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SURVEY ON THE RELATIONSHIP BETWEEN TONGUE CHARACTERISTICS AND TRADITIONAL MEDICINE BODY CONSTITUTION TYPES IN STUDENTS

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ABSTRACT

Objectives: To evaluate the relationship between tongue characteristics and Traditional Medicine body constitution types in healthy volunteers from the Faculty of Traditional Medicine (TM) in the University of Medicine and Pharmacy at Ho Chi Minh City (UMP).

Subjects and research methods: The cross-sectional study of 424 TM students at the UMP was conducted from January to April 2024. Primary outcome variables included body constitution (BC) types (via the Vietnamese version of the Constitution in Chinese Medicine Questionnaire), and tongue characteristics (extracted by ZMT-1A machine). Chi-square tests were used to analyze relationships between BC types and tongue characteristics.

Results: Distribution analysis showed that the Neutral constitution was the most common (64.6%). BC types related with tongue body characteristics include color, size, fissures, and papillae ($p < 0.05$); BC types also correlated with tongue coating characteristics include color, thickness, moisture, and dirty level ($p<0.05$). Specifically, Yin-deficiency, Qi-deficiency, and Dampness-heat constitutions showed pink to dark red body tongue. Yang-deficiency, Yin-deficiency, Dampness-heat, and Blood-stasis displayed tongue fissures, while papillae only appeared in Dampness-heat. Dampness-heat showed a yellowish-white coating. Additionally, moist tongue coating was predominantly found in Yang-deficiency, Qi-deficiency, Dampness-heat, and Blood-stasis types.

Conclusions: Tongue diagnosis – including tongue body color, papillae, fissures, coating color, and moisture level – provides a rapid assessment of TM BC and thus indicates trends in disease development. This enables physicians to guide individuals in targeted lifestyle changes to improve their quality of life.

Keywords: Tongue diagnosis, tongue characteristics, body constitution types, CCMQ.

1. INTRODUCTION

Global healthcare models are increasingly adopting personalized medicine approaches, a field where Traditional Medicine (TM) excels. Disease prevention has traditionally been prioritized over treatment, leading to increasing interest in the early identification and intervention of imbalanced body constitution types in TM practice, aiming to make timely adjustments before disease progression occurs [1]. Currently, TM body constitution (BC) type is mainly identified using the Constitution in Chinese Medicine Questionnaire (CCMQ), which can be time-consuming and labor-intensive. The nine BC types include: Neutral (N), Qi-deficiency (QDF), Yang-deficiency (YGD), Yin-deficiency (YND), Phlegm-dampness (PD), Dampness-heat (DH), Blood-stasis (BS), Qi-depression (QDP), and Inherited-special (ISC) [2].

Tongue diagnosis, a distinctive diagnostic method in TM, offers a quick assessment that supports diagnosis and treatment. TM theory suggests that BC types may be related to tongue characteristics, indicating the potential for using tongue features to guide appropriate intervention for BC in clinical practice [2], [3]. TM BC refers to relatively stable individual characteristics in morphology, physiological function, and mental state, reflecting the state of qi, blood, body fluids, and internal organs. BC is shaped by long-term factors such as lifestyle, diet, environment and can adapt accordingly. Observing an individual's BC over time is essential for disease trend prevention. CCMQ questionnaire is nowadays the standard assessment tool for determining a BC type [2].

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The study focuses on medical students, a population often under stress and academic pressure, which may lead to imbalanced or unhealthy lifestyles. In TM, mental strain, irregular eating, and unhealthy lifestyle habits impact the fundamental elements – essence, qi, blood, body fluids, and internal organs – which may, in turn, affect BC and tongue characteristics [2].

2. MATERIALS AND METHOD

2.1. Research subjects

Participants were selected from first- to sixth-year students in the Faculty of Traditional Medicine at UMP. Inclusion criteria required participants to consent to the study, present a single TM constitution type, have no tongue pathology, and do not use foods that might alter tongue body or coating color within 24 hours prior to participation.

2.2. Sample size

The formula used is:

$$n = Z^2_{1-\alpha/2} \frac{p(1-p)}{d^2}$$

where n is the sample size, α is 0.05 for a 95% confidence level, Z0.975 is 1.96, d represents the margin of error, and p is the expected proportion. Given the absence of a known p-value, p being 0.5 was assumed to maximize the sample size. Allowing for a 10% sample loss, the estimated sample size is 424 students.

2.3. Research time: From August 2024 to October 2024.

2.4. Research method

Cross-sectional descriptive study. The study used the CCMQ questionnaire, which has been standardized for Vietnamese and has been found to be a reliable tool for assessing BC in Vietnamese people. The questionnaire includes 60 questions that are used to classify 9 constitution types [3]. The ZMT-1A is a computerized Automatic Tongue Diagnosis System suitable and useful for clinical diagnosis, teaching, and research. It has been tested at Longhua Hospital and Shuguang Hospital in Shanghai and has been used in several previous studies. Data collection methods: Students are required to rinse their mouths twice with prepared saline solution before participating in direct tongue imaging (ZMT-1A system) and an interview with the researcher to determine their TM BC type (using the standardized-Vietnamese-version-of-the-CCMQ). Study variables: The study variables were the BC type, tongue characteristics, and the student's general demographic information. The general demographic information assessment included gender, age, school year, and hometown. Tongue diagnostic characteristics, including tongue body color, shape, blood stasis spots, teeth marks, fissures, papillae, tongue coating color, thickness, moisture level, dirtiness, and peeling, are nominal or binary variables collected from the ZMT-1A. The BC type was a categorical variable with nine specific types. Tongue characteristics and BC types were regarded as the study's outcome variables. Data analysis methods: The data were analyzed using SPSS 22.0 software. Descriptive statistics included mean, median, standard deviation (for quantitative variables), and percentage (for qualitative variables). To analyze the relationship between BC types and tongue features, Fisher's test was used when more than 20% of values were below 5; otherwise, the Chi-square test was applied. The significance was set at $\alpha=0.05$, meaning the test results were considered reliable at a 95% confidence level.

2.5. Ethical Considerations: This study was conducted with approval from the Ethics Committee in Biomedical Research of the University of Medicine and Pharmacy at Ho Chi Minh City (No. 1931/ĐHYD-HĐĐĐ) on August 15th, 2024.

3. RESULTS

Clinical characteristics of the participants: Of the 424 students who signed up, 85 were excluded for having two or more BC types, resulting in 339 eligible students (42.2% male, 57.8% female). The age distribution was non-normal ($p<0.05$), with a median age of 21 years (range: 19-27). Most students came from outside Ho Chi Minh City, with a ratio of 3.2 to 1.

Student's body constitution characteristics: The most common constitution type was Neutral (26.5% in males, 38.1% in females, 64.6% overall). The least common type was Dampness-heat (0.6% in females, 2.1% overall); in males, the least common was Blood-stasis (0.3%) ($p<0.05$).

Student's tongue characteristics: The predominant tongue characteristics were normal features, including deep pink tongue color (38.1%), medium tongue size (89.4%), no teeth marks (90.6%), no tongue cracks (51.9%), no papillae (67.8%), white coating (72.9%), thin coating (64.6%), moist coating (49.3%), no dirty coating (99.1%), and no peeling (97.6%). The only abnormal feature observed was blood stasis spots (12.4%).

Relationship between Constitution Types and Tongue Characteristics in Students

The study showed that BC types were associated with tongue body color ($p<0.05$). The predominant tongue colors for each BC were as follows: pink for Yin-deficiency (64.3%), pale-purple for Qi-deficiency (52.9%), and dark-red for Dampness-heat (85.7%).

Table 1. Relationship between Constitution Types and Tongue body color

Tongue body color	TM BC types									Total	P*
	N	YGD	YND	QDF	QDP	PD	DH	BS	ISC		
Pale	1	0	0	0	0	0	0	0	0	1	<0.001
	0.3%	0%	0%	0%	0%	0%	0%	0%	0%	0.3%	
% BC	0.5%	0%	0%	0%	0%	0%	0%	0%	0%		
Light pink	43	6	1	9	4	4	0	3	5	75	
	12.7%	1.8%	0.3%	2.7%	1.2%	1.2%	0%	0.9%	1.5%	22.1%	
% BC	19.6%	33.3 %	7.1%	26.5%	25%	50%	0%	30%	38.5%		
Pink	104	6	9	4	0	4	1	0	1	130	
	30.7%	1.8%	2.7%	1.2%	0%	1.2%	0.3%	0%	0.3%	38.8%	
% BC	47.5%	33.3%	64.3%	11.8%	0%	50%	14.3%	0%	7.7%		
Red-edges	2	0	0	0	2	0	0	0	0	4	
	0.6%	0%	0%	0%	0.6%	0%	0%	0%	0%	1.2%	
% BC	0.9%	0%	0%	0%	12.5%	0%	0%	0%	0%		
Dark-red	7	0	2	0	0	0	6	0	0	15	
	2.1%	0%	0.6%	0%	0%	0%	1.8%	0%	0%	4.4%	
% BC	3.2%	0%	14.3%	0%	0%	0%	85.7%	0%	0%		
Dark-pink	9	0	0	3	2	0	0	3	2	19	
	2.7%	0%	0%	0.9%	0.6%	0%	0%	0.9%	0.6%	5.6%	
% BC	4.1%	0%	0%	8.8%	12.5%	0%	0%	30%	15.4%		
Dark-purple	0	0	0	0	0	0	0	0	0	0	
	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
% BC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Pale-purple	53	6	2	18	8	0	0	4	5	95	
	15.6%	1.8%	0.6%	5.3%	2.4%	0%	0%	1.2%	1.5%	28%	
% BC	24.2%	33.3%	14.3%	52.9%	50%	0%	0%	40%	38.5%		
Blood stasis spots											0.586
No	191	15	11	29	13	8	7	10	13	297	
	56.3%	4.4%	3.2%	8.6%	3.8%	2.4%	2.1%	2.9%	3.8%	87.6%	
Yes	28	3	3	5	3	0	0	0	0	42	
	8.3%	0.9%	0.9%	1.5%	0.9%	0%	0%	0%	0%	12.4%	

**: Fisher's exact test*

In the study sample, BC types were associated with tongue size, fissures, and papillae ($p<0.05$). Most BC types showed a predominance of normal tongue size, except for Yang-deficiency. Tongue fissures were more common in Yang-deficiency and Yin-deficiency. Additionally, the presence of papillae was more frequent in the Dampness-heat type.

Table 2. Relationship between Constitution Types and Tongue body shape

Tongue body shape	TM BC types									Total	P*
	N	YGD	YND	QDF	QDP	PD	DH	BS	ISC		
Tongue size											
Thick	0	0	0	0	2	0	0	0	0	2	
	0%	0%	0%	0%	0.6%	0%	0%	0%	0%	0.6%	
% BC	0%	0%	0%	0%	12.5%	0%	0%	0%	0%		
Thin	16	9	0	2	0	2	2	3	0	34	<0.001
	4.7%	2.7%	0%	0.6%	0%	0.6%	0.6%	0.9%	0%	10%	
% BC	7.3%	50%	0%	5.9%	0%	25%	28.6%	30%	0%		
Normal	203	9	14	32	14	6	5	7	13	303	
	59.9%	2.7%	4.1%	9.4%	4.1%	1.8%	1.5%	2.1%	3.8%	89.4%	
% BC	92.7%	50%	100%	94.1%	87.5%	75%	71.4%	70%	100%		
Teeth marks											
Yes	198	14	12	33	16	8	7	10	9	307	
	58.4%	4.1%	3.5%	9.7%	4.7%	2.4%	2.1%	2.9%	2.7%	90.6%	0.065
No	21	4	2	1	0	0	0	0	4	32	
	6.2%	1.2%	0.6%	0.3%	0%	0%	0%	0%	1.2%	9.4%	
Fissures											
No	120	5	3	20	11	5	0	3	9	176	
	35.4%	1.5%	0.9%	5.9%	3.2%	1.5%	0%	0.9%	2.7%	51.9%	
% BC	54.8%	27.8%	21.4%	58.8%	68.8%	62.5%	0%	30%	69.2%		0.002
Yes	99	13	11	14	5	3	7	7	4	163	
	29.2%	3.8%	3.2%	4.1%	1.5%	0.9%	2.1%	2.1%	1.2%	48.1%	
% BC	45.2%	72.2%	78.6%	41.2%	31.3%	37.5%	100%	70%	30.8%		
Papillae											
No	144	18	7	27	13	6	2	6	7	230	
	42,50%	5,30%	2,10%	8%	3,80%	1,80%	0,60%	1,80%	2,10%	67,80%	
% BC	65,80%	100%	50%	79,40%	81,30%	75%	28,60%	60%	53,80%		0.002
Yes	75	0	7	7	3	2	5	4	6	109	
	22,10%	0%	2,10%	2,10%	0,90%	0,60%	1,50%	1,20%	1,80%	32,20%	
% BC	34,20%	0%	50%	20,60%	18,80%	25%	71,40%	40%	46,20%		

**: Fisher's exact test*

No black-gray tongue coating was observed in the study. Constitution types were associated with coating color ($p<0.05$): Neutral, Yang-deficiency, Qi-deficiency, Qi-stagnation, and Inherited-special types showed predominantly white coating, while Dampness-heat showed mainly white-yellow coating.

Table 3. Relationship between Constitution Types and Tongue coating color

Tongue coating color	TM BC types									Total	P*
	N	YGD	YND	QDF	QDP	PD	DH	BS	ISC		
White	172	16	7	23	11	4	0	5	9	247	
	50.7%	4.7%	2.1%	6.8%	3.2%	1.2%	0%	1.5%	2.7%	72.9%	
% BC	78.5%	88.9%	50%	67.6%	68.8%	50%	0%	50%	69.2%		
Yellow	5	0	1	0	0	0	0	0	0	6	
	1.5%	0%	0.3%	0%	0%	0%	0%	0%	0%	1.8%	
% BC	2.3%	0%	7.1%	0%	0%	0%	0%	0%	0%		
White-yellow	26	2	5	10	5	2	6	5	4	65	
	7.7%	0.6%	1.5%	2.9%	1.5%	0.6%	1.8%	1.5%	1.2%	19.2%	<0.001
% BC	11.9%	11.1%	35.7%	29.4%	31.3%	25%	85.7%	50%	30.8%		
No coating	16	0	1	1	0	2	1	0	0		
	4.7%	0%	0.3%	0.3%	0%	0.6%	0.3%	0%	0%		
% BC	7.3%	0%	7.1%	2.9%	0%	25%	14.3%	0%	0%		
Black-gray	0	0	0	0	0	0	0	0	0	0	
	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
% BC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	

**: Fisher's exact test*

BC types associated with tongue coating thickness, moisture, and dirty level ($p<0.05$). A thin coating was predominant in Neutral, Yang-deficiency, Yin-deficiency, Qi-deficiency, Dampness-heat, and Inherited-special types. The moist coating was more common in Neutral, Yin-deficiency, Qi-depression, and Inherited-special types, while a wet coating was predominant in Yang-deficiency, Qi-deficiency, Dampness-heat, and Blood-stasis types. A clean (non-dirty) coating predominated across all constitution types.

Table 4. Relationship between Constitution Types and Tongue coating characteristics

Tongue coating	TM BC types									Total	P*
	N	YGD	YND	QDF	QDP	PD	DH	BS	ISC		
Tongue coating thickness											
Thin	138	17	9	25	7	4	6	5	8	219	
	40.7%	5.0%	2.7%	7.4%	2.1%	1.2%	0.6%	1.5%	2.4%	64.6%	
% BC	63%	94.4%	64.3%	73.5%	43.8%	50%	85.7%	50%	61.5%		
Thick	55	1	3	8	8	0	0	5	5	85	<0.001
	16.2%	0.3%	0.9%	2.4%	2.4%	0%	0%	1.5%	1.5%	25.1%	
% BC	25.1%	5.6%	21.4%	23.5%	50%	0%	0%	50%	38.5%		
Sparse /No coating	26	0	2	1	1	4	1	0	0	35	
	7.7%	0%	0.6%	0.3%	0.3%	1.2%	0.3%	0%	0%	10.3%	
% BC	11.9%	0%	14.3%	2.9%	6.3%	50%	14.3%	0%	0%		
Moisture level											
Dry	9	0	0	0	0	0	0	0	0	10	
	2.7%	0%	0%	0%	0%	0%	0%	0%	0%	2.9%	
% BC	4.1%	0%	7.1%	0%	0%	0%	0%	0%	0%		
Moist	123	1	8	12	9	4	1	1	8	167	<0.001
	36.3%	0.3%	2.4%	3.5%	2.7%	1.2%	0.3%	0.3%	2.4%	49.3%	
% BC	56.2%	5.6%	57.1%	35.3%	56.3%	50%	14.3%	10%	61.5%		
Wet	87	17	5	22	7	4	6	9	5	162	
	25.7%	5%	1.5%	6.5%	2.1%	1.2%	1.8%	2.7%	1.5%	47.8%	
% BC	39.7%	94.4%	35.7%	64.7%	43.8%	50%	85.7%	90%	38.5%		
Dirtiness											
No	219	18	14	34	15	8	7	10	11	336	
	64.6%	5.3%	4.1%	10%	4.4%	2.4%	2.1%	2.9%	3.2%	99.1%	
% BC	100%	100%	100%	100%	93.8%	100%	100%	100%	84.6%		0.005
Yes	0	0	0	0	1	0	0	0	2	3	
	0%	0%	0%	0%	0.3%	0%	0%	0%	0.6%	0.9%	
% BC	0%	0%	0%	0%	6.3%	0%	0%	0%	15.4%		
Peeling											
No	211	18	14	34	16	8	7	10	13	331	
	62.2%	5.3%	4.1%	10%	4.7%	2.4%	2.1%	2.9%	3.8%	97.6%	0.963
Yes	8	0	0	0	0	0	0	0	0	8	
	2.4%	0%	0%	0%	0%	0%	0%	0%	0%	2.4%	

*: *Fisher's exact test*

4. DISCUSSION

4.1. Student's body constitution characteristics

Among the 339 students in the study sample, the balanced constitution (Neutral type) accounted for the majority, with 219 students (64.6%), while 120 students (35.4%) had an imbalanced constitution. Within the imbalanced group, Qi-deficiency was the most common (10.0%) – double the rate of the next most frequent type, Yang-deficiency (5.3%). This aligns with findings from Tang et al., where the Neutral constitution was most prevalent, and Qi-deficiency was the most common type among imbalanced constitutions [4]. In TM theory, young people have abundant Qi and blood, stable organ function, and physical strength, which is why the Neutral constitution is the most common among healthy young individuals.

Qi-deficiency is the most prevalent type among imbalanced constitutions, in both genders (6.2% in males and 3.8% in females). This may be due to an imbalance in the production and utilization of Qi energy in medical students. Specifically, the high-stress academic environment, competitiveness, heavy course-work, and frequent exams demand significant mental exertion, which can lead to chronic stress and affect the physiological functions of the Heart and Spleen, resulting in Qi depletion [5]. Too little rest and an irregular diet can drain the body's Qi supply.

4.2. Student's tongue characteristics

Since the tongue images in this study may show multiple features simultaneously, this research analyzed the frequency of each tongue characteristic. Results indicated that normal tongue features were more common, such as dark-pink color, medium size, no teeth marks, no fissures, no papillae, white coating, thin, moist, clean, and no peeling. Only one abnormal feature, blood stasis spots, appeared frequently. These findings contrast with the study by Zhang et al., where prevalent features included light red color, fissures, papillae, yellow coating, a smooth, greasy texture, and dryness. This difference may be due to variations in climate between the two countries, as well as in constitution, diet, and lifestyle between Vietnamese and Chinese students [6].

4.3. Relationship between Constitution Types and Tongue Characteristics in Students

This is the first study in Vietnam to explore the relationship between TM BC and tongue characteristics in a medical student population. TM BC types were associated with tongue color ($p<0.05$). Specifically, a deep-pink tongue was predominant in Yin-deficiency (64.3%), pale purple in Qi-deficiency (52.9%), and dark-red in Dampness-heat (85.7%), while no dominant tongue color was observed for Yang-deficiency. Comparing this with Zhang et al., we find a similarity in Dampness-heat type, where red tongues were also common (57.4%). This red color aligns with TM's concept of Heat symptoms. However, in Zhang's study, both Yang-deficiency and Qi-deficiency showed a light-pink tongue color (91.1%), differing from this study, which observed no dominant tongue color for Yang-deficiency and found pale-purple as a distinguishing color for Qi-deficiency [6]. This difference may stem from a wider color range in our study, which included eight categories (pale, light-pink, pink, red on tongue edges, dark-red, dark-pink, dark-purple, pale-purple) compared to four in Zhang's study (purple, light-pink, pink, other). Additionally, Yin-deficiency in this study was associated with a pink tongue, which was not described in Zhang's work. This could suggest that pink and red tongues are related to Heat symptoms [7]. However, further observation of additional tongue features (coating, papillae, and moisture levels), is needed to distinguish between Excess-Heat and Empty-Heat in Yin-deficiency cases.

TM constitution types were associated with tongue size, fissures, and papillae ($p<0.05$). For tongue size, a normal size was predominant across constitution types, except in Yang-deficiency (50% thin, 50% normal). According to TM diagnostics, a thin tongue with a pale color indicates blood deficiency, while a thin tongue with a red color and no coating suggests Yin-deficiency with internal Heat. Both are signs of chronic conditions [8]. Since students with chronic symptoms or using medications were excluded, it is consistent that most constitution types exhibited a normal tongue size. Regarding tongue fissures, Neutral, Qi-deficiency, Qi-depression, Phlegm-Dampness, and Inherited-special constitutions typically showed no fissures. In TM, tongue fissures often indicate Excess-Heat or Yin-deficiency in the body, so the absence of fissures in these types aligns with their fewer Heat-related symptoms [8]. For tongue papillae, Neutral, Yang-deficiency, Qi-deficiency, Qi-depression, Phlegm-Dampness, Blood-stasis, and Inherited-special types generally showed no papillae, while Dampness-heat showed papillae frequently. Red papillae are always an indication of Heat and may also signal blood stasis, according to TM theory, supporting the reliability of these findings [8]. However, unlike Zhang's study, which observed tongue fissures and papillae in the Neutral, Yang-deficiency, Qi-deficiency, Qi-depression, Phlegm-Dampness, and Blood-stasis types, this difference may be due to variations in the constitution types, climate, dietary habits, and lifestyle between Vietnamese and Chinese students [6].

TM constitution types were also associated with tongue coating color ($p<0.05$). White coating was predominant in the Neutral, Yang-deficiency, Qi-deficiency, Qi-depression, and Inherited-special types, while Dampness-heat showed a predominance of white-yellow coating. Compared with Deng et al., white coating was predominant in Neutral, Qi-deficiency,

and Yang-deficiency types but not in Qi-depression or Inherited-special types. These differences may be due to variations in constitution and dietary habits between Vietnamese and Chinese students [9]. In TM, Yang-deficiency and Qi-deficiency differ only in the degree of body warmth; thus, when Qi or Yang is deficient, cold tends to arise or easily invade, resulting in a white tongue coating [2].

TM constitution types were associated with the thickness, moisture, and dirty level of tongue coating ($p<0.05$). For coating thickness, the thin coating was predominant in the Neutral, Yang-deficiency, Yin-deficiency, Qi-deficiency, Dampness-heat, and Inherited -special types, consistent with Zhang's findings [6]. In TM theory, tongue coating is formed by stomach Qi, with a normal thin coating being characteristic of the Neutral type. When stomach Qi is weakened (as in Qi-deficiency), new coating formation decreases, resulting in a thin coating for Yang-deficiency, Yin-deficiency, Dampness-heat, and Inherited-special types. For coating moisture, the moist coating was predominant in Neutral, Yin-deficiency, Qi-stagnation, and Inherited-special types, while Yang-deficiency, Qi-deficiency, Dampness-heat, and Blood-stasis types showed a predominantly wet coating. This contrasts with Zhang's findings [6], where Neutral, Yin-deficiency, and Qi-stagnation showed mostly dry and no wet coating. This difference may be due to variations in constitution and dietary habits. Lastly, a clean coating was predominant across all constitution types for coating dirty levels. This is likely due to oral hygiene habits, particularly among medical students, who generally show no signs of dirty coating.

5. CONCLUSIONS

The findings reveal significant associations between TM constitution types and various tongue characteristics: tongue body color ($p<0.05$), tongue size, fissures, and papillae ($p<0.05$); coating color ($p<0.05$); coating thickness, moisture, and dirty level ($p<0.05$). These associations between constitution types and tongue features validate TM's approach of "seeing the exterior to understand the interior", affirming the interconnectedness of internal structure and external.

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