

CLINICAL STUDY

Reliability and validity of tongue color analysis in the prediction of symptom patterns in terms of East Asian Medicine

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calculated. To examine intra- and inter-rater reliabilities and criterion validity of the color analysis method, three raters were asked to calculate color parameters for 20 digital image samples. Finally, four hierarchical regression models were formed.

RESULTS: Color parameters showed good or excellent reliability (0.627-0.887 for intra-class correlation coefficients) and significant criterion validity (0.523-0.718 for Spearman's correlation). In the hierarchical regression models, age was a significant predictor of *Yin* deficiency ($\beta = 0.192$), and b^* value of the tip of the tongue was a determinant predictor of *Yin* deficiency, Phlegm, and Heat patterns ($\beta = -0.212, -0.172, \text{ and } -0.163$). Luminance (L^*) was predictive of *Yin* deficiency ($\beta = -0.172$) and Cold ($\beta = 0.173$) pattern.

CONCLUSION: Our results suggest that color analysis of the tongue using the $L^*a^*b^*$ system is reliable and valid, and that color parameters partially serve as symptom pattern predictors in EAM practice.

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Key words: Medicine, East Asian Traditional; Complementary therapies; Tongue inspection; *Yin* deficiency; Symptom pattern

INTRODUCTION

East Asian medicine (EAM), tongue inspection (TI) is a process which involves visually inspecting the body of the tongue for color, shape, moisture, and movement,

Abstract

OBJECTIVE: To examine whether color parameters of tongue inspection (TI) using a digital camera was reliable and valid, and to examine which color parameters serve as predictors of symptom patterns in terms of East Asian medicine (EAM).

METHODS: Two hundred female subjects' tongue substances were photographed by a mega-pixel digital camera. Together with the photographs, the subjects were asked to complete *Yin* deficiency, Phlegm pattern, and Cold-Heat pattern questionnaires. Using three sets of digital imaging software, each digital image was exposure- and white balance-corrected, and finally L^* (luminance), a^* (red-green balance), and b^* (yellow-blue balance) values of the tongues were

and the tongue coating for color, thickness, and distribution.¹ According to EAM, the tongue is directly connected to the internal organs through the heart, liver, spleen, lung, kidney, and urinary bladder meridians.² As the tongue is a sensitive mirror for changes in internal organs, TIs serve as an important guide in determining pathological patterns. For example, pale redness of the tongue proper refers to a blood deficiency or Cold pattern, whereas dark redness or blueness of the tongue proper refers to an aggravated Heat or Cold pattern.³ Thickness of the tongue coating is associated with a Phlegm or food retention pattern.³ The pattern (or symptom pattern) refers to a group of symptoms, defined in terms of EAM theory, whereby a medical condition is diagnosed and treated in EAM practice.

Although TI is an important diagnostic method to identify symptom patterns, expertise is a matter of subjective experience, and the results of the TI are influenced by environmental factors, such as light source or brightness.⁴ Moreover, the results of traditional TIs are obscure, expressed in the form of a three or four rank scale, such as "pale," "normal," "red" and "dark red," which is problematic when attempting to quantify and establish efficacy.^{2,3} Some studies have been conducted to quantify the results of traditional TIs and are categorized into two types: the development of medical instruments and the facilitation of mathematical algorithms. Kim *et al.*^{5,6} developed a digital tongue imaging system and reported that the thickness of the tongue coating was reliable and well-matched to clinician assessment. Yamamoto *et al.*⁷ reported that hyperspectral imaging system results for the tongue images were a feasible surrogate for expert visual tongue analysis. In terms of the facilitation of algorithms, Pang *et al.*⁸ and Watsuji *et al.*⁹ reported that Bayesian networks and fuzzy theory were useful for determining diseases or symptom patterns, respectively. However, these instruments and algorithms have some limitations in terms of broad application because the instruments are not widely used, and there is a need for special knowledge to apply the algorithms. Therefore, an assessment tool for TI that is popular, easy-to-use, and can present quantitative parameters is needed. Recently, the usage of mega-pixel digital cameras has been widely adopted in various medical fields, including dentistry, ophthalmology, and dermatology.¹⁰⁻¹² Moreover, parameters of color systems, such as RGB (red, green, blue) and L*a*b* (luminance, red-green balance, yellow-blue balance), can be calculated using digital imaging software, such as Adobe Photoshop and Picture Color Analyzer.¹³ The L*a*b* system is one of the standard color models used to describe all visible colors and presents information regarding luminance.¹³ Some studies have performed reliability tests when conducting traditional TI or applying a TI medical device.¹⁴⁻¹⁷ However, few studies

have addressed the intra-rater and inter-rater reliabilities of color parameters of the L*a*b* system using a popular digital camera and digital imaging software. Therefore the first purpose of our study was to calculate tongue L*, a*, and b* parameters using a digital camera and digital imaging software and to examine whether this color analysis method has satisfactory intra- and inter-rater reliabilities. It is also important to examine criterion validity, that is to say, to examine whether the color analysis method results using the L*a*b* system are consistent with those evaluated by experts.⁶ As such, the criterion validity of each color parameter was also examined, together with intra- and inter-rater reliabilities.

The second purpose of our study was to examine whether color parameters served as predictors of symptom patterns which is a subcategory of a disease or disorder in EAM. Although some studies have reported the relationship between color parameters of the TI and symptom patterns,^{7,9} few studies have addressed the association of color parameters of the tongue with validated pattern questionnaire measures. Recently, the *Yin* deficiency questionnaire (YDQ), the Phlegm pattern questionnaire (PPQ), and the Cold-Heat pattern questionnaire (CHPQ) were developed and validated.¹⁸⁻²⁰

Together with the relationship between tongue color parameters and symptom patterns, we examined aging effect on the symptom patterns. It is generally accepted that the thickness of the tongue coating is related to the severity of Phlegm or *Yin* deficiency pattern.² For example, tongue surface is tinged with white or yellow as Phlegm pattern develops, whereas it is tinged with red as *Yin* deficiency pattern develops.² Park *et al.*²¹ recently reported that there were aging effects on the PPQ and YDQ scores in normal college students ($n = 75$). Therefore it may be important to examine whether aging effects on the Phlegm and *Yin* deficiency patterns can be replicated in patients, and to evaluate which among tongue color and age is better at determining symptom patterns.

In summary, in the present study, color parameters were calculated using digital images and color analysis software, and intra- and inter-rater reliabilities and criterion validity tests were conducted. Finally, the ability of the color parameters and aging for predicting symptom patterns was examined.

METHODS AND MEASURES

Subjects and data collection

This study was a chart review study, the entire process of which is depicted in Figure 1. The electronic medical records (EMRs) of all 200 outpatients that visited Women's Health Clinic of the Kyung Hee University Oriental Medical Hospital in Gangdong, Korea from April 2011 to February 2012 were

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