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"Study on the scalp characteristics of Chinese people with hair loss"

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Abstract

According to data from the National Health Commission of the People's Republic of China, approximately 250 million people are affected by hair loss, and this issue is increasingly prevalent among younger individuals. Hair loss is no longer a concern solely for middle-aged men, as an increasing number of women are also affected. While non-invasive, data-driven methods for skin condition and problem characterization have gained widespread attention, there remains considerable potential for research on the inherent characteristics of the scalp in individuals with hair loss. This study aimed to investigate the physiological characteristics of the scalp in relation to hair loss among 195 young and middle-aged Chinese women, and to identify age-related changes and influencing factors. Participants were classified into hair loss (HL, n=61) and non-hair loss (NHL, n=134) groups based on the BASP classification. Scalp barrier function, skin color, microcirculation parameters, and self-reported questionnaire data were collected and analyzed. Compared to the NHL group, the HL group had significantly higher scalp moisture content (CM), transepidermal water loss (TEWL), and skin color parameters (L*, a*, b*) (all $p<0.05$), suggesting compromised barrier function and possible inflammatory processes. No significant differences were observed in scalp sebum(SM), pH, or temperature. Age-stratified analysis revealed specific turning points in physiological parameters, indicating dynamic scalp changes with aging that may be associated with the onset and progression of alopecia. Questionnaire data showed that family history of hair loss, oily skin type, and frequent shampooing were significantly correlated with hair loss (all $p<0.05$). Scalp physiological characteristics vary significantly between individuals with and without hair loss and are influenced by age and personal traits. These findings provide valuable insights for early intervention and the development of personalized scalp care products for the Chinese population.

Keywords: Hair Loss; Scalp characteristics; Non-invasive testing; Chinese people

1. Introduction

According to data from the National Health Commission of the People's Republic of China, more than 250 million individuals in China experience hair loss, with a growing prevalence among younger populations. Among these cases, over 95% are classified as androgenetic alopecia (AGA), the most common form of progressive hair loss. AGA manifests differently between sexes: men typically exhibit receding hairlines or thinning and loss of hair in the vertex region, while women primarily present with diffuse thinning over the crown, often displaying a widened parting or a characteristic "Christmas tree" pattern[1]. Epidemiological studies have shown that the prevalence of AGA is higher in Caucasian populations and relatively lower in Asian and African populations. In China, the reported prevalence is approximately 21.3% in men and 6.0% in women[2]. However, due to increasing psychological stress and changes in lifestyle and dietary patterns, the incidence of hair loss is rising. Hair loss not only has physiological consequences—such as reduced protection of the scalp from UV radiation—but also significantly affects appearance, leading to considerable psychological distress and emotional burden. As a result, researchers have actively sought effective treatment strategies[3-5].

As a vital external organ, the scalp not only reflects the health status of the skin but also serves as an indicator of systemic conditions, including endocrine function and overall physiological balance. This study aims to analyze scalp data and hair loss status in 195 Chinese women aged 20–45 to investigate the differences in baseline scalp characteristics between individuals with and without hair loss, evaluate the impact of age on hair loss, and identify potential contributing factors through structured questionnaires. The findings of this research are expected to enhance the understanding of the relationship between scalp health and hair loss and provide a scientific foundation for the development of personalized scalp care products tailored to the characteristics of the Chinese population.

2. Materials and Methods

2.1 Research objects

A total of 195 Chinese female volunteers aged between 20 and 45 years were recruited for this study. The study was conducted in accordance with the "Ethical Review Measures for Biomedical Research Involving Humans" (2016) issued by the National Health Commission of China, the Declaration of Helsinki (2013) by the World Medical Association (WMA), and the International Ethical Guidelines for Health-related Research Involving Humans (2016) by CIOMS. Inclusion criteria required participants to have no scalp diseases, no systemic dermatological conditions, and no recent history of relevant skin treatments or medication use. Pregnant or lactating women were excluded. All participants provided written informed consent prior to enrollment.

2.2 Test indicators and instruments

All assessments in this study were conducted using non-invasive skin analysis instruments. The measurement indicators were categorized into three dimensions: barrier function, scalp color, and scalp microcirculation. The specific indicators and corresponding instruments are listed in the table below.

Table 1. Skin test indicators and instruments

Indicator Dimensions	Metric Name	Instrument	Instrument manufacturer
Barrier level	Moisture Content (CM)	Corneometer CM 825	Courage+Khazaka electronic GmbH, Germany
	Transepidermal water loss (TEWL)	Tewameter® TM 300	
	Sebum Secretion Level (SM)	Sebumeter SM815	
	pH	Skin-pH-Meter pH905	
Color level	L*	Smart Skin Care®	IT Access Co.,Ltd.
	a*		
	b*		
Microcirculation level	Temperature	FC-IR 100	Shenzhen Furuinuo Technology Co., Ltd.

2.3 Methods

The 195 eligible volunteers were classified into a hair loss group (HL, n = 61) and a non-hair loss group (NHL, n = 134) according to the BASP classification method [6]. First, participants were required to rest quietly in a seated position for 30 minutes in a controlled environment, during which they completed a structured questionnaire covering factors potentially influencing hair loss, including family history of alopecia, self-assessed hair loss status, dietary habits, and physical activity. Subsequently, they underwent scalp assessments in the testing room. All measurements were conducted under standardized environmental conditions (temperature: 20 ± 2 °C; relative humidity: 50 ± 10%). All collected data were recorded and archived. Scalp conditions were evaluated based on the analysis of the measured physiological indicators. The experimental procedure is illustrated in the figure below.

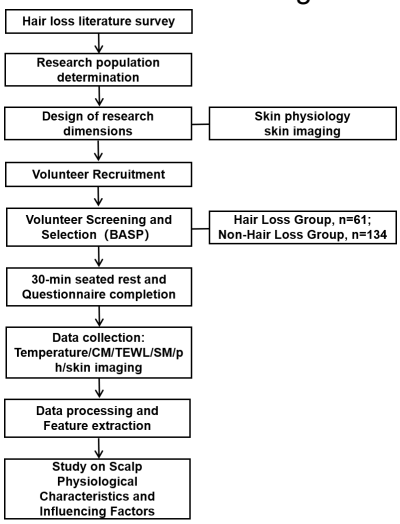


Figure 1. Research method flow chart

2.4 Stastics Analysis

Statistical analysis and significance testing were performed using IBM SPSS Statistics 25.0. All statistical results were presented as mean ± standard deviation (M ± SD). Normality

tests indicated that the data did not follow a normal distribution. Therefore, non-parametric statistical methods were employed. Specifically, the Mann-Whitney U test was used to assess differences in scalp parameters between the hair loss and non-hair loss groups, and Spearman correlation analysis was conducted to evaluate the associations between questionnaire variables and hair loss. All tests were two-tailed, with a significance level set at 0.05; a p-value less than 0.05 was considered statistically significant. MATLAB Starter Application R2023b was used to analyze the age-related trends in scalp physiological indicators and to determine the corresponding fitting functions.

3. Results

3.1 Differences in Scalp Parameters Between Alopecic and Non-Alopecic Populations

As shown in Figure 2, significant differences in scalp parameters were observed between the HL and NHL groups. In barrier function dimensions, the HL group exhibited significantly higher CM values (45.39 ± 26.22) compared to the NHL group (25.02 ± 16.51, $P < 0.05$), along with elevated TEWL (15.09 ± 9.09 vs. 12.18 ± 5.01, $P < 0.05$), suggesting potential impairment of scalp barrier function in alopecic individuals. For chromatic parameters, the HL group demonstrated significantly higher values in brightness (L: 117.03 ± 8.54 vs. 110.46 ± 7.92), redness (a: 133.24 ± 2.49 vs. 131.40 ± 1.60), and yellowness (b*: 136.47 ± 2.54 vs. 134.60 ± 2.96, all $P < 0.05$). These chromatic alterations may reflect inflammatory processes (e.g., erythema) or microcirculatory changes associated with alopecia [7]. No significant intergroup differences were detected in SM (176.07 ± 82.14 vs. 155.37 ± 72.87), pH (5.72 ± 0.52 vs. 5.87 ± 0.44), or temperature (36.42 ± 0.58 vs. 36.52 ± 0.45, all $P > 0.05$).

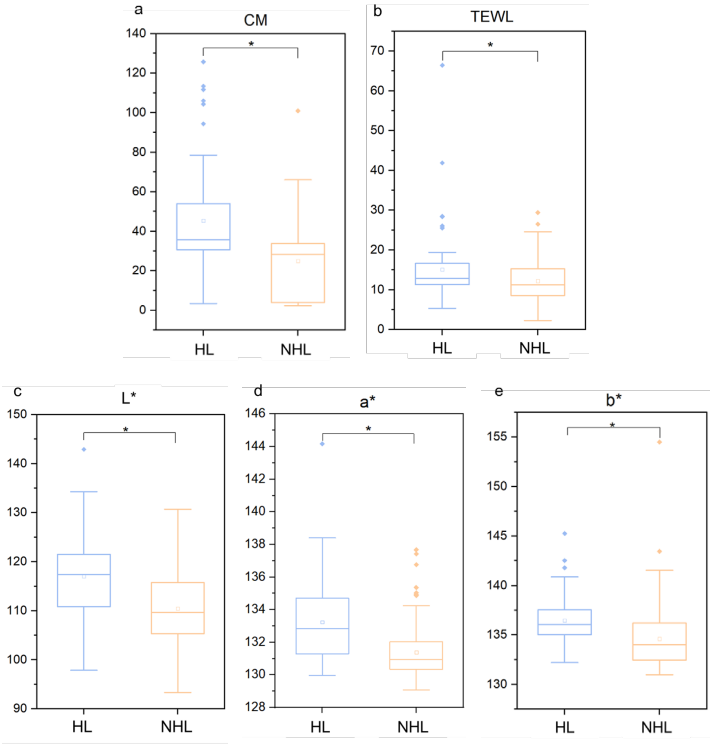


Figure 2. Differences in scalp parameters between the hair loss group and the non-hair loss group: (a) CM; (b)TEWL; (c) L*; (d) a*; (e) b*. *$P < 0.05$, indicate significant differences between groups based on Mann-Whitney U test.

3.2 Age-Stratified Differences in Scalp Parameters Between Alopecic and Non-Alopecic Populations

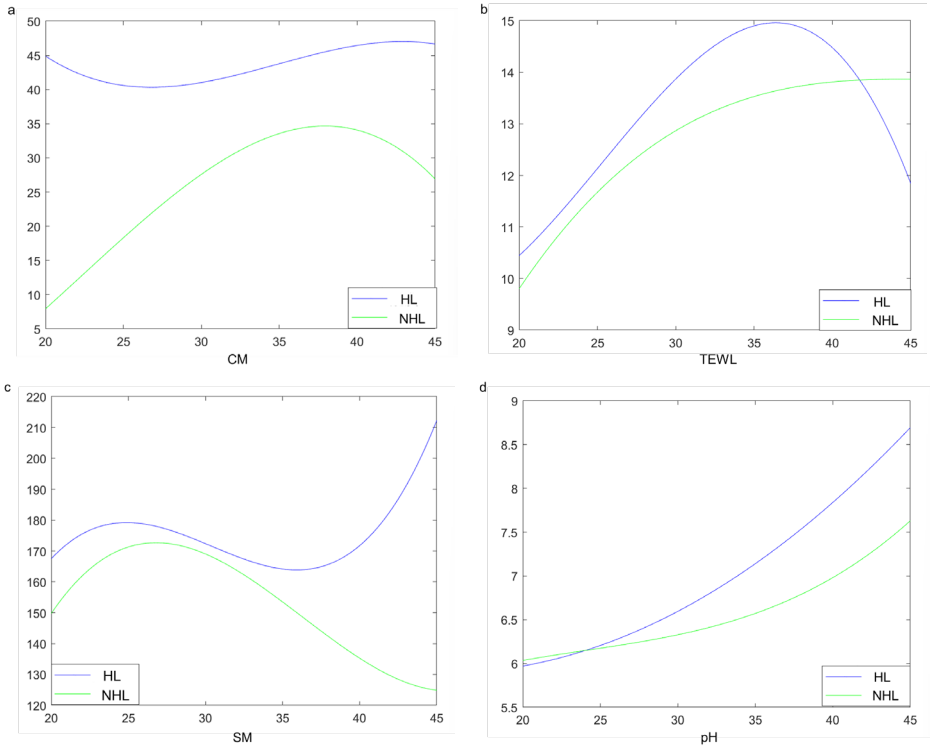
To compare the differences in scalp physiological parameters between individuals with and without hair loss across different age groups, this study analyzed both groups under the same indicators in a unified dimensional framework.

In terms of barrier function, the scalp CM was consistently higher in the hair loss group across all age stages compared to the non-hair loss group. The CM in the hair loss group peaked at age 43 and then declined, whereas the peak in the non-hair loss group occurred at age 37. TEWL was higher in the hair loss group before age 42, but higher in the non-hair loss group after age 42; the hair loss group reached the TEWL peak at age 36. Scalp SM was consistently higher in the hair loss group, showing a significant increase after age 35, while it declined in the non-hair loss group during the same period. Scalp pH increased with age in both groups. Before age 24, the pH was higher in the hair loss group, but after age 24, it was higher in the non-hair loss group.

In terms of color dimension, the L* value of the scalp, representing brightness, was consistently higher in the hair loss group, indicating a lighter scalp tone. In this group, brightness declined before age 36 and increased afterward; in the non-hair loss group, it increased before age 34 and decreased thereafter. The a* value, indicating redness, was higher in the hair loss group before age 38, suggesting a redder tone, while after age 38, the non-hair loss group showed greater redness. The b* value, representing yellowness, was higher in the hair loss group before age 37, while the non-hair loss group had higher values after age 37.

In terms of microcirculation, scalp temperature in both groups decreased with age; however, the overall temperature was lower in the hair loss group, with a more pronounced downward trend, suggesting potential microcirculatory insufficiency.

These findings highlight the importance of age-related changes in scalp physiological characteristics. The study identified turning points for several parameters, indicating that the progression of hair loss is closely associated with specific physiological changes in the scalp. With increasing age, the scalp's barrier function may deteriorate, potentially contributing to hair loss [8]. The risk of hair loss significantly increases with age in women [9] , and this risk may be predicted by analyzing skin physiological parameters to estimate the age of onset or population-level trends of hair loss. Such insights could support early prevention and inform the development of anti-hair loss cosmetic and pharmaceutical products.



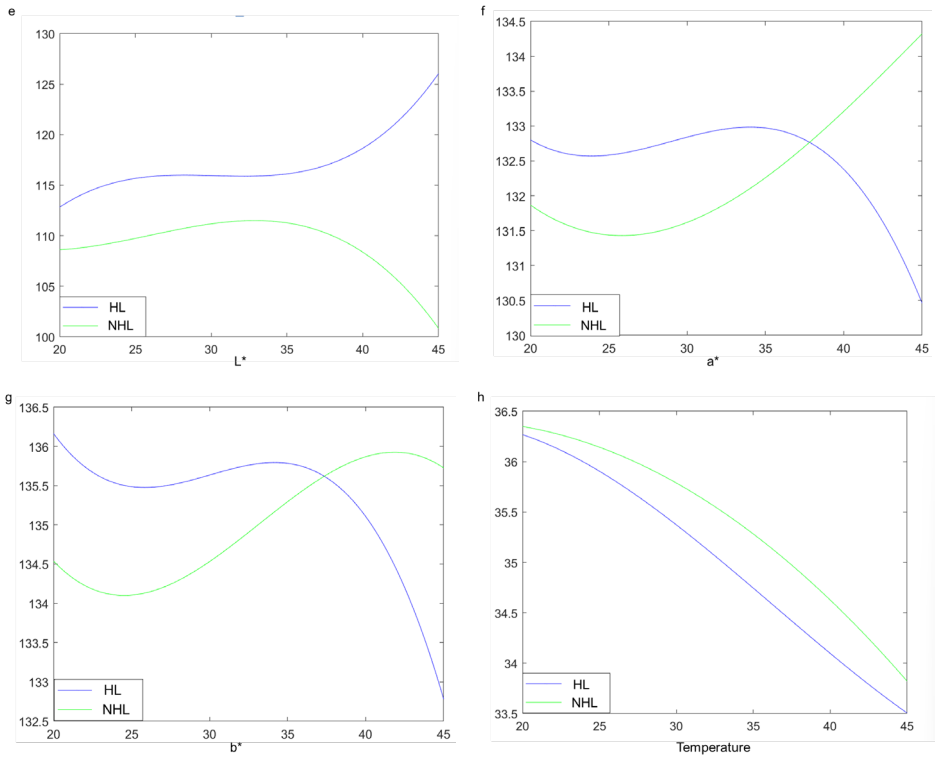


Figure 3. Comparison of age-related trends in the same indicator between hair loss and non-hair loss groups: (a) CM; (b) TEWL; (c) SM; (d) pH; (e) L*; (f) a*; (g) b*; (h) Temperature.

3.3 Investigation of Factors Influencing Hair Loss

The correlations between questionnaire items and hair loss status were analyzed using the Spearman correlation method. As shown in Table 2, several variables demonstrated significant associations with hair loss. Other factors, such as BMI, dietary habits, sleep quality, and frequency of weekly exercise, were not significantly correlated with hair loss status ($p > 0.05$).

A significant positive correlation was observed between the presence of hair loss in family members and the subject's own hair loss status ($r = 0.124$, $p < 0.05$), suggesting a potential genetic predisposition. This finding is consistent with previous studies indicating a strong familial aggregation in androgenetic alopecia[10].

A significant negative correlation was found between facial skin type and hair loss status ($r = -0.124$, $p < 0.05$), indicating that individuals with oily facial skin were more likely to be in the hair loss group. This may be related to sebaceous gland activity, as androgenetic alopecia is associated with enlarged sebaceous glands and increased sebum production around the hair follicles, potentially contributing to hair loss[11].

Additionally, shampooing frequency was positively correlated with hair loss status ($r = 0.125$, $p < 0.05$), possibly reflecting behavioral changes in individuals with hair loss who may wash their hair more frequently due to excessive scalp oiliness or anxiety about hair loss. However, it remains unclear whether frequent hair washing exacerbates hair loss. Some studies have shown that increased shampooing frequency can significantly elevate TEWL (transepidermal water loss), impairing the scalp barrier function[12].

Table 2. Factors Influencing Hair Loss. * $p < 0.05$, indicating a statistically significant correlation.

Questionnaire Item	Correlation with T/FT Grouping

BMI Value	0.108
Family History of Hair Loss	0.124*
Facial Skin Type	-0.124*
Dietary Pattern	0.096
Sleep Quality	-0.054
Weekly Exercise Frequency	0.054
Hair Washing Frequency	0.125*

5. Conclusion

This study demonstrated that individuals with hair loss exhibited impaired scalp barrier function, abnormal pigmentation parameters, and potential microcirculatory insufficiency. These changes showed characteristic turning trends with age and were closely associated with the occurrence of hair loss. In addition, hair loss showed a clear familial aggregation, and oily skin type and higher shampooing frequency were significantly associated with hair loss status. These findings provide scientific evidence and early intervention references for scalp health management and the development of personalized anti-hair loss hair care products for Chinese women.

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