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Author(s)	Kato, Keiko
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Studies on Sebum on Scalp and Shampoo

—Time-Lapse Changes in the Amounts of Triglyceride and Free Fatty Acid on the Scalp and Subjective Symptoms for One Week—

Keiko Kato

Abstract

As indicators of dirt on the scalp and hair, the amounts of triglyceride and free fatty acid on the scalp and the severity of subjective symptoms in the head were investigated immediately before and after shampoo and subsequently at various times for one week in seven healthy men aged 19 to 23 years.

1. The amount of triglyceride on the scalp was higher than that of free fatty acid on the scalp for 24 hours after shampoo, while the latter was higher than the former 72 hours after it. Both triglyceride and free fatty acid decreased to constant level immediately after shampoo, and the beneficial effect of shampoo was made clear.
2. The severity of itching in the head increased for 72 hours after shampoo and subsequently showed a tendency of slight increase. The severity of greasy scalp showed a tendency to increase. Both symptoms resolved completely immediately after the next shampoo on day 8, and the removal of unpleasant feeling by shampoo was demonstrated.
3. Based on the results presented, it is considered desirable for adults who want to live a healthy and pleasant life to perform the next shampoo within 72 hours of the previous one.

Key Words: shampoo, sebum on scalp, triglyceride, free fatty acid, subjective symptoms

I. Introduction

It is one of important work of nurses to wash the scalp and hair of inpatients who cannot perform shampoo without help. However, the target frequency of shampoo for such patients is usually once a week. This may not be sufficient, but no reports have been presented concerning the appropriate frequency of shampoo for persons who cannot perform shampoo without help.

Since there are many sebaceous glands on the scalp which is covered with hair, a bacterial flora is formed, and sebum is secreted to cover the scalp and is then incorporated into the hair. As a result, the scalp and hair become greasy and the severity of subjective symptoms, including itching, increases a few days after shampoo. Shampoo is performed to clean the dirty scalp and hair.

Department of Nursing, College of Medical Technology,Hokkaido University

Among lipids contained in the sebaceous glands of the scalp, triglyceride and wax account for about 60% and over 20%, respectively[1,2]. The composition of wax remains unchanged on the scalp, and triglyceride and wax protect the scalp and hair. However, triglyceride is degraded to free fatty acid mainly by lipase secreted by indigenous bacteria. Unsaturated fatty acid contained in free fatty acid, its lipid peroxide, and the like may stimulate the scalp and give rise to bad smell and dandruff. Free fatty acid and dandruff promote proliferation of bacteria, and thus a vicious circle is formed. Briefly, the adverse effect on dirty scalp and hair on healthy life is mainly ascribable to free fatty acid, and its formation is closely related to triglyceride secretion[1-7].

We investigated changes in the amounts of triglyceride and free fatty acid on the scalp and in the severity of subjective symptoms in the head for one week in order to determine the frequency of shampoo that is requiered for a healthy and pleasant adult life.

II. objectives

1. As indicators of dirt on the scalp and hair, the amounts of triglyceride and free fatty acid on the scalp were measured at various times for one week and immediately before and after shampoo in order to determine the appropriate frequency of shampoo and to assess its effect.
2. At the same time, the severity of pleasant or unpleasant feering in the head was measured at various times and investigated for its relationship to 1.

III. Materials and Methods

1. Subjects

The Subjects were seven healthy men aged 19 to 23 years. They were students of H university. They had short hair, belonged to same art circle, and had not habit of sport and their scalp and hair were free from special features or troubles.

2. Experimental methods

(1) Measurements

The following two measurements 1) and 2) were carried out for eight consecutive days. Shampoo was only performed on days 1 and 8 (168 hours after the first shampoo) according to the methods of Ujiie et al.[8] and Sasaki et al.[9] for bed-ridden patients. It was performed using Kelly's pad on the bed by the same method. The subjects did not perform shampoo, hair dressing, hair setting, or the like for themselves throughout the eight-day experimental period.

1) Determination of triglyceride and free fatty acid

Sebum was collected from three zones each of the parietal and frontal regions of scalp according to Okamoto's method for collecting sebum from scalp[10]. The sebum samples collected were divided into those for measuring triglyceride and free fatty acid. The absorbance of each sample was determined using a commercially available serum kit (TG-EN kainos and NEFA kainos manufactured by kainos Co., Ltd.) by spectrophotometry and converted to

$\mu g/cm^2$.

2) Investigation of measurement (a total of ten measurements)

Measurement was performed 30 minutes before shampoo on day 1, 30 minutes and 24, 48, 72, 96, 120, and 144 hours after it, and 30 minutes before and after the next shampoo on day 8.

IV. Results

1. Changes in the amounts of triglyceride and free fatty acid with time

Table 1 and Figure 1 show the time-lapse changes in the amounts of triglyceride and free fatty acid in the frontal regions on the scalp for one week. Table 2 and Figure 2 show the time-lapse changes in the amounts of triglyceride and free fatty acid in the parietal regions on the scalp for one week.

The mean amount of triglyceride in the seven subjects was doubled 24 hours after the first shampoo and thereafter almost reached a plateau (a tendency of slight decrease was noted in the parietal region). The mean amount of free fatty acid showed a tendency of continuous increase in the frontal region, while it showed a rapid increase for 72 hours after shampoo and the almost reached a plateau in the parietal region. The amount of triglyceride was higher than that of free fatty acid for 24 hours after the first shampoo, but there was little difference between the two parameters 48 hours after it. After 72 hours, the amount of free fatty acid was higher than that of triglyceride and this condition continued until the second shampoo on day 8. The amounts of triglyceride and free fatty acid showed a decrease to a constant amount immediately after the second shampoo, and the amount of free fatty acid was lower than that of triglyceride.

2. Changes in the composition ratios of triglyceride and free fatty acid with time

Table 3 and Figure 3 show the time-lapse changes in the ratios of triglyceride and free fatty acid in the frontal regions on the scalp for one week. Table 4 and Figure 4 show the time-lapse changes in the ratios of triglyceride and free fatty acid in the parietal regions on the scalp for one week.

The mean ratio of triglyceride in the seven subjects was higher than that of free fatty acid for 24 hours after the first shampoo. After 72 hours, however, the free fatty acid ratio became higher than the triglyceride ratio, and this condition continued until the second shampoo. The triglyceride ratio was increased above the free fatty acid ratio again immediately after the second shampoo.

3. Changes in the severity of itching with time

Table 5 and Figure 5 show the time-lapse changes of subjective symptoms - the severity of itching in the head for one week.

The mean severity of itching in the head in the seven subjects increased for 72 hours after the first shampoo. It thereafter remained unchanged and then showed a tendency of slight

Table 1. Time-lapse changes in the amounts of triglyceride (TG) and free fatty acid (FFA) in the frontal regions on the scalp for one week (N=7)

Time of collecting sebum samples		The amount of TG (μg/cm^2, mean±S.E.)	The amount of FFA (μg/cm^2, mean±S.E.)
day 1	30 min. before 1st. shampoo	159.25±17.73	129.72±48.67
	30 min. after 1st. shampoo	78.12± 5.07	24.78± 3.71
day 2	24 hours after 1st. shampoo	164.97±17.73	77.75± 8.22
day 3	48 hours after 1st. shampoo	164.96±22.59	151.83±26.40
day 4	72 hours after 1st. shampoo	169.88±22.27	225.07±21.53
day 5	96 hours after 1st. shampoo	191.38±22.99	268.95±16.70
day 6	120 hours after 1st. shampoo	176.96±18.72	275.00±14.98
day 7	144 hours after 1st. shampoo	181.10±23.69	309.84±23.84
day 8	167.5 hours after 1st. shampoo (30 min. before 2nd. shampoo)	164.38±21.63	338.97±27.65
	168.5 hours after 1st. shampoo (30 min. after 2nd. shampoo)	84.12± 5.99	46.53± 5.33

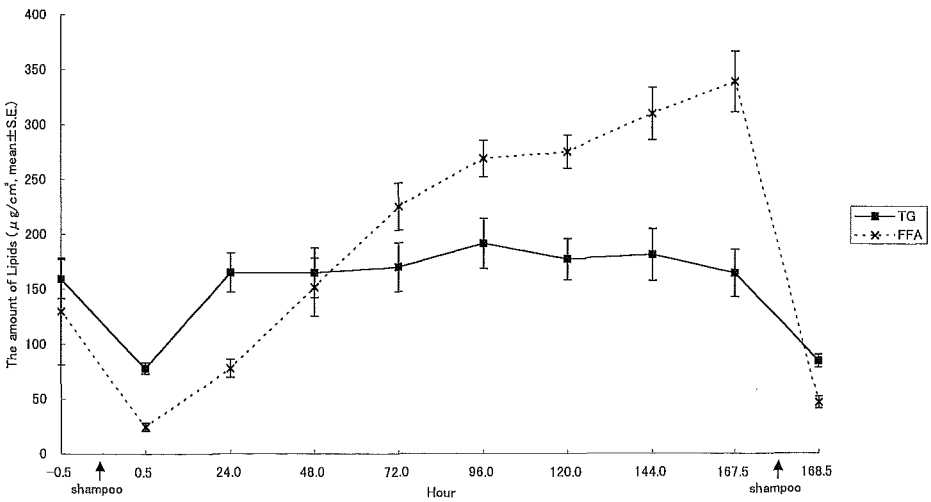

Figure 1. Time-lapse changes in the amounts of triglyceride (TG) and free fatty acid (FFA) in the frontal regions on the scalp for one week (N=7, μg/cm^2 mean±S.E.)

Table 2. Time-lapse changes in the amounts of triglyceride (TG) and free fatty acid (FFA) in the parietal regions on the scalp for one week (N=7)

Time of collecting sebum samples	The amount of TG ($\mu g/cm^2$, mean±S.E.)	The amount of FFA ($\mu g/cm^2$, mean±S.E.)
day 1 30 min. before 1st. shampoo	140.13±15.90	162.75±43.99
30 min. after 1st. shampoo	82.44±10.59	27.98± 7.71
day 2 24 hours after 1st. shampoo	204.99±29.64	106.96±21.50
day 3 48 hours after 1st. shampoo	186.10±19.74	211.69±34.85
day 4 72 hours after 1st. shampoo	169.74±19.71	293.67±33.88
day 5 96 hours after 1st. shampoo	166.27±21.38	301.49±19.89
day 6 120 hours after 1st. shampoo	146.65±13.66	312.32±29.49
day 7 144 hours after 1st. shampoo	144.07±16.81	295.46±27.66
day 8 167.5 hours after 1st. shampoo (30 min. before 2nd. shampoo)	141.78±22.71	277.87±38.33
168.5 hours after 1st. shampoo (30 min. after 2nd. shampoo)	86.29±11.04	38.67± 9.03

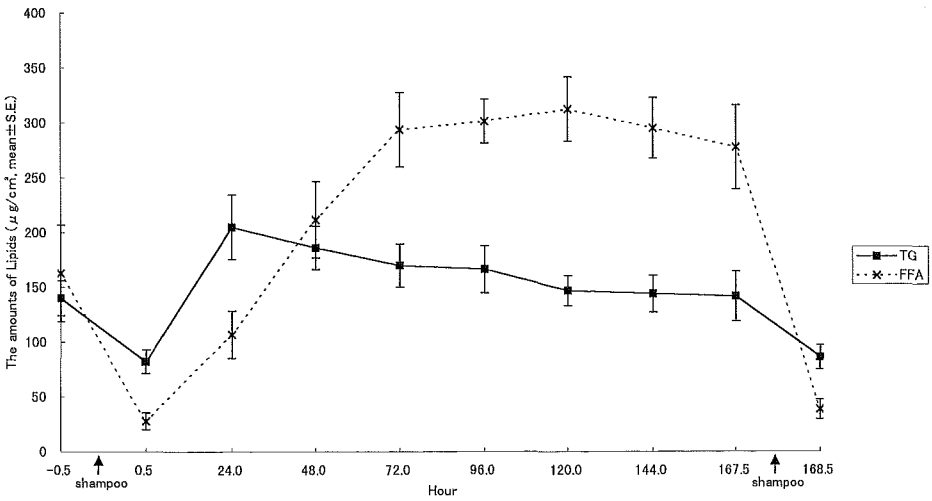

Figure 2. Time-lapse changes in the amounts of triglyceride (TG) and free fatty acid (FFA) in the parietal regions on the scalp for one week (N=7, $\mu g/cm^2$ mean±S.E.)

Table 3. Time-lapse changes in the ratios of triglyceride (TG) and free fatty acid (FFA) in the frontal regions on the scalp for one week (N=7)

Time of collecting sebum samples		The ratio of TG (%, mean±S.E.)	The ratio of FFA (%, mean±S.E.)
day 1	30 min. before 1st. shampoo	63.99±5.80	36.03±5.80
	30 min. after 1st. shampoo	75.92±3.51	24.08±3.51
day 2	24 hours after 1st. shampoo	67.49±2.57	32.52±2.57
day 3	48 hours after 1st. shampoo	53.09±3.42	46.89±3.42
day 4	72 hours after 1st. shampoo	42.64±3.20	57.36±3.20
day 5	96 hours after 1st. shampoo	40.85±2.79	59.15±2.79
day 6	120 hours after 1st. shampoo	38.67±2.60	61.33±2.60
day 7	144 hours after 1st. shampoo	36.29±2.76	63.71±2.76
day 8	167.5 hours after 1st. shampoo (30 min. before 2nd. shampoo)	32.50±2.76	67.50±2.76
	168.5 hours after 1st. shampoo (30 min. after 2nd. shampoo)	64.39±3.47	35.68±3.47

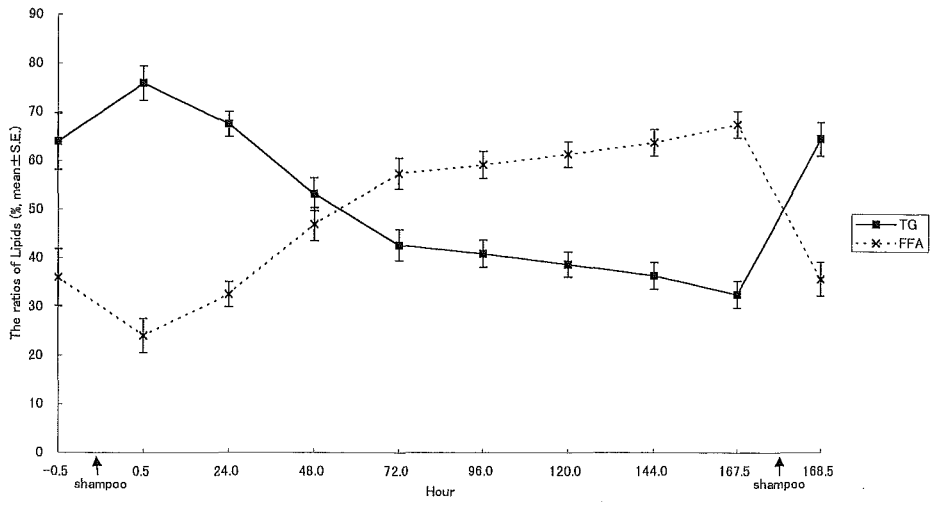

Figure 3. Time-lapse changes in the ratios of triglyceride (TG) and free fatty acid (FFA) in the frontal regions on the scalp for one week (N=7, %, mean±S.E.)

Table 4. Time-lapse changes in the ratios of triglyceride (TG) and free fatty acid (FFA) in the parietal regions on the scalp for one week (N=7)

Time of collecting sebum samples	The ratio of TG (%, mean±S.E.)	The ratio of FFA (%, mean±S.E.)
day 1 30 min. before 1st. shampoo	52.89±5.94	47.12±5.94
30 min. after 1st. shampoo	76.89±3.57	23.11±3.57
day 2 24 hours after 1st. shampoo	66.31±3.75	33.69±3.75
day 3 48 hours after 1st. shampoo	48.10±3.04	51.90±3.04
day 4 72 hours after 1st. shampoo	36.57±1.70	63.43±1.70
day 5 96 hours after 1st. shampoo	35.01±2.41	64.99±2.41
day 6 120 hours after 1st. shampoo	32.42±2.64	67.53±2.64
day 7 144 hours after 1st. shampoo	32.94±2.78	67.06±2.78
day 8 167.5 hours after 1st. shampoo (30 min. before 2nd. shampoo)	34.07±3.29	65.93±3.29
168.5 hours after 1st. shampoo (30 min. after 2nd. shampoo)	70.98±3.93	29.01±3.93

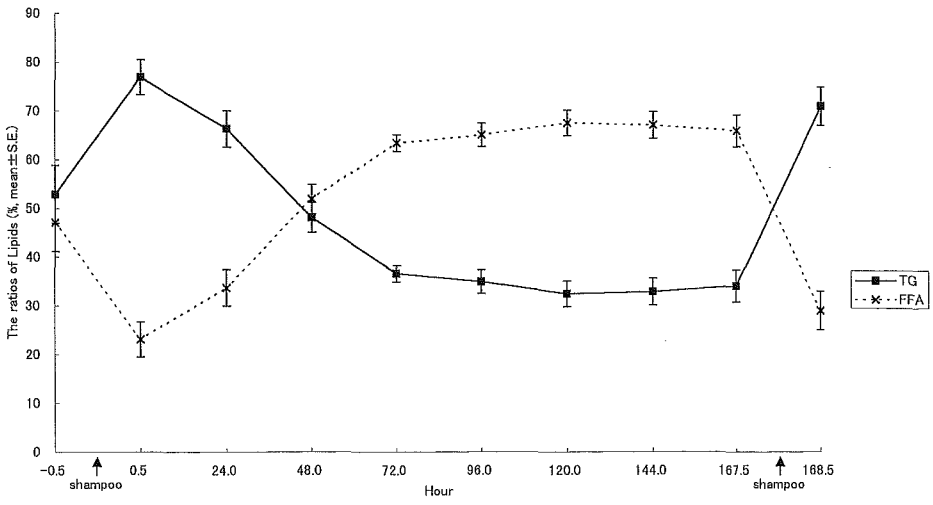

Figure 4. Time-lapse changes in the ratios of triglyceride (TG) and free fatty acid (FFA) in the parietal regions on the scalp for one week (N=7, %, mean±S.E.)

Table 5. Time-lapse changes of subjective symptoms-the severity of itching and greasy sensation in the head for one week (N=7, scores, mean±S.E.)

	Time of investigation	The severity of itching	The severity of greasy sensation
day 1	30 min. after 1st. shampoo	0	0
day 2	24 hours after 1st. shampoo	0.43±0.19	0.14±0.13
day 3	48 hours after 1st. shampoo	1.00±0.20	0.71±0.26
day 4	72 hours after 1st. shampoo	1.43±0.1	1.00±0.20
day 5	96 hours after 1st. shampoo	1.43±0.19	1.29±0.17
day 6	120 hours after 1st. shampoo	1.57±0.19	1.57±0.28
day 7	144 hours after 1st. shampoo	2.00±0.35	1.86±0.31
day 8	167.5 hours after 1st. shampoo (30 min. before 2nd. shampoo)	1.71±0.17	1.71±0.26
	168.5 hours after 1st. shampoo (30 min. after 2nd. shampoo)	0	0

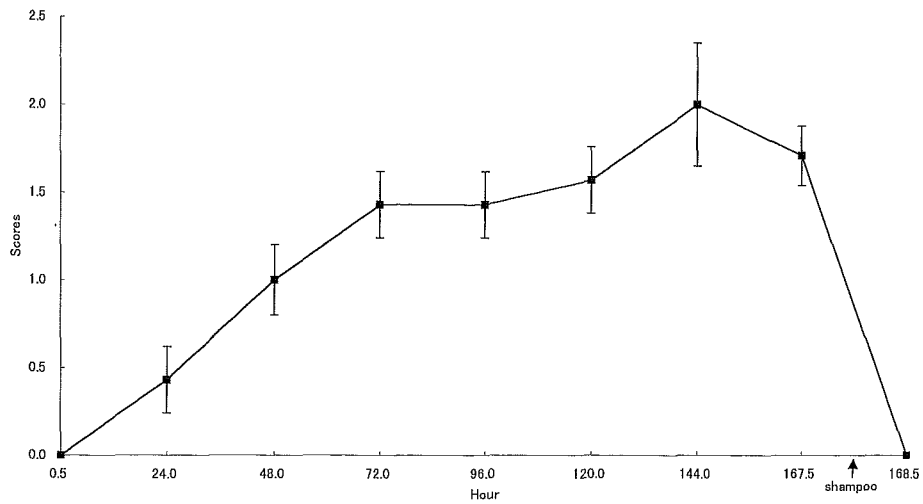

Figure 5. Time-lapse changes of subjective symptoms-the severity of itching in the head for one week (N=7, scores, mean±S.E.)

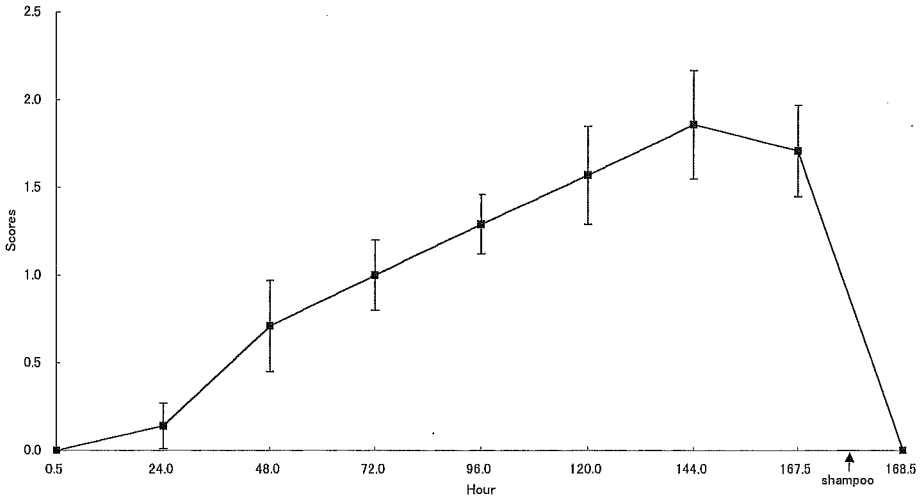

Figure 6. Time-lapse changes of subjective symptoms-the severity of greasy sensation in the head for one week (N=7, scores, mean±S.E.)

increase. It resolved completely immediately after the second shampoo.

4. Changes in the severity of greasy sensation with time

Table 5 and Figure 6 show the time-lapse changes of subjective symptoms - the severity of greasy sensation in the head for one week.

The mean severity of greasy sensation in the seven subjects almost showed a tendency to increase from immediately after the first shampoo to immediately before the second shampoo. In particular, it showed a linear increase 48 to 144 hours after the first shampoo. It disappeared completely immediately after shampoo.

V. Discussion

1. Changes in the amounts of triglyceride and free fatty acid on the scalp for one week

Changes in the amounts of triglyceride and free fatty acid on the scalp were investigated at various times for one week. The amount of triglyceride was higher than that of free fatty acid for 24 hours after the first shampoo, but the amount of free fatty acid was higher than that of triglyceride 72 hours after it. This condition continued until the next shampoo on day 8. Free fatty acid is not secrerted from the sebaceous glands[1-2], while triglyceride is not synthesized from free fatty acid in vitro although it is formed by biosynthesis in vivo[5-6]. Accordingly, it appears that the amount of triglyceride reached a plateau early as a result of hydrolysis by lipase and rancidity[6], although triglyceride secretion from the sebaceous glands continued, and the amount of free fatty acid became higher.

The total amount of triglyceride and free fatty acid on the scalp showed no linear increase. In the frontal region, it showed a tendency to increase, but showed a tendency of slight increase from 96 hours after the first shampoo to immediately before the next one on day 8. In the

parietal region, it remained unchanged from 72 hours after the first shampoo to immediately before the next one. This was presumably ascribable to the following two causes. 1) The sebum was incorporated from the scalp to the hair. 2) After the sebum on the scalp increased to a constant level, triglyceride secretion was suppressed. However, it could not be determined whether 1) or 2) or both were contributory, because the amount of sebum on the scalp was not measured in the present study.

Individual variations were noted in the amounts of triglyceride and free fatty acid. However, it was apparent from the time-lapse changes in the composition ratios of triglyceride and free fatty acid that there was little difference in the process of secretion and degradation between triglyceride and free fatty acid. Briefly, the ratio of triglyceride was higher than that of free fatty acid for 24 hours after the first shampoo, but the former was lower than the latter 72 hours after it, and this condition continued until the second shampoo. These results suggest that as a result of progression of degradation from triglyceride to free fatty acid, the adverse effect of free fatty acid, especially stimulation to scalp, became stronger than the scalp protective effect of triglyceride from 72 hours after shampoo[5-7].

Triglyceride and free fatty acid decreased to a constant amount immediately after the first and second shampoo. Since the amount of free fatty acid was lower than that of triglyceride, the beneficial effect of shampoo was demonstrated[5-6].

2. Changes in the severity of itching and greasy sensation for one week

The severity of itching in the head increased for 72 hours after the first shampoo. It subsequently remained unchanged and then showed atendency of slight increase. Briefly, it showed almost the same change as the amount of free fatty acid for one week after the first shampoo. These sesults indicate that the stimulating effect of free fatty acid on the scalp is related to the severity of itching in the head[6]. In the present study, the sensation that comes when the scalp and hair are covered with sebum is expressed as greasy sensation. The greasy sensation in the head subjectively represents the incorporation of sebum into the hair. The severity of greasy sensation on the scalp almost showed a tendency to increase from immediately after the first shampoo to immediately before the second shampoo and was also increased after the total amount of triglyceride and free fatty acid on the scalp almost reached a plateau. These results suggest that sebum was incorporated into the hair after reaching a constant amount on the scalp[5,7]. Itching and greasy sensation on the scalp resolved completely immediately after shampoo on day 8, and removal of unpleasant feeling by shampoo was clarified.

3. Appropriate frequency of shampoo and its beneficial effect

The results of the present study which was performed using triglyceride and free fatty acid on the scalp and subjective symptoms in the head as indicators of dirt on scalp and hair suggest that it is necessary to perform the next shampoo within 72 hours of the previous one for adult who want to live healty and pleasant life and that shampoo is useful to help them to live such

a life.

VI. Conclusion

The subjects were seven healty men aged 19 to 23 years. As indicators of dirt on the scalp and hair, the amounts of triglyceride and free fatty acid on the scalp and the severity of subjective symptoms in the head were measured at various times and immediately before and after shampoo.

1. The amount of triglyceride on the scalp was higher than that of free fatty acid for 24 hours after the first shampoo. However, the latter was higher than the former 72 hours after it, and this condition continued until the next shampoo on day 8. Triglyceride and free fatty acid decreased to a constant amount immediately after the first and second shampoo.
2. The severity of itching in the head increased for 72 hours after the first shampoo. It subsequently remained unchanged and then showed a tendency of slight increase. It showed almost the same tendency as the amount of free fatty acid for one week. The severity of greasy sensation in the head almost showed a tendency of increase from immediately after the first shampoo to immediately before the next shampoo on day 8. Both itching and greasy sensation in the head resolved completely immediately after shampoo on day 8.
3. Based on the results presented, it is considered that the next shampoo should be performed within 72 hours of the previous one so that adults can live a healty and pleasant life and that shampoo is useful to help them to live such a life.

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The author published part of the results of the present study together with Mai Shirato, Kae Endo, and Satomi Imamura at 22th scientific meeting of the Japan Nursing Research Association.

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