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Effects of Soap and Detergents on Skin Surface pH, Stratum corneum Hydration and Fat Content in Infants

Key Words
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Fat content
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Soap
Syndet

Abstract

Background: In adults the influence of cleansing preparations on the pH, fat content and hydration of the skin is well documented. Studies in newborn and small infants have not been reported. **Objective:** Our study aimed at examining whether similar effects can be ascertained in infants. **Methods:** Infants without skin disease, aged 2 weeks to 16 months, entered an open, controlled and randomized study. Ten infants each had skin washed with tap water (control group), liquid detergent (pH 5.5), compact detergent (pH 5.5) or alkaline soap (pH 9.5). The pH, fat content and hydration were measured before and 10 min after cleansing. Findings were statistically evaluated by parametric covariance analysis. **Results:** The skin pH increased from an average of 6.60 after cleansing in all groups. The smallest increase (+0.19) was observed in the control group, the largest (+0.45) after washing with alkaline soap. After treatment with liquid or compact detergent, the increase of the pH was only 0.09 higher than for the control group. In comparison to the compact and liquid detergents, the alkaline soap group had a significantly higher increase in pH. The fat content (mean starting value: 4.34 μg/cm^2) decreased after washing in all groups; the smallest effect was observed in the control group (decrease of 0.93 μg/cm^2), the highest for the alkaline soap group (decrease of 4.81 μg/cm^2). In comparison to the compact and liquid detergents, the alkaline soap group had a higher decrease in fat content. This difference was significant for compact detergents. No statistically significant differences were observed for hydration before versus after washing. **Conclusion:** Each cleansing agent, even normal tap water, influences the skin surface. The increase of the skin pH irritates the physiological protective 'acid mantle', changes the composition of the cutaneous bacterial flora and the activity of enzymes in the upper epidermis, which have an acid pH optimum. The dissolution of fat from the skin surface may influence the hydration status leading to a dry and squamous skin.

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The skin of newborns and small infants differs in some characteristics from the skin of adults [1–4]: The connection between the dermis and the epidermis is less strong, the permeability of the stratum corneum is higher, and melanin production is decreased. Until puberty the sebaceous glands have no function. In newborns and small infants the pH of the skin surface is higher and the free fatty acid content is lower than in adults.

With this special characteristic of infant skin in mind, numerous skin cleansing preparations have been developed. They can be categorized into two groups: alkaline soaps and acidic or neutral synthetic detergents. From studies of skin it is well known that alkaline soaps increase the pH of the skin surface, prolong the time of neutral pH, influence alkaline resistance, and dissolve fat-soluble and water-soluble components from the skin surface [1, 5–8]. In addition, it has been shown that the irritant potential of synthetic detergents is lower than that of alkaline soaps.

Our study aimed at examining whether similar effects can be observed in infants. Our study was designed to compare the pH, the fat and water content of the skin surface before and 10 min after washing with alkaline soap or one of two detergent; washing with tap water was performed in the control group.

Patients and Methods

Study Population

After obtaining informed consent from the parents, 40 infants aged 2 weeks to 16 months (mean 3.2 months) were studied between January and May 1992. The infants were inpatients of the Children's Hospital of the University of Vienna. Patients with skin diseases or a history of skin diseases were excluded from the study. The infants were inpatients because of diseases listed in table 1. None of the patients with problems of primary adaptation, malformations of the head or hydronephrosis received a systemic treatment. The infants with infections of the upper respiratory system were given an inhalation therapy 3 times daily, the infants with seizures an antiepileptic drug therapy. Before starting the open and controlled study all patients had a normal skin care which included washing once a day with an alkaline soap and afterwards application of a fatty cream. The study was approved by the local Ethics Committee. The infants were randomly assigned to one of four groups of 10 infants each. The groups were stratified by diagnosis, age and sex, as shown in table 1. The infants of group 1, the control group, were treated with tap water without cleansing agent. In group 2 a compact syndet, in group 3 a liquid syndet and in group 4 an alkaline soap were used. Three infants did not complete the study because their parents withdrew permission.

Cleansing Agents

As a control we used the local tap water, which had a pH of 7.89–8.2. Both liquid and compact syndets had a pH of 5.5. They contained amino acids, nicotinic acid amide, lactic acid, fatty acid alcylamide, esters of polyol fatty acids, surface active substances and correctives. Both represented a commercial formula. The alkaline soap was characterized by a pH of 9.5 and contained sodium salts of various fatty acids and Lamepon S.

Measurements

Measurements were made in the morning on the day after admission when the skin had been untreated for 24 h. All patients had the same environmental conditions: all rooms for the patients had air-conditioning which guaranteed a constant relative humidity and room temperature. The washing and the measurements were performed on the skin of the manubrium sterni and on the outer upper quadrant of the right buttock area. These locations were representative of covered skin. For uncovered skin we chose the right cheek and the dorsum of the right hand for washing and measurements. After taking the initial measurements the cleansing procedure was performed in a standard fashion. After moisturizing the skin with warm tap water, the soap or the syndet was administered with a wash-cloth. One minute later the skin was rinsed with warm tap water again and dried with a towel. In the control group the procedure was performed with tap water. 10 min after washing and drying the second series of measurements was taken.

Skin pH Measurement

Skin surface pH was determined by means of a pH meter (Radiometer, Copenhagen) with the use of a flat glass electrode (G232C) and a calomel electrode (K401). The distance of the two electrodes was 2 cm. The measurement device was calibrated with phosphate buffer pH 7.0 before and after each measurement. The tip of the electrode was pressed firmly against the skin. The measurements were taken when the measurement remained constant for 30 s. Duplicate recordings on the same spot were performed.

Fat Content Measurement

The skin surface fat content was measured using a Sebumeter® (Schwarzkopf). The method uses photometric measurement of light transmitted through a transparent plastic film (area 64 mm^2) which is pressed against the skin with a constant pressure of 6 N for 30 s, to allow adhesion to the skin. The fat of the skin which is absorbed into the film changes the light permeability; the permeability change is proportional to the fat content of the skin. The sebumeter readings were converted into $\mu g/cm^2$.

Water Content Measurement

The skin surface hydration state was evaluated by use of the Corneometer® (Schwarzkopf). This instrument measures the electrical capacity of the stratum corneum, which is dependent upon the water content and the high dielectric constant of water relative to other skin components. The measuring principle is based on distinctly different dielectric constants of water and other materials. A condensator (120 mm×30 mm) in touch with the skin absorbes the water of the skin, so that the capacity of the condensator is changed proportional to the water content, expressed as hydration units.

Statistical Methods

Parametric covariance analysis was used to test whether statistically significant changes of pH, fat, and hydration after cleansing were present. Starting values and age were covariates; gender and location of cleansing were taken into account as main effects in addition to the treatment. We allowed for interactions, but in no case did the interactions contribute significantly to explain the variation.

Table 1. Diagnosis, age and sex of the infants in the four groups

	Group 1	Group 2	Group 3	Group 4
Diagnosis				
Preterms with problems of primary adaptation	3	2	3	4
Malformations	2	2	4	2
Infections of the upper respiratory system	2	2	2	0
Seizures	2	2	0	0
Hydronephrosis	1	2	1	1
Age				
Mean age in days	110.9	189.8	146.4	151.4
Sex				
Female	5	6	5	3
Male	5	4	5	4
Total				
Total number of patients	10	10	10	7

Group 1: control group; group 2: cleansing agent compact detergent; group 3: cleansing agent liquid detergent; group 4: alkaline soap.

Results

No significant correlation between age and changes in pH, fat content, and hydration due to cleansing could be found. Similarly, these treatment effects do not seem to depend on the location of cleansing and gender.

pH Value

The starting value of the skin pH (mean 6.6 for all infants) was not statistically different in the four groups (fig. 1). After washing, the skin pH increased highly significantly in all groups ($p<0.01$). The increases of the pH value differed for the cleansing agents. The control group showed the smallest increase (+0.198), whereas the largest increase was seen in the alkaline soap group (+0.453). The two groups with compact or liquid detergents with an acid pH (groups 2 and 3) had nearly the same results: increase in group 2 +0.294 and in group 3 +0.291.

In comparison to the control group, the increase of the pH in the three treatment groups with cleansing agents (groups 2, 3, 4) was statistically significant. Comparison between compact (group 2) and liquid detergent (group 3) showed no statistical difference. Comparison between both detergents groups (group 2, 3) to alkaline soap group (group 4) showed a statistically significant difference in pH increase after washing (table 2).

Lipid Content

The baseline lipid content averaged 4.34 μg/cm² and no significant differences existed between the four groups (fig. 2). Treatments resulted in significantly decreased lipid contents and the decreases differed for the cleansing agents. The smallest decrease was observed for the control group [–0.93 μg/cm²), whereas the largest decrease was seen after washing with the alkaline soap (–4.81 μg/cm²). There were no staatistically significant differences between the two groups with detergents with an acid pH (groups 2, 3).

The multiple comparisons between the different groups showed only statistical differences in the alkaline soap group, and that with the control group and the liquid detergent group (table 2).

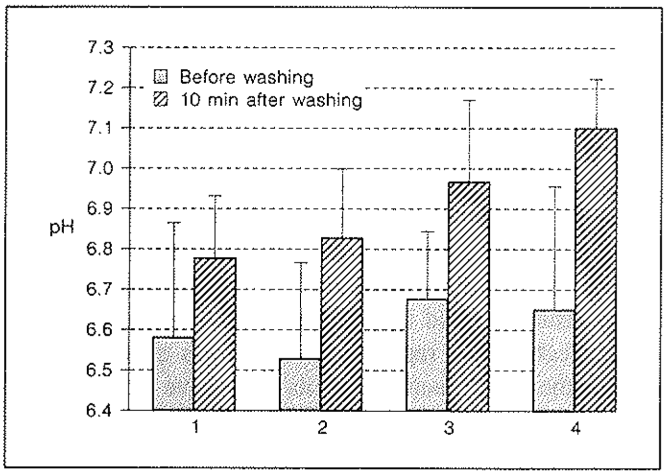
Table 2. The p values of the correlations between the results of the pH, fat content and hydration of the four groups

Correlations	pH	Fat	Hydration
Group 1: group 2	0.01	0.06	0.81
Group 1: group 3	0.02	0.48	0.51
Group 1: group 4	0.00	0.01	0.62
Group 2: group 3	0.93	0.27	0.36
Group 2: group 4	0.00	0.25	0.81
Group 3: group 4	0.00	0.04	0.17

Groups as in table 1.

Hydration Content

The mean hydration of all groups amounted to 107.07 at baseline (fig. 3), and no significant differences existed between the four groups. Due to the treatment, an increase was seen in group 3, and decreases in groups 1, 2 and 4. The largest decrease was observed after washing with alka-

1


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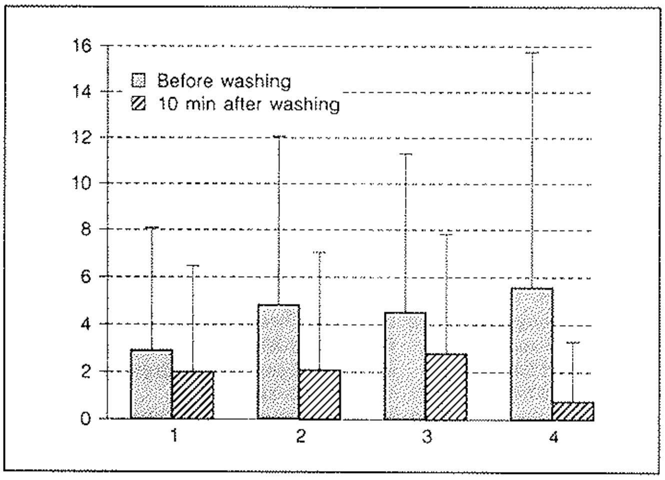

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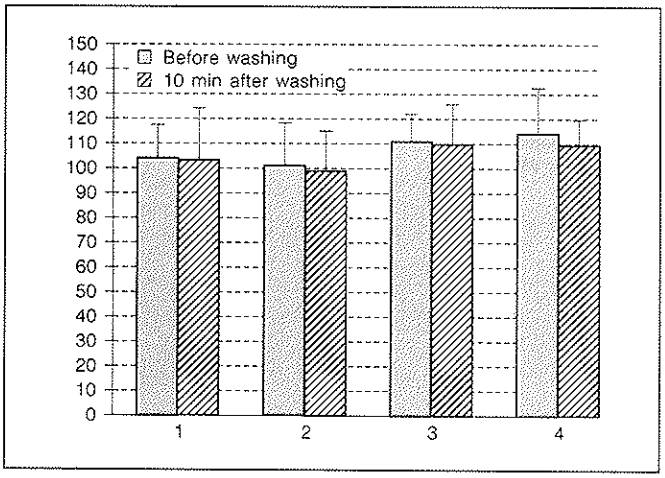

Fig. 1. Mean values and standard deviations of skin pH, for the control group (1), cleansing agent compact detergent (2), cleansing agent liquid detergent (3), and alkaline soap (4).

Fig. 2. Mean values and standard deviations of the fat content of the skin (μg/cm²). Groups as in figure 1.

Fig. 3. Mean values and standard deviations of the water content of the skin (hydration units). Groups as in figure 1.

line soap. The differences were not statistically significant. Further, there were no statistically significant differences in comparison to the control group or in comparison of the alkaline soap group to the other groups (table 2).

Discussion

The 'acid mantle', according to Marchionini and Hausknecht [9], is of importance for the function of the skin and its bacterial flora. In 1987, Korting et al. [6] confirmed an influence of the skin pH on the composition of the cutaneous bacterial flora. Öhman and Vahlquist [10] noticed that many enzymes in the upper epidermis, such as hydrolytic enzymes, enzymes in the lipid metabolism and a vitamin A esterifying enzyme, have a pH optimum of 5.6. They suggested that in the course of human evolution certain enzymes have become adapted to the low pH in the upper human epidermis and utilize the pH gradient to control their activity. Laube [7] reported that an increase of the skin pH leads to an increase of the permeability of the skin surface. He also observed an inflammatory reaction of the skin after application of a cleansing agent with a pH of 9.6. It is now generally accepted that the acidic pH of the skin surface has a protective function.

A common problem in infants is a dry and squamous skin. The causes are not clear and often multifactorial. Thune et al. [8] showed that the structural lipids such as the surface lipids, which are mostly of sebaceous origin, and the stratum corneum lipids, which are derived from the lamellar bodies, are essential for the water-retaining capacity and the hydration state of the skin surface. Thus, dissolving fat from the skin surface, which occurs when cleansing agents are used, may influence the hydration status. This possible effect of cleansing agents especially in infants has not been examined until now.

Our results show that the mean surface pH of infants with no skin disease was 6.6 (SD ± 0.25). It is higher than in adults where the 'normal skin pH' is now defined as the pH on the surface of the skin of the lower arm of a healthy adult Caucasian male; it is in the range of 5.4–5.9 [11]. The higher pH in small infants is well documented [12–14] and may be caused by a different chemical composition of the skin surface lipids [2]. In all groups the pH increased after washing, even when using tap water, which had an alkaline pH of 7.8–8.2 in our local area. The most pronounced influence on the skin surface pH was exerted by the alkaline soap. Compact or liquid detergents, which both had a pH of 5.5 similar to the 'normal' physiological skin pH in adults, increased the skin pH statistically significantly less than the alkaline soap.

These results correspond with previous findings [1, 5, 6, 8] and confirm that detergents with an acid pH are more agreeable to the skin and physiologically more effective.

Results of the skin fat measurements were similar to those of the pH. Fat was dissolved from the skin surface in each experimential group. Whereas the loss of fat was nearly at the same when using tap water or detergents, the loss was significantly greater in the alkaline soap group. The hypothesis of Thune et al. [8] that dissolving fat from the skin surface may influence the hydration status could not be confirmed. The water content of the skin surface was not statistically influenced by cleansing agents. This might be explained by a different structure and composition of the skin of newborns and small infants. On the other hand, in each group the baseline water content varied greatly. A larger sample size would be required for sufficient statistical power for detecting some differences. That will be done in further experiments.

Our experiment clearly shows that each agent used for cleansing influenced the skin surface of infants. From our measurements 10 min after washing, no conclusion could be drawn regarding long-term effects of the cleansing agents. But it should be considered that even these short-term effects, when repeated several times every day, can disturb the 'acid mantle' and its protective function, and lead to dry and squamous skin in some infants.

References

1 Braun F, Lachmann D, Zweymüller E: Der Einfluß eines synthetischen Detergens (Syndet) auf das pH der Haut von Säuglingen. Hautarzt 1986;37:329–334.

2 Ramasastry P, Downing DT, Pochi PE, Strauss JS: Chemical composition of human skin surface lipids from birth to puberty. J Invest Dermatol 1970;54:139–144.

3 Solomon LM, Esterly NB: Neonatal dermatology. The newborn skin. J Pediatr 1970;77:888–894.

4 Wilhelm KP, Cua A, Maibach H: Skin aging. Effect on transepidermal water loss, stratum corneum hydration, skin surface pH, and casual sebum content. Arch Dermatol 1991;127:1806–1809.

5 Korting HC, Hübner K, Greiner K, Hamm G, Braun-Falco O: Differences in the skin surface pH and bacterial microflora due to the long-term application of synthetic detergent preparations of pH 5.5 and pH 7.0. Acta Derm Venereol (Stockh) 1990;70:429–457.

6 Korting HC, Kober M, Mueller M, Braun-Falco O: Influence of repeated washings with soap and synthetic detergents on pH and resident flora of the skin of forehead and forearm. Acta Derm Venereol (Stockh) 1987;67:41–47.

7 Laube F: Die Veränderung des pH, der Alkaliresistenz, der Alkali- und Säure-Neutralisation der Haut nach verschiedenen Reinigungsbädern. Dermatologica 1956;112:453–467.

8 Thune P, Nilsen T, Hanstad IK, Gustavsen T, Lövig Dahl H: The water barrier function of the skin in relation to the water content of stratum corneum, pH and skin lipids. Acta Derm Venereol (Stockh) 1988;68:277–283.

9 Marchionini A, Hausknecht W: Säuremantel der Haut und Bakterienabwehr. Klin Wochenschr 1938;17:663–666.

10 Öhman H, Vahlquist A: In vivo studies concerning a pH gradient in human stratum corneum and upper epidermis. Acta Derm Venereol (Stockh) 1993;74:375–379.

11 Braun-Falco O, Korting HC: Der normale pH-Wert der menschlichen Haut. Hautarzt 1986; 37:126–129.

12 Beare JM, Cheeseman EA, Gailey AAH, Neill DW, Merrett JD: The pH of the skin surface of infants aged one to seven days. Br J Dermatol 1959;71:165–180.

13 Beare JM, Cheeseman EA, Gailey AAH, Neill DW, Merrett JD: The effect of age on the pH of the skin surface in the first week of life. Br J Dermatol 1960;72:62–66.

14 Behrendt H, Green M: Skin pH pattern in the newborn infant. J Dis Child 1958;95:35–41.