Assessment of biophysical properties of the scalp: Comparison according to the androgenetic alopecia with seasonal variations

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Abstract

Background: The scalp exfoliates and regenerates periodically, and lipids such as ceramides form stratum corneum with keratinocytes to function as a barrier to protect skin from external factors. In androgenetic alopecia patients' scalp, follicles are miniaturized causing barrier disruption. Therefore, we assumed that change patterns of scalp characteristics, caused by environmental factors, would be different depending on presence-absence of alopecia. Thus, we assessed the biophysical parameters of scalp of Alopecia group and Non-alopecia group in summer and winter.

Methods: Subjects were pre-screened and divided into Alopecia group and Non-alopecia group. Scalp hydration, sebum content, trans-epidermal water loss (TEWL) and stratum corneum content were measured with non-invasive methods. Results were compared between seasons, and between groups. In winter, the scalp keratinocytes were collected by tape stripping to analyze ceramides, as barrier-related lipids.

Results: Alopecia group showed significant differences in all biophysical parameters comparing between seasons. Comparing between groups, differences in scalp hydration and TEWL were significant in summer. Scalp hydration, sebum content and TEWL in winter also showed differences. As a result of lipid analysis, the total amount of ceramides was higher in Alopecia group.

Conclusion: Comparing biophysical parameters between Alopecia group and Non-Alopecia group with seasonal variations, Alopecia group showed significant changes in the scalp characteristics, showing more sensitive response to environmental factors than Non-alopecia group. It is believed to be due to the disrupted scalp barrier function. Although lipid analysis

showed no statistical significance, there is a difference in the total amount of ceramides and further research is expected.

Keywords: Scalp; Hair loss; Barrier function; Ceramides; Seasonal variations;

Introduction.

The scalp is physically bordered anteriorly by the face and laterally and posteriorly by the neck, covering cranial vault. The scalp is structurally similar to the skin of other areas as it consists of soft tissue layers, but it has a high density of hair follicles and a relatively large amount of sebum secretion.[1] The surface of the scalp is covered with an acid film along with melanin pigment to protect the scalp from physical factors such as ultraviolet rays and microbial infections, and regulates body temperature through sweating and contraction and relaxation of arrector pili muscle.[2] One of the major functions of the scalp is barrier function. The scalp repeats exfoliation and regeneration through periodic desquamation of keratinocytes, as with the skin in other parts of the body. The keratinocytes of the scalp forms a “Brick and Mortar” structure with lipids such as ceramides to respond to environmental factors externally and prevent water loss internally. [3, 4]

Scalp hair is divided into extracorporeal, which protrudes above the surface of the scalp, and intracorporeal, which is embedded in the scalp. The extracorporeal part is completely separated from the scalp and has aesthetic function and protection of head from physical trauma or ultraviolet rays. However, the intracorporeal part grows from the hair follicles 4mm below the scalp and interacts with the arrector pili muscle and sebaceous glands, hair growth and hair loss are directly related to the scalp conditions. [5] Hair repeats growth and falling out according to the hair growth cycle, and the symptom of excessive hair loss due to inhibition of hair growth or accelerated hair loss is called alopecia. Androgenetic alopecia, the most common type of hair loss, is caused by hypersensitivity to male sex hormone androgen. [6, 7] Androgenetic alopecia is a kind of non-scarring alopecia, which does not directly cause damage or lesions on the scalp, however hair follicle miniaturization, which caused by androgenetic alopecia, may cause damage to the arrector pili muscle, and induce excessive sebum secretion, microinflammation, impairing the scalp barrier function. [8, 9]

Therefore, we assumed that there will be differences in the scalp characteristics between Alopecia group and Non-Alopecia group, and that the change patterns in response to the environment will also be different. Seasons were selected as an environmental factor to evaluate the change pattern, and the test was conducted in August, 2020, very hot and humid summer (average temperature: 27.7 ℃, average relative humidity: 78.4%) and in January, 2021, cold and dry winter (average temperature: -1.4 ℃, average relative humidity: 60.1%) according to the distinct seasons of South Korea. [10] The subjects were divided into Alopecia group and Non-Alopecia group through screening by a dermatologist and the scalp characteristics were collected from a total of 120 subjects, 30 each in summer and winter. For scalp characteristics, scalp hydration, sebum content, trans-epidermal water loss, and stratum corneum content were evaluated to investigate the scalp barrier function. In addition, a preliminary study was carried out on the content of ceramides, lipids related to the skin barrier, after collecting keratin from the scalp in winter.

Materials and Methods.

In order to investigate the seasonal scalp characteristics of the Alopecia group and Non-Alopecia group, subjects aged 18 to 54 years were recruited and screened by a dermatologist according to the Basic and Specific (BASP) classification. (Figure 1) In summer and winter, 30 subjects were selected as Alopecia group and Non-alopecia group, respectively, and thus, scalp biophysical characteristics were collected from a total of 120 people. The test was conducted after approval by the Institutional Review Board. (Approval number: 2020021201-202101-HR-001-0)

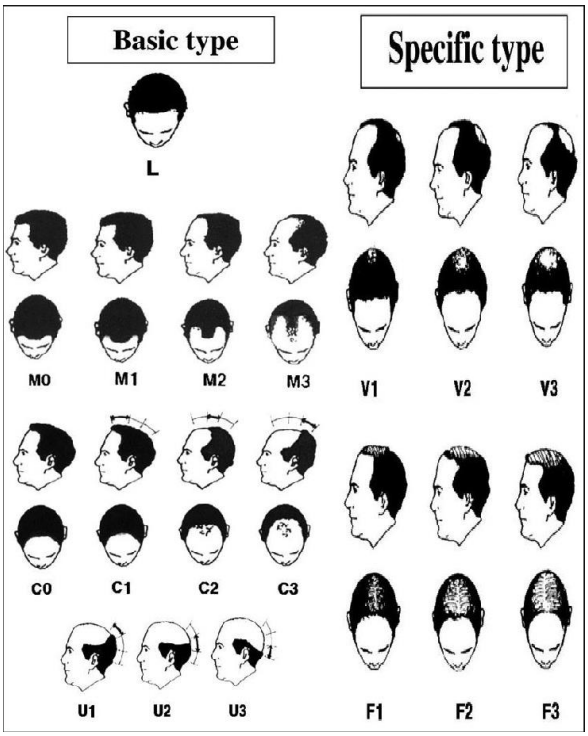

Figure 1. Basic and Specific (BASP) classification [11]

Subjects visited the research institution, filled out a consent form and recorded their gender and age through a demographic survey. All measurements were performed after acclimatization for at least 30 minutes under constant temperature and humidity conditions (22±2 ℃, 50±10% relative humidity) without air movement and direct sunlight. The evaluation items were scalp hydration, sebum content, trans-epidermal water loss, and stratum corneum content. Items were measured using DermaLab ® USB Hydration (Cortex Technology, Denmark), Skin-O-Mat® Sebumeter (COSMOMED, Germany), Vapometer (Delfin Technologies, Finland), respectively, and stratum corneum content was measured with SquameScan 850A Instrument (Heiland electronic GmbH, Germany) after tape stripped using D-Squame® D100 Standard Sampling Discs (Clinical and Derm, LLC, USA). In winter, stratum corneum samples obtained by tape stripping methods were analyzed to quantitate ceramide content, which is performed by LaSS Corporation.

For statistical analysis, comparisons between seasons and groups were per performed using IBM SPSS Statistics (IBM Statistics, USA). All results were preceded by normality test, independent t-test or Mann-Whitney U test methods were adopted depending on the

satisfaction or normality. The results of statistical analyses were determined to be significant at the 95% confidence interval.

Results.

The demographic information and results of questionnaires on scalp and hair characteristics are shown in Table 1 and Table 2 below.

Table 1. Demographic information

Season	**Group**	**Alopecia group**		**Non-Alopecia group**	
Summer	Gender	Male: 6	Female: 24	Male: 7	Female: 23
	Age	36.4 ± 10.19		30.8 ± 9.33	
Winter	Gender	Male: 10	Female: 20	Male: 10	Female: 20
	Age	38.1 ± 9.90		27.3 ± 8.88	

Table 2. Characteristics of scalp and hair

Items	Responses	Response rate			
		Summer		Winter	
		Alopecia group	Non-Alopecia group	Alopecia group	Non-Alopecia group
Hair thickness	Thick	10.00	6.67	13.33	26.67
	Average	43.33	60.00	33.33	36.67
	Thin	46.67	33.33	53.33	36.67
Hair damage	Severe	16.67	20.00	26.67	16.67
	Mild	76.67	60.00	70.00	56.67
	None	6.67	20.00	3.33	26.67
Hair elasticity	Elastic	10.00	3.33	0.00	20.00
	Average	70.00	76.67	70.00	63.33
	Not elastic	20.00	20.00	30.00	16.67
Hair surface	Smooth	6.67	13.33	10.00	26.67
	Average	83.33	73.33	63.33	53.33
	Coarse	10.00	13.33	26.67	20.00
Scalp dandruff	A lot	13.33	16.67	3.33	10.00

	Average	60.00	73.33	73.33	80.00
	Less	26.67	10.00	23.33	10.00
Scalp trouble	A lot	3.33	3.33	3.33	3.33
	Average	50.00	50.00	53.33	50.00
	Less	46.67	46.67	43.33	46.67
Scalp hydration	A lot	3.33	3.33	3.33	3.33
	Average	63.33	63.33	66.67	70.00
	Less	33.33	33.33	30.00	26.67
Scalp sebum	A lot	16.67	20.00	26.67	26.67
	Average	70.00	60.00	56.67	63.33
	Less	13.33	20.00	16.67	10.00
Scalp itchiness	A lot	6.67	0.00	6.67	0.00
	Average	53.33	66.67	53.33	63.33
	Less	40.00	33.33	40.00	36.67
Smoking	Yes	16.67	6.67	10.00	16.67
	No	83.33	93.33	90.00	83.33
Drinking	Yes	33.33	33.33	23.33	63.33
	No	66.67	66.67	76.67	36.67
Exposure to sunlight	Less than an hour	50.00	63.33	50.00	50.00
	1-3 hour	40.00	33.33	46.67	46.67
	More than 3 hours	10.00	3.33	3.33	3.33
Sleep time	Less than 5 hours	10.00	6.67	6.67	3.33
	5-8 hours	73.33	83.33	80.00	73.33
	More than 8 hours	16.67	10.00	13.33	23.33
Scalp irritation	Yes	30.00	50.00	30.00	30.00
	No	70.00	50.00	70.00	70.00
Scalp stinging	Yes	3.33	3.33	3.33	13.33
	No	96.67	96.67	96.67	86.67

Scalp hydration, sebum content, TEWL, and stratum corneum content were measured and compared between seasons and the presence-absence of alopecia. As a result of seasonal comparison, there were statistically significant differences in all four biophysical parameters in Alopecia group. In Non-Alopecia group, there were differences in TEWL and stratum

corneum content only. Both Alopecia group and Non-Alopecia group showed similar tendency in sebum content, TEWL, and stratum corneum content, but when it comes to scalp hydration, it was statistically significantly greater in summer in Alopecia group, whereas it remains stable in Non-Alopecia group. (Figure 2)

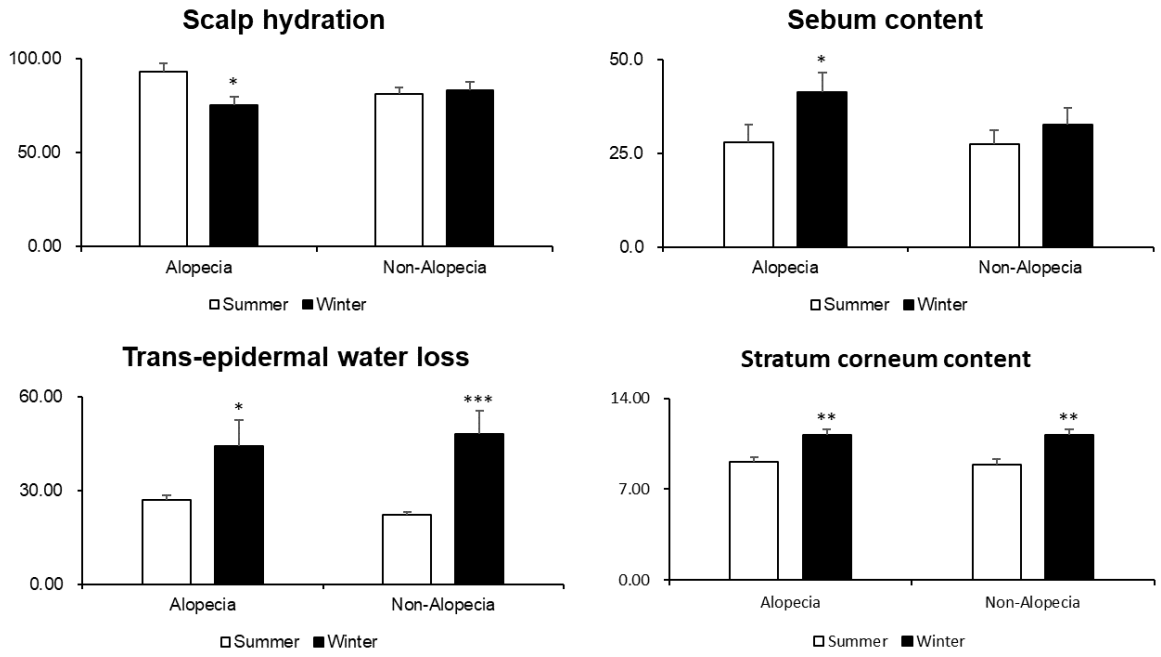

Figure 2. Comparison of scalp biophysical characteristics by season

When compared between groups, there were statistically significant differences in scalp hydration and TEWL, but there was no significant difference in winter. However, scalp hydration of Alopecia group was noticeably decreased, which was significantly different from that of Non-Alopecia group. TEWL and stratum corneum content tended to increase in winter than in summer in both groups. (Figure 3)

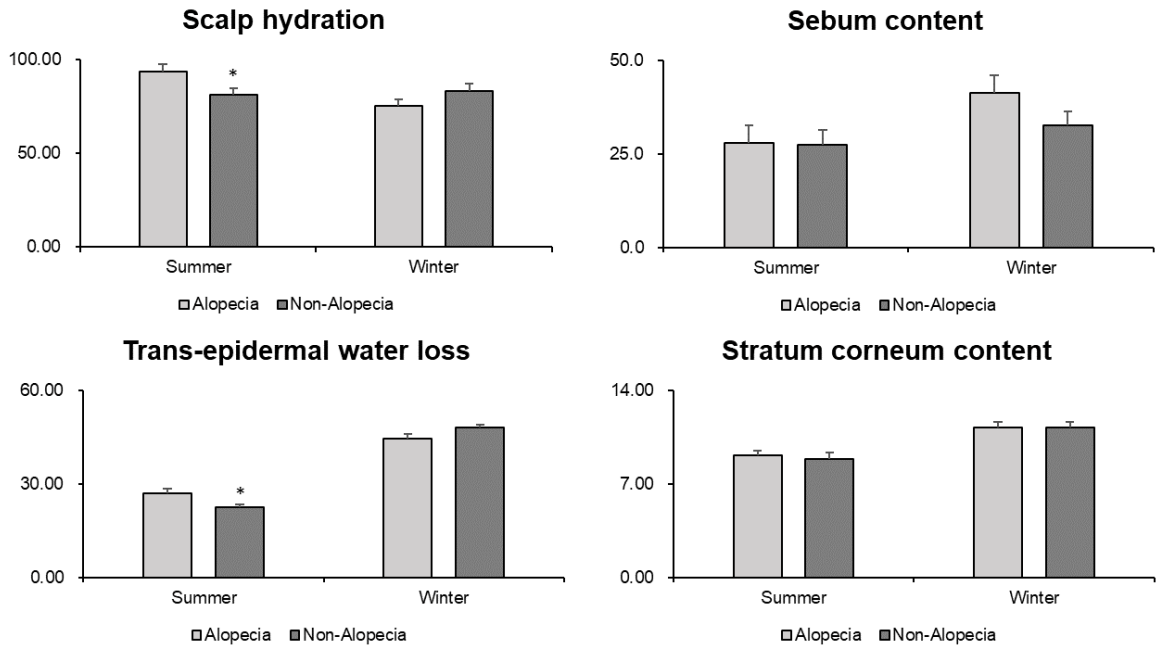

Figure 3. Comparison of scalp biophysical characteristics by groups

As a result of lipid analysis, ceramide content of tape stripped stratum corneum content in winter tended to be higher in Non-Alopecia group, but there was no statistical significance. (Figure 4)

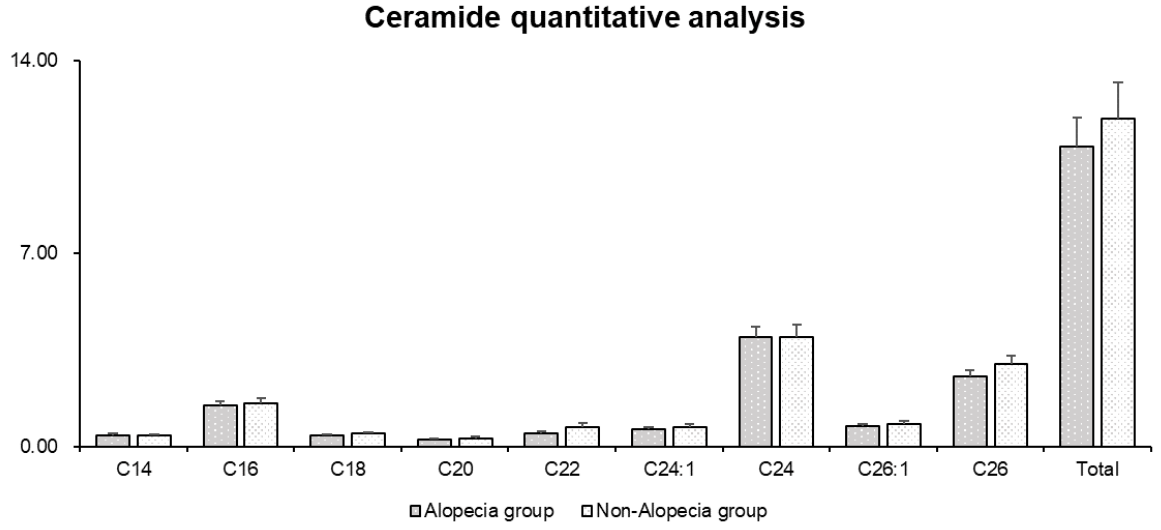

Figure 4 . Results of ceramide analysis

Discussion.

This study was performed to investigate the change patterns of scalp of Alopecia group and Non-Alopecia group adapting to environmental factors. Based on the results, it was clear that there were differences between Alopecia group and Non-Alopecia group in biophysical parameters. With seasonal variations, both Alopecia group and Non-Alopecia group showed a big differences in the TEWL and stratum corneum contents, however, scalp hydration and scalp sebum content increased significantly only in Alopecia group, showing a more sensitive response to environmental factors compared to Non-alopecia group. We considered the disrupted barrier function to be the cause and analyzed the ceramides involved in the barrier function. Contrary to what was predicted based on former studies, lipid analysis showed no statistical significance between Alopecia group and Non-Alopecia group in total amount of ceramides. Therefore, it is thought that further research is needed.

Conclusion.

In this study, we hypothesized that the patterns of changes in the biophysical properties of scalp in Alopecia group and Non-Alopecia group would be different depending on the external environmental factors, temperature, and humidity. Comparing the scalp biophysical parameters according to the androgenetic alopecia with seasonal variations, there was a significant difference in scalp characteristics and in change patterns between the Alopecia group and Non-Alopecia group, as expected. We thought that it would be related to the barrier function of the scalp, but there were limitations in result interpretation. In the next step, focusing on the scalp susceptibility to the temperature and humidity, we expect that research to develop on the correlation with the scalp barrier function and the mechanisms and hope that it will be helpful as a fundamental data for the development of cosmetics, from seasonal scalp care products to products for scalp with hair loss.

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Conflict of Interest Statement.

NONE.

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