Causal effects refer to the degree of change in the outcome when the treatment variable changes by one unit while all other conditions remain unchanged. In this framework, the "identify effect ()" method (i.e., property of the causal graph model) was used to identify the estimate of the effect.

(v) Estimating causal effects. DoWhy supports various methods based on identification criteria, as well as non-parametric confidence intervals and permutation tests to test the statistical significance of the estimates obtained. In this study, the chosen type of causality effect is the estimated average treatment effect (ATE) model, and the chosen estimation method is propensity score matching.

(vi) Validation analysis. Since the above results are based on assumptions, validation is necessary. Therefore, the accuracy of the hypothesis is verified by adding random confounding factors, placebo intervention and data subset verification. If the causal effect value obtained from random confounding factors and data subset verification is stable, and the causal effect value obtained after the placebo intervention test is close to 0, the hypothesis is correct.

3 Results

3.1 General statistical analysis

The pandas package programming in Python language was used to perform statistical analysis, and the frequency of basic information and the frequency of influencing factors that changed when the constitution type changed were counted, forming 13 536 effective data. In the valid data, males accounted for 43.1%, females accounted for 56.9%, and 74.5% were not an only child at home; 76.2% were aged 30 or below, and 23.7% were aged 31 – 60. The frequency proportion between the constitution types transforming and the corresponding changed influencing factors is shown in Figure 2. The comparative analysis demonstrated that the changes in dietary habit and sleeping duration caused a relatively large relative proportion of constitution type changes, indicating the changes in these two factors had a relatively large impact on constitution fitness changes. In contrast, the changes in overtime situation, living environment, work/life calamity, family atmosphere and business trip frequency caused a relatively low relative proportion of constitution type changes, and the continuity of the changes of these five factors was low, indicating the changes in these five factors had a relatively low impact on constitution changes.

3.2 Apriori-DEMATEL and individual factor corresponding frequency analysis

3.2.1 Apriori-DEMATEL analysis results After calculation by the Apriori-DEMATEL algorithm, the four-dimensional data of degree of influence, degree of being influenced, degree of centrality, and degree of causality were obtained (Table 2). (i) Degree of influence and degree of being influenced were analyzed assess to the degree of influence of each factor on constitution changes. Table 2 demonstrates that E_1 (dietary habit), E_2 (sleeping habit), E_3 (sleeping duration), E_4 (exercise habit), E_5 (emotion state), and E_6 (stress level) had a higher degree of influence, indicating that these six factors had a greater
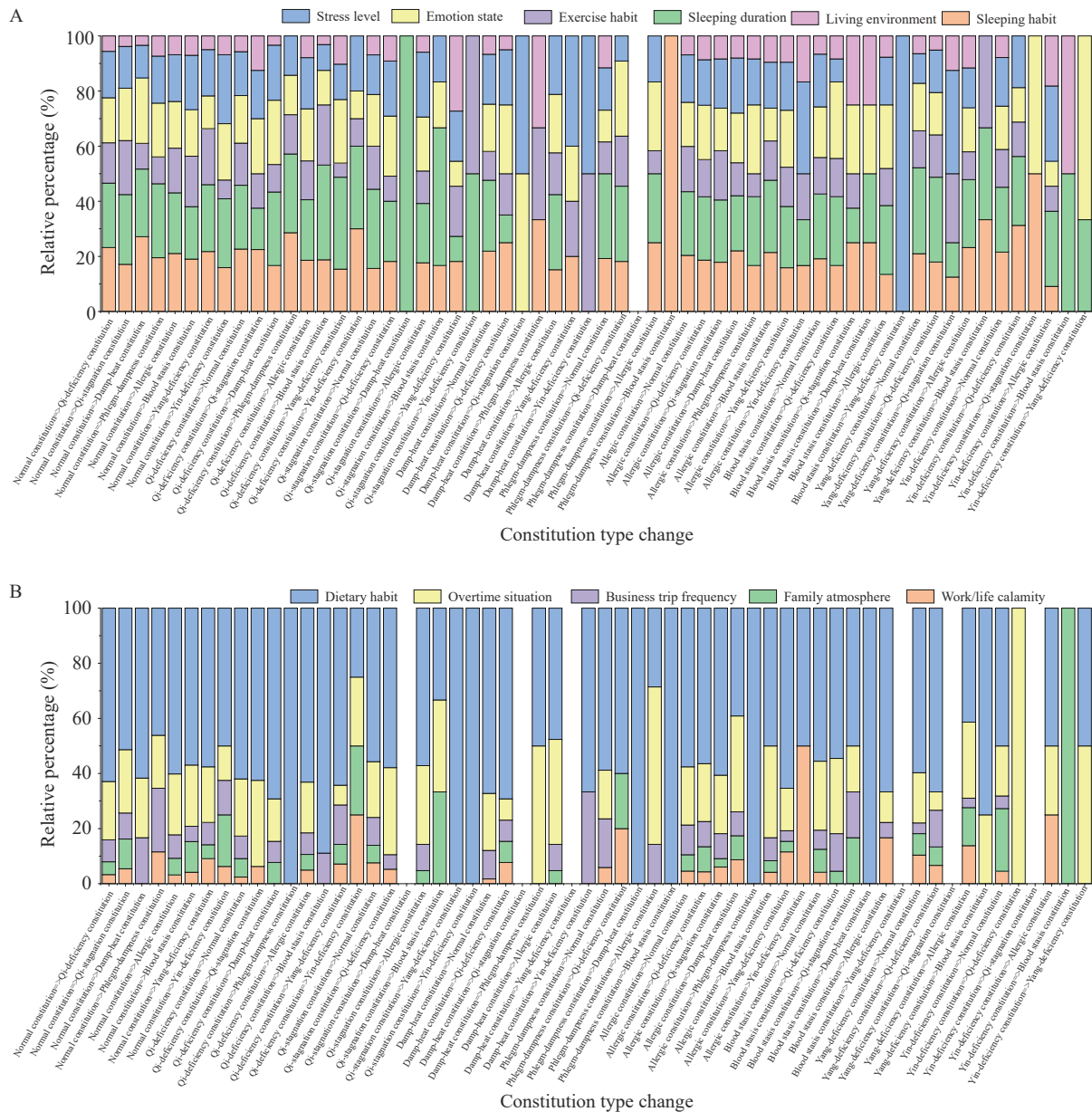
Figure 2 The frequency proportion between the constitution types transforming and the corresponding changed influencing factors

A, relative percentage of six influencing factors. B, relative percentage of five influencing factors.

impact on other factors. Conversely E_8 (work/life calamity) and E_9 (family atmosphere) had a higher degree of being influenced, indicating that these two factors were easily influenced by other factors. (ii) Degree of centrality indicates the location of a factor in the system and the magnitude of its role. Table 2 shows that E_1 (dietary habit), E_2 (sleeping habit), E_3 (sleeping duration), E_4 (exercise habit), E_5 (emotion state), and E_6 (stress level) had a higher degree of centrality, indicating that these factors had a certain important role in the process of constitution changes. (iii) The degree of causality represents the influence of a factor on other factors. If the degree of causality is greater than 0, it indicates that this factor is the causal factor, otherwise it is the outcome factor. Moreover, the larger the absolute value in the whole system, the more

important the impact. In other words, the larger the absolute value, the greater the effect on constitution changes. Table 2 demonstrates that the causal factors including E_1 (dietary habit), E_2 (sleeping habit), E_3 (sleeping duration), E_4 (exercise habit), E_5 (emotion state), and E_6 (stress level), while the other five factors were the outcome factors. Among the causal factors, E_1 (dietary habit), E_2 (sleeping habit), E_3 (sleeping duration), and E_6 (stress level) had greater values, indicating that these four factors had a greater degree of influence on other factors. Conversely, among the five outcome factors, the absolute values of E_8 (work/life calamity) and E_9 (family atmosphere) were greater, indicating that these two factors were more susceptible to being influenced by other factors.

Table 2 Calculation results of influence degree of each factor based on the Apriori-DEMATEL algorithm

Factor	Influence	Being influenced	Centrality	Causality
E_1	8.387	7.048	15.435	1.339
E_2	8.387	7.048	15.435	1.339
E_3	8.387	7.048	15.435	1.339
E_4	8.387	7.567	15.954	0.820
E_5	8.387	7.307	15.694	1.080
E_6	8.387	7.048	15.435	1.339
E_7	6.965	7.567	14.532	– 0.602
E_8	5.766	8.111	13.877	– 2.345
E_9	5.766	8.111	13.877	– 2.345
E_{10}	6.189	7.835	14.024	– 1.646
E_{11}	7.249	7.567	14.816	– 0.318

3.2.2 Frequency analysis of corresponding factors and constitution changes results Combined with Table 2 and general statistical analysis, it was found that E_1 (dietary habit), E_2 (sleeping habit), E_3 (sleeping duration), and E_6 (stress level) were important factors for constitution changes, exerting significant influence on other factors. However, the degree of centrality of these six factors, E_1 (dietary habit), E_2 (sleeping habit), E_3 (sleeping duration), E_4 (exercise habit), E_5 (emotion state), and E_6 (stress level), was high, which played an important role in the process of constitution changes. According to the above results, the corresponding frequency statistics of six factors, including exercise habit, dietary habit, sleeping duration, sleeping habit, stress level, and emotional state, were plotted using Origin 2017 software (Figure 3). To visually display the proportion of each factor to the frequency of each constitution change, the Y-axis maximum value was consistently set for each factor.

The total frequency of exercise habit on 60 constitution type changes was 1 288. The frequency of exercise habit on normal constitution => Qi deficiency constitution, normal constitution => allergic constitution, Qi deficiency constitution => normal constitution, and allergic constitution => normal constitution was more than 178, and the frequency ratio was more than 13.8% (Figure 3A). The total frequency of 60 constitution type changes caused by dietary habit was 2 221. Moreover, dietary habit on normal constitution => Qi deficiency constitution, normal constitution => allergic constitution, Qi deficiency constitution => normal constitution, and allergic constitution => normal constitution was more than 323, and the frequency ratio was more than 14.5% (Figure 3B). The total frequency of 60 constitution type changes caused by sleeping duration was 1983. The total frequency of sleeping duration on normal constitution => Qi deficiency constitution, normal constitution => allergic constitution, Qi deficiency constitution => normal constitution, and allergic constitution => normal constitution was more than

271, and the frequency ratio was more than 13.7% (Figure 3C). The total frequency of sleeping habit on 60 constitution type changes was 1 770, and the frequency of sleeping habit on normal constitution => Qi deficiency constitution, normal constitution => allergic constitution, Qi deficiency constitution => normal constitution, and allergic constitution => normal constitution was more than 265, and the frequency ratio was more than 15% (Figure 3D). The total frequency of stress level on 60 constitution type changes was 1 424. The frequency of stress level on normal constitution => Qi deficiency constitution, normal constitution => allergic constitution, Qi deficiency constitution => normal constitution, and allergic constitution => normal constitution was more than 186, and the frequency ratio was more than 13.1% (Figure 3E). The total frequency of emotion state on 60 constitution type changes was 1 460. The frequency of emotion state on normal constitution => Qi deficiency constitution, normal constitution => allergic constitution, Qi deficiency constitution => normal constitution, and allergic constitution => normal constitution was more than 198, and the frequency ratio was more than 13.6% (Figure 3F).

In summary, although there were some differences in the constitution changes and frequency corresponding to these six factors, the frequency accounted for over 12%, and for the changes of the same constitution type, their trends were roughly the same, of which the four constitution changes (normal constitution => Qi deficiency constitution, normal constitution => allergic constitution, Qi deficiency constitution => normal constitution, and allergic constitution => normal constitution), accounted for a relatively large frequency. Therefore, exercise habit, dietary habit, sleeping duration, sleeping habit, stress level, and emotion state had a greater impact on the constitution transformation between the Qi deficiency constitution, normal constitution, and allergic constitution.

3.3 DoWhy framework analysis

Based on the general statistical and factors analyses, the frequency ratios of factor and constitution both changed and unchanged were shown in Table 3, and the following hypotheses are proposed based on Table 3 combined with the significance level values assumed in section 2.7: H_1, dietary habit will affect constitution changes; H_2, sleeping habit will affect constitution changes; H_3, sleeping duration will affect constitution changes; H_4, exercise habit will affect constitution changes; H_5, emotion state will affect constitution changes; H_6, stress level will affect constitution changes; H_7, emotion state will lead to changes in stress level, and then affect constitution changes; H_8, emotion state will lead to changes in dietary habit, and then affect constitution changes; H_9, emotion state will lead to changes in stress level, and then lead to
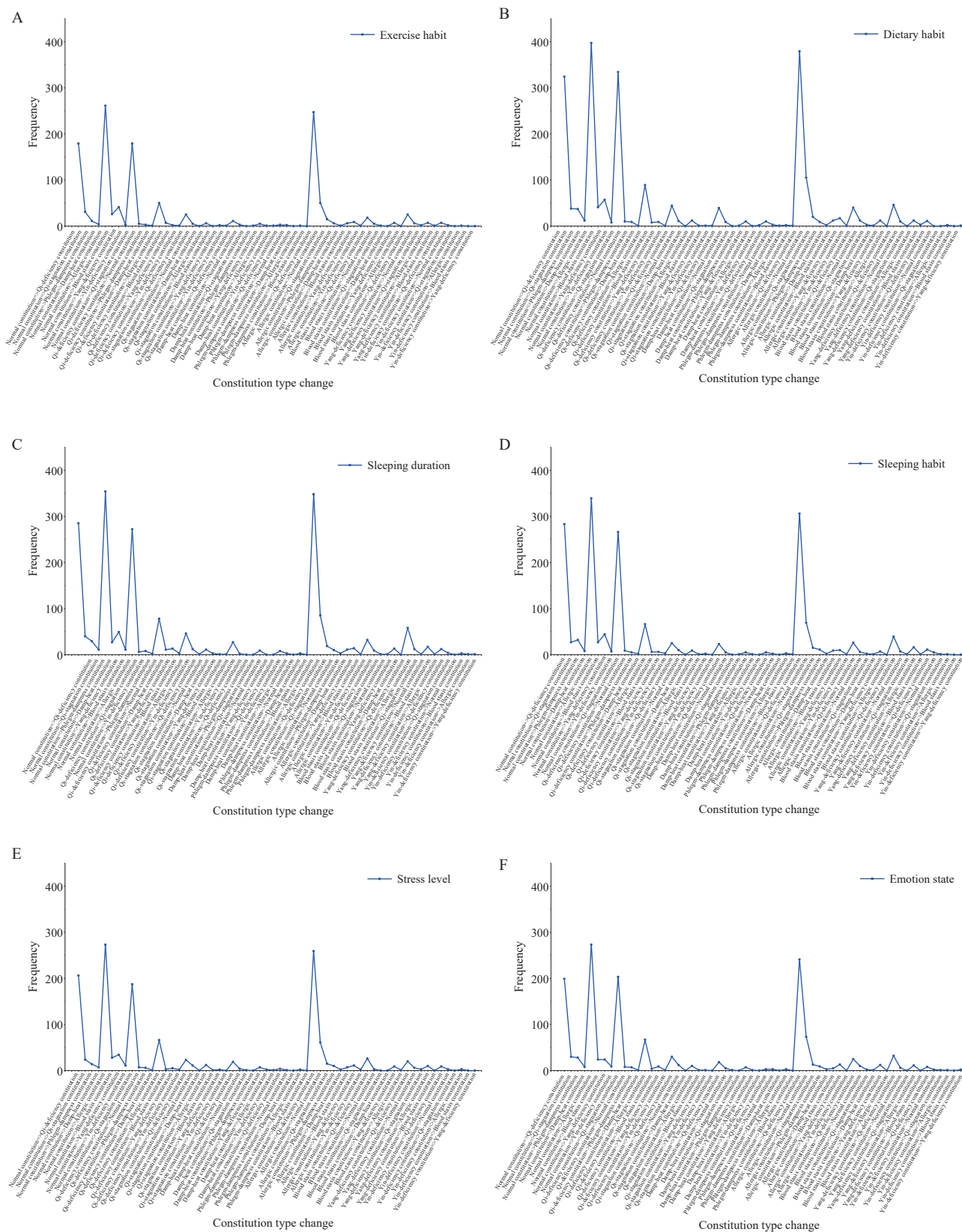
Figure 3 Frequency of constitution type changes corresponding to six influencing factors
A, exercise habit. B, dietary habit. C, sleeping duration. D, sleeping habit. E, stress level. F, emotion state.

changes in dietary habit, and ultimately affect constitution changes; H_{10}, sleeping habit will lead to changes in sleeping duration, and then affect constitution changes; H_{11}, stress level will lead to changes in dietary habit, and then affect constitution changes; H_{12}, exercise habits will lead to changes in sleeping duration, and then affect constitution changes. Causal diagrams were also drawn according to the above assumptions (Figure 4).

Table 3 Frequency ratios of factor and constitution both changed and unchanged

Influencing factor	Factor and constitution [n (%)]	
	Both changed	Both unchanged
Dietary habit	2 428 (47%)	5 309 (63%)
Sleeping duration	2 165 (42%)	5 147 (61%)
Sleeping habit	1 945 (38%)	5 587 (66%)
Emotion state	1 607 (31%)	6 365 (76%)
Stress level	1 584 (31%)	6 280 (75%)
Exercise habit	1 438 (28%)	6 382 (76%)
Overtime situation	898 (18%)	7 079 (84%)
Living environment	632 (12%)	7 718 (92%)
Business trip frequency	385 (8%)	7 899 (94%)
Family atmosphere	263 (5%)	8 184 (97%)
Work/life calamity	178 (3%)	8 183 (97%)

The causal effects of six factors in section 2.4 were analyzed independently based on the DoWhy framework Table 4. Overall, most of these six factors had significant causality with body constitution. Among them, the highest result value of stress level was 0.137 2, which indicated that 13.72% more likely to change in constitution if the stress level changes than if the stress level does not change, and its robustness test results were ideal, indicating that the causal effect between stress level this factor

Figure 4 Directed acyclic causal diagram model

and constitution is significant. The result values of sleeping habit, exercise habit, and emotion state were lower compared with the stress level, but the values were positive, and the robustness test results were ideal, indicating that the change of these three factors would lead to a higher probability of constitution changes, and the causal effect between constitution was significant. The result values of dietary habit and sleeping duration were lower, and the value of sleeping duration was negative, but tended to 0, indicating that the probability of constitution changes when these two factors changed and the probability of constitution changes when these two factors were unchanged were similar, that is, the causal effect between these two factors and constitution were not significant.

Table 4 Causal effects of different factors on constitution type changes

Influencing factor	ATE model mean value	Robustness test-new effect		
		Addition of random confounding factor	Data subset verification	Placebo intervention
Dietary habit	0.000 1	0.000 1	0.000 1	0.000 0
Sleeping habit	0.051 2	0.051 2	0.051 5	0.000 8
Sleeping duration	− 0.004 1	− 0.004 1	− 0.003 4	0.000 0
Exercise habit	0.072 0	0.072 0	0.071 6	0.002 1
Emotion state	0.033 0	0.033 0	0.031 0	0.000 3
Stress level	0.137 2	0.137 2	0.136 3	− 0.000 6

4 Discussion

In recent years, BAI et al. [13] collected and analyzed the TCM constitution data of more than 100 000 Chinese individuals, describing the distribution characteristics of TCM constitution types. The results revealed that the proportion of individuals with normal constitution in each group was less than one-third, which had decreased compared to 10 years ago, while the proportion of biased constitutions had increased. Biased constitutions are known to markedly affect an individual's health status and demonstrate a tendency toward diseases [14]. Therefore, understanding the influencing factors of constitution changes is a necessary step to alter biased constitutions through maintenance.
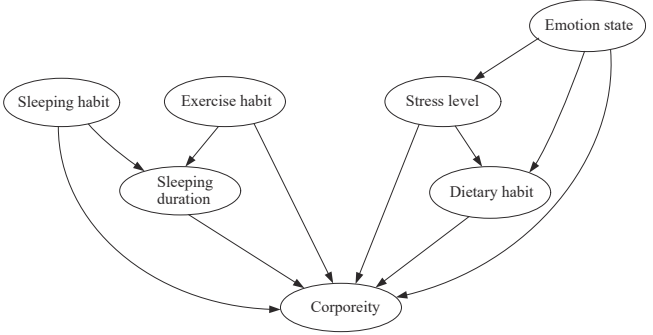
The advantage of this study lies in the utilization of standardized TCM constitution identification data released by China Association of Chinese Medicine [9], as well as the dynamic tracking of individual constitution-related data multiple times, forming dynamic individual constitution data. This paper combines general statistical analysis with the application of the Apriori-DEMATEL algorithm to analyze the correlation of factors influencing dynamic constitution changes and employs the DoWhy causal inference framework to analyze the causality between constitution and factors. The combination of multiple methods makes the analysis process and results more reliable.

However, the factors influencing the transformation of TCM constitution are intricate and manifold, with each

factor mutually affecting one another. In this study, due to limitations in sample data, only 11 influential factors were analyzed, potentially resulting in incomplete findings. It is anticipated that subsequent studies will encompass a more comprehensive analysis of influencing factors while optimizing statistical analysis methods to enhance the scientific rigor and comprehensiveness of the results.

By extensively collecting constitution data from different individuals at different times and applying the Apriori-DEMATEL algorithm, this study identified six original factors and five resultant factors of constitution type changes. Statistical analysis revealed that changes in dietary habit, sleeping habit, sleeping duration, and stress level among the original factors were prone to influencing changes in other factors. Moreover, changes in dietary habit, sleeping habit, sleeping duration, exercise habit, emotion state, and stress level played crucial roles in the process of constitution changes, exhibiting strong correlations with constitution types. Through the combination of the multiple analyses, we found that sleep habits and other four factors (sleeping habit, exercise habit, emotion state, and stress level) showed significant causality with constitution, while dietary habit and sleeping duration indirectly led to constitution changes by affecting other factors. By applying general statistical analysis methods to analyze the frequency of constitution changes in the six factors, we found that the frequency of constitution transitions between Qi deficiency, normal constitution, and special diathesis accounted for a relatively large proportion, indicating that these six factors played an important role in constitution changes.

4.1 The relationship between sleeping and constitution

Sleeping is a necessary state for maintaining human health [15]. According to the 2023 China Sleep Report [16], nearly half of the population (47.55%) averages less than 8 h of sleep per night. While most people have good sleep quality, individuals with a postgraduate education level tend to have shorter and poorer sleep quality. In TCM, it is believed that good sleep contributes to the balance of Yin and Yang energies, as well as the smooth flow of Qi blood. Conversely, poor sleep can lead to imbalances between Yin and Yang, as well as disruptions in Qi blood circulation, which may result in changes in the constitution and even exacerbate or trigger disease onset. Therefore, individuals with biased constitutions should adjust their sleep schedules and maintain good sleeping habits.

4.2 The relationship between diet and constitution

Inner Cannon of Huangdi (*Huang Di Nei Jing*, 《黄帝内经》) states: "the source of Yin lies in the five flavors; five zang-organs pertaining to Yin are damaged by five flavors". A balanced and reasonable dietary structure

contributes to physical health [17] and maintains the stability of the constitution. The five flavors of sour, bitter, sweet, spicy, and salty correspond to the liver, heart, spleen, lung, and kidney, respectively. If one excessively craves any of these flavors, it may affect the corresponding organ, and in severe cases, disrupt the Qi of the five zang-organs, leading to changes in constitution [18]. Therefore, dietary adjustments should be made according to the characteristics of the five flavors-spicy disperses, sour contracts, sweet harmonizes, bitter fortifies, and salty softens-and the different cravings of each organ [18]. Tailored dietary plans should be adopted for individuals with different biased constitutions, and management of dietary habits for individuals with normal constitutions should be strengthened.

4.3 The relationship between exercise and constitution

The role of exercise in promoting health and longevity requires attention to the quality, quantity, and mode of exercise [19]. "Movement" is the reason for the generation of Tai Chi, an important factor in the origin of life. Proper exercise can promote the smooth flow of Yang-Qi, circulation of blood, and the generation of Yin and Yang, giving rise to all things [20]. Conversely, lack of exercise can lead to insufficient Yang-Qi, inadequate circulation of blood throughout the body, and thus cause changes in the constitution.

4.4 The relationship between emotion and constitution

TCM believes that humans undergo emotional changes such as joy, anger, worry, thought, grief, fear, and surprise, collectively known as the "seven emotions", among which anger, joy, thought, worry, and fear are referred to as the "five moods". These emotions can easily affect the upward and downward movement of Qi in the body. If one of these emotions occurs excessively, it can cause disorder in the upward and downward movement of Qi, thereby leading to changes in the constitution. The "five moods" also affect the functioning of the five zang-organs. TCM holds that joy damages the heart, anger damages the liver, thought damages the spleen, grief damages the lungs, and fear damages the kidneys. Excessive stimulation of a certain emotion can affect the functions of the organs, leading to the accumulation of nutrient-defense substances, damaging the organs, and ultimately forming a biased constitution [21]. Emotional activities are generated by the response of the essential Qi of zang-fu organs to external environmental factors. The essential Qi of zang-fu organs is the physiological basis for emotional activities, and abnormal emotions are prone to illnesses [22]. With rapid social development and increasing pressure, fluctuating emotions should be taken seriously. Individuals should be guided to relax and relieve psychological pressure appropriately, avoid great joy and

sadness, excessive mood swings, and then prevent or improve biased constitution. The relationship between a person's mental state and the Qi and blood of zang-fu organs is closely related. If the circulation of blood in the heart is not smooth, it can lead to obstruction of the operation of the zang-fu organs and an increase in psychological pressure [23]. Over time, this can cause changes in the constitution from a balanced state to an imbalanced one. Therefore, reducing psychological stress helps maintain a stable constitution.

5 Conclusion

We found that dietary habit, sleeping habit, sleeping duration, exercise habit, emotion state, and stress level have a greater impact on the changes in constitution in TCM and a strong correlation between constitutions. These six factors can indirectly or directly affect constitution changes, and they play an important role in the changes between Qi deficiency, normal constitution, and allergic constitution. If diet, sleep, stress, and other conditions are in good and stable state, constitution changes are mostly biased constitution shift to normal constitution; conversely, if there are unhealthy dietary habits, such as smoking, drinking, and poor sleeping habits, constitution changes are mostly normal constitution shift to the biased constitution. In daily life, a healthy and good lifestyle can effectively slow down psychological and physical problems, and improve biased constitution, so that it gradually tends to be peaceful, thereby raising the quality of life. Biased constitution easily affects physical health, improving the body needs to first adjust following the causes of constitution changes. This study can provide some data support and accurate analysis references for improving biased constitution. In future studies, additional influencing factors can be incorporated to analyze their relationship between the factors and constitutions, and the causal relationship can be examined through DoWhy or other advanced causal frameworks.

Competing interests

The authors declare no conflict of interest.

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基于多方法的中医体质动态变化因素分析

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【摘要】目的 基于一般统计学、Apriori-DEMATEL 算法、DoWhy 因果推理框架等方法探究中医体质动态变化影响因素。方法 对 18 – 60 岁人群进行中医体质识别数据的动态采集，包括采集时间、体质类型以及饮食习惯、睡眠习惯、睡眠时间、运动习惯、情绪状态、压力情况、生活环境、工作/生活变故、家庭氛围、出差频次、加班情况 11 个体质影响因素。采用一般统计分析分析不同类型体质变化对应影响因素的相对百分比，采用 Apriori-DEMATEL 算法分析饮食习惯等 11 种体质影响因素与体质变化之间的相关性，采用 DoWhy 因果推理框架分析饮食习惯、睡眠习惯、睡眠时间、运动习惯、情绪状态、压力情况之间的因果关系。探讨构成类型转换变化因素的频率，确定构成类型动态变化的关键影响因素。结果 经过预处理后形成 13 536 条有效数据，基于 Apriori-DEMATEL 算法将因素划分成饮食习惯、睡眠习惯、睡眠时间、运动习惯、情绪状态和压力情况这 6 个原因因素及居住环境、工作/生活变故、家庭氛围、出差频次和加班情况这 5 个结果因素。结合一般统计学分析发现，在原因因素中饮食习惯、睡眠习惯、睡眠时间和压力情况这 4 个因素的变化对其他因素的影响程度大，在体质调摄过程中，应对上述 4 个因素重点关注，保持体质的平衡；在 5 个结果因素里面，工作/生活变故和家庭氛围这两个因素的数值绝对值较大，说明这两个因素易受其他因素的影响。饮食习惯、睡眠习惯、睡眠时间、运动习惯、情绪状态和压力情况这六个因素变化的中心度较高，说明这六个因素的变化是体质发生改变的重要性因素。根据各因素对应体质变化频数统计发现以上六个因素的变化在气虚质、平和质和特禀质间的体质转变频数占比较大，说明这六个因素的改变对这三种体质类型的变化发挥重要作用。结合 Apriori-DEMATEL 算法和 DoWhy 因果推理框架分析的结果，推断饮食习惯和睡眠时间通过影响其他因素的变化间接导致体质变化。结论 本文从动态数据和多种分析方法入手，探讨了中医体质动态变化的影响因素，结果表明饮食习惯、睡眠习惯、睡眠时间、运动习惯、情绪状态和压力情况的变化对气虚质、平和质和特禀质的转化有较大影响。在日常生活中要注意这六个因素的变化，并制定相应的改善方案，减少转化为偏体质的概率。本研究也为中医体质类型动态变化的影响因素分析提供了数据支持和客观化分析参考。

【关键词】DEMATEL；中医体质类型改变；影响因素；动态数据；DoWhy 因果推断框架