Report

Correlation between pH and irritant effect of cleansers marketed for dry skin

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Abstract

Background Although it is important that dermatologists and the general population know the irritation potential of products marketed for dry skin used for body cleansing, this information is not usually available.

Objective To assess the irritative effect of different soaps and liquid cleansers recommended for sensitive skin. To study the correlation of the irritation effect of each substance with its pH and with the presence or absence of syndet in the product.

Methods Seventeen products marketed for dry skin and 12 common soaps used by the general population were studied. Fresh soap emulsions (8%) were applied to the volar side of the right forearm of 30 individuals with sensitive skin for 5 consecutive days using aluminum chambers. The appearance of irritation (erythema, scaling and fissures) was recorded, scored, and expressed in an Irritation index (IrIn). The pH of each solution was measured.

Results Products with a low IrIn were White Dove™ (Dove, Lever Pond's, Toronto, Ontario, Canada), Dove Baby™, Cetaphil™ (bar) (Cetaphil, Gulderma Lab., Forth Worth, TX, USA), Dove liquid cleanser for hands™, Dove pink™, and Aderma™ (Adenma, Pierre Fabre, Dermo-Cosmetique, Boulagne, France). Most corresponded to syndet products. Among the most used brand-name soap, Camay Classic™ (Camay, Procter & Gamble de Mexico, México, U.F.) had the lowest IrIn. Dove Baby™ was the only product with a neutral pH. A significant correlation between pH and the IrIn of cleansers was found ($P < 0.006$).

Conclusions Most products recommended for sensitive skin have a considerable irritation effect, which is related to the pH of the product. Better regulation of advertisement specifications including the pH level and type of cleanser contained is necessary for the majority of soaps and cleansers.

Introduction

Soaps are important for healthcare professionals in preventing the spread of infectious diseases.[1] However, the main purpose of soap is lost when these substances induce skin irritation and injury.

Most soaps and detergents are alkaline and induce an increase in cutaneous pH, which affects the physiologic protective "acid mantle" of the skin by decreasing the fat content.[2] In addition, repeated washings with soap may reduce the normal skin flora, leading to an increased colonization of the skin with coagulase-negative staphylococci; this effect has been linked to the shift in skin pH caused by soaps.[3] Lastly, it has been found that applying agents that specifically inhibit gram-positive cocci, such as antibacterial soap, generally increases gram-negative rods.[4]

Recently, a new generation of cleansers (synthetic detergents or syndets) has emerged. Syndets with a pH approximately 5.5 seem to be specially relevant because they do not modify skin pH.[5] However, the majority of soap bars and liquid detergents available on the market are a mixture of soap and syndet.[6]

Disruption of stratum corneum and changes in pH are key elements in the induction of irritant contact dermatitis and pruritus by soaps. These conditions are exacerbated in the winter months in patients with dry, sensitive skin.

The aim of this study was to assess the irritation effect of a group of bar soaps and liquid cleansers recommended for dry skin and to correlate the irritation effect of each product with their pH.

Materials and Methods

Subjects

The irritation effect of the soaps and cleansers was assessed using 30 healthy volunteers (15 female and 15 male), ranging in age from 18 to 41 years (mean 24 years), who were free of skin or systemic diseases. These individuals had a positive patch test for 1.0%

sodium lauryl sulfate (SLS), which is considered a useful substance in identifying sensitive skin.[7–10] Although the commonest form of sensitive skin is sensory (symptomatic irritant response), the correlation of such a manifestation type (burning, stinging) with conventional irritation is inconsistent.[11] So, we decided to identify individuals with sensitive skin by using the standard patch test with SLS.[12] This study was approved by our institutions Bioethics Committee, and all subjects gave their written consent.

Definition of the soaps commonly used by the general population

Three hundred subjects were interviewed about the brand-name soap of their personal use.

Soap emulsions

We prepared 8% emulsions[13] in tap water of 27 soap bars: 15 recommended for sensitive skin and 12 corresponding to soaps most used by people attending our hospital. Two undiluted liquid cleansers recommended for dry skin were also evaluated. Deionized water was used as a negative control.[14] Each solution was poured into a dark flask and identified by a number. The clinicians performing the irritation test did not know the product code.

Determination of pH

The pH of each emulsion was recorded using the Chemcadet pH meter (Cole-Parmer Instrument Co., Chicago, IL).

Irritation test

0.50 ml of each soap emulsion or liquid cleanser was applied to a disc of absorbent Whatman paper 6 mm in diameter and 1.0 mm thick. These discs were fitted into round flat aluminum chambers (Epitest Ltd, Oy, Finland), which were fixed to the volar side of the right forearm of each subject.
Exposure time to the soaps lasted for 5 days; the first for 24 h, beginning on Monday morning; then fresh solutions were applied to the same site for 6 h daily for the next 4 days. The minimum interval among applications was 12 h. After daily removal of the material, the skin was cleansed with running water and gently dried with a paper towel. The use of cream, oils or any other kind of soap on the treated skin was avoided.[15–18]
The treated site was observed every day, 1 h after the removal of the chambers, and the final evaluation was made on the Monday morning following the removal of the chambers on the previous Friday afternoon. This schedule was specifically designed for soaps and is not suitable for other irritants;[13] however, it has been used to evaluate other types of skin care products.[19]

Evaluation

The irritation effect of soaps was evaluated by three "blinded" independent clinicians.

Measurements

Skin irritation was scored as follows:

Erythema (E)
0 None
1+ Speckling moderate
2+ Uniform moderate
3+ Intense
4+ Intense (red hot) with edema

Scaling (S)
0 None
1+ Fine
2+ Moderate
3+ Intense with large scales

Fissure formation (F)
0 None
1+ Fine
2+ Pronounced unique or multiple
3+ Wide with hemorrhage or exudation

The average of the erythema, scaling and fissure values was obtained for each substance, and its sum was considered as the irritation index (IrIn). A soap was considered as a mild irritant when its IrIn was below or near to 1.0.[13]

Irritant postinflammatory hyperpigmentation was also assessed and registered as present or absent.

When the statistical analysis was completed, the name of every soap or skin cleanser was disclosed. The study was carried out in winter (average temperature 14 °C).

Statistical analysis

Statistical analysis was performed using the Kruskal–Wallis one-way analysis of variance with all pairwise comparison procedures (Dunn's and Neuman-Keuls method).

Results

Commonly used soaps by the general population

The majority of the general population interviewed (42.5%, Table 1) preferred some kind of Zest™ soap (herbal, citrus sport, neutral or aqua). Palmolive™ was the second most used brand-name soap (18.5%), and Dove™ was in third place (11.5%).

Irritant effect

Six products had IrIn values around 1.0 and were considered as nonaggressive or nonirritant: White Dove™, Dove Baby™, Cetaphil ™ (bar), Dove liquid cleanser for hands™, Dove pink™ and Aderma™. All other products had a high IrIn ranging from 2.599 to 5.426 (Table 2).

Table 1 Irritant effect of different soaps on individuals with sensitive skin

Brand name	Erythema	Scaling	Fissures	IrIn
Aderma (dermopan)	0.600*	0.600*	0.266*	1.466**
Avecyde (liquid)	1.800	0.800	0.733	3.333
Avéne	1.200	0.933	0.466	2.599
Cetaphil	0.460	0.933	0.000	1.393
Dove white	0.200	0.000	0.000	0.200
Dove baby	0.533	0.600	0.000	1.133
Dove (liquid))	0.666	0.600	0.133	1.399
Dove pink	0.666	0.666	0.133	1.465
Johnson's baby	1.666	1.400	0.133	3.199
Johnson's baby/oat	1.333	1.400	0.066	2.799
Lux with glycerin	1.533	1.466	0.266	3.265
Nivea baby creamy	1.800	1.466	0.200	3.466
Nivea bath care	1.666	1.400	0.266	3.332
Nivea bath care, almond	1.533	1.400	0.066	2.999
Nivea bath care, oat	1.400	1.333	0.400	3.133
Oilatum	2.428	1.714	0.428	4.570
Natural oilatum	2.000	2.000	0.142	4.142
Zest neutral	2.140	1.785	0.290	4.215
Zest citrus sport	1.714	1.857	0.000	3.571
Zest herbal	1.857	1.428	0.428	3.713
Zest aqua	2.428	1.857	0.714	4.999
Palmolive green	1.857	1.428	0.428	3.713
Palmolive (white)	2.428	1.000	0.571	3.999
Palmolive botanicals	2.428	1.142	0.571	4.141
Palmolive botanicals with chamomile	2.714	0.714	0.000	3.428
Camay classic	1.857	1.000	0.430	3.287
Camay gala	3.142	1.285	0.857	5.284
Camay soft	3.142	1.142	1.142	5.426
Rosa venus	2.428	0.857	0.285	3.570

Soap emulsions or liquid cleansers were applied to the skin of forearm of 30 individuals as stated in Materials and Methods. Then, the presence of erythema, scaling and fissures was recorded and the irritation index (IrIn) determined.
*Arithmetic mean of the values of each parameter of skin irritation; **Sum of the values of skin irritation (IrIn).

pH

Only one of the products tested (Dove Baby™) had a neutral pH. Four soaps had a pH near 7.0, and another had a very acidic pH 3.61 (Avecyde™), whereas the remainder had high pH 9.85–12.35 (Table 2).

Correlation between pH and irritation effect

On the basis of our results, the soaps tested were grouped into three categories: (1) soaps with a low IrIn and pH near the neutral zone; (2) soaps with a high IrIn (> 3.571) and high pH (from 9.5 to 10.65); and products with the highest pH (> 11) and IrIn (from 2.79 to 3.466) (Fig. 1). The correlation between these two parameters was statistically significant ($P < 0.006$)

Hyperpigmentation

Almost all the products studied induced hyperpigmentation. Although we did not perform a statistical analysis of these data, it was evident that the degree of hyperpigmentation was related to the level of inflammation induced by the different products (post-inflammatory hyperpigmentation, data not shown).

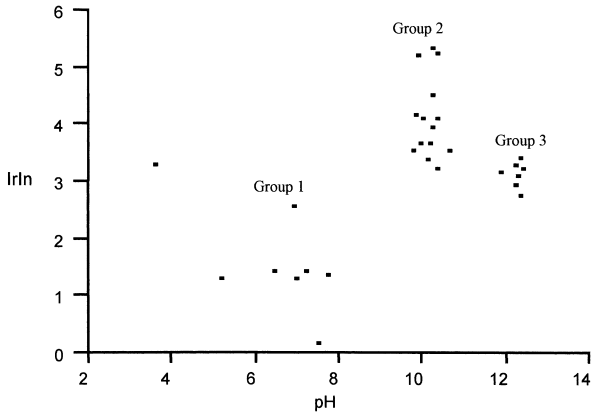

Figure 1 Correlation between pH and irritation index (IrIn). We identified three groups of soaps: low IrIn and pH near neutral zone; high pH and high IrIn; and highest pH and moderate IrIn

Table 2 Irritation index, pH and composition of tested cleansers

Brand name	Irritation*	pH	Composition
Aderm	1.466	6.44	Syndet
Avecyde	3.333	3.61	Syndet
Avéne	2.599	6.94	Syndet
Cetaphil	1.393	7.72	Syndet
Dove white	0.200	7.53	Syndet
Dove baby	1.133	7.0	Syndet
Dove (liquid)	1.399	5.16	Syndet
Dove pink	1.465	7.23	Syndet
Johnson's baby	3.199	11.9	Soap
Johnson's baby oat	2.799	12.35	Soap
Lux with glycerin	3.265	12.38	Soap
Nivea baby creamy	3.466	12.35	Syndet**
Nivea bath care	3.332	12.21	Syndet**
Nivea bath c. Almond	2.999	12.22	Syndet**
Nivea bath c. Oat	3.133	12.30	Syndet**
Oilatum	4.570	10.26	Syndet**
Natural oilatum	4.142	10.01	Syndet**
Zest neutral	4.215	9.85	Soap
Zest citrus sport	3.571	9.75	Soap
Zest herbal	3.713	9.97	Soap
Zest aqua	4.999	9.89	Soap
Palmolive green	3.713	10.18	Soap
Palmolive (white)	3.999	10.23	Soap
Palmolive botanicals	4.141	10.38	Soap
Palmolive botanicals/camomile	3.428	10.13	Soap
Camay classic	3.287	10.38	Soap
Camay gala	5.284	10.36	Soap
Camay soft	5.426	10.26	Soap
Rosa venus	3.570	10.65	Soap

The pH of each emulsion or liquid cleanser was recorded by using the Chemcadet pH meter (Cole-Parmer Instrument Co.).
*Irritation index, **plus mineral oil

Discussion

Most soaps and cleansers usually remove dirt adequately, but their use is not devoid of adverse side-effects. These adverse effects include damage to the barrier function of the skin, increased susceptibility to environmental irritants and antigens, skin irritation with erythema and edema, and reduction of the cosmetic qualities of the skin, such as moisture and smoothness. These changes are usually subtle, occurring slowly over time, and are more important in elderly and atopic patients.[20,21] Often, the association of these problems with the use of a particular type of soap is overlooked.[22] Skin dryness can be exacerbated by dry climate and the influence of hard water, which increases the irritant effect of soaps or detergents.[6]

Although it is important that dermatologists and the general population are aware of the irritation potential of products used for body cleansing, this information is not usually available; therefore, we decided to analyze the irritation effect of brand name products rather than isolated substances.

The chamber test used for assessing the irritant effects of soaps deliberately magnifies the conditions of exposure in order to enhance the effect of different products. The purpose of the chamber test is to achieve maximum effect of each compound, providing greater sensitivity and discriminating power, thus emphasizing the differences between soaps as much as possible.[19,23] In this regard, it is very likely that the "use test" or the repeated open test do not have the discriminating power that we were looking for in this study.

Cumulative irritant dermatitis is the most common type of irritant contact dermatitis, and develops as a result of a series of repeated and damaging insults to the skin hampering the adequate recovery of this tissue.[24–26] The repetitive irritation test with Finn chambers employed in this study allowed us to induce this syndrome.[27]

In this study we found that a group of five soap bars and one liquid skin cleanser (White Dove™, Dove Baby™, Cetaphil™ (bar), Dove liquid cleanser for hands™, Dove pink™ and Aderma™), have a low irritant effect. Only one of these soaps had a neutral pH, being the second less irritant to sensitive skin (Dove Baby™). It is important to recognize that Dove™, Cetaphil and Aderma™, which have a lower IrIn, are considered as synthetic detergents.[13] Commonly used soaps by the general population are soap based (Table 3).

As the soaps more frequently used by the general population showed a high irritation index (3.285–5.4) they should not be recommended for individuals with sensitive skin.

We found a significant correlation between pH and skin irritation ($P < 0.006$). However, the group of soap bars with the highest pH (> 11) only had a moderate IrIn. We do not have a suitable explanation for this phenomenon, but it is feasible that those products with a very high pH have a down-regulatory effect on the release of endogenous factors involved in skin inflammation.

It has been reported in the past that the prolonged disturbance of the skin acid mantle is not sufficient to induce clinical irritation.[28] Recently, it has been found that normal use of an alkaline soap bar causes a small increase in pH, perceived by subjects studied to be more irritating than a syndet.[29] In addition, the application of sodium lauryl sulfate under occlusion with a solution with high pH causes a low but significant increase in transepidermal water loss.[30] Therefore, we think that the alteration of skin pH produced by toilet soaps is an important factor to induce irritation in sensitive skin, contributing to eczema production in these patients. It is important to recall that the cumulative skin irritation in older adults requires prolonged recovery time, and that repeated exposure to harsh soaps could hinder appropriate skin repair.[31]

The dissociation constant (pKa) of a substance is another factor that contributes to the irritation potential of a substance, and a high value of this parameter seems to be predictive for

skin irritation.[32] However, all the soaps and cleansers tested in this study were comprised of a complex mixture of substances, and therefore we could not determine their pKa.

The prices of the products tested ranged from $0.0028 to $0.14 US dollars per gram. Interestingly there was no significant correlation between the price of the products and their irritation potential. In fact, the lowest IrIn was achieved by a soap with a price of 0.0082 US dollars per gram. Therefore, it is necessary that dermatologists point out that a highly price soap is not necessarily the best option for individuals with sensitive skin.

In addition, our results further indicate that good soaps are not characterized by their fragrance or appearance, nor by the place in which they are sold. Physicians, dermatologists included, should have accurate information about soaps and cleansers marketed for dry skin.

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