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Instrumental and sensory evaluation of the frictional response of the skin following a single application of five moisturizing creams

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Synopsis

Application of a cream to the skin induces tactile changes of the surface. The frictional characteristics of products are important in consumer acceptance.

The frictional resistance following application of five moisturizing creams was studied using sensory analysis and a newly developed sliding friction instrument. The methods gave comparable results. During application of the products, an immediate reduction in friction was obtained, followed by a gradual increase. A urea-containing cream gave rise to high frictional values, whereas a cream containing a high concentration of oils gave low frictional values. Separate consumer tests showed different preferences due to the different behavior of the creams. Successful correlation between consumer tests and instrumental data would be a key to introducing new quantitative measures of product performance.

INTRODUCTION

In the cosmetic and pharmaceutical industries it is important to develop topical formulations that have maximum consumer and patient acceptability. Otherwise, the formulations will not be used, even if they have suitable biological effects.

Application of products to the skin induces tactile and visual changes of the skin surface. Volatile compounds, such as water, evaporate, and the remaining constituents are mixed with other substances on the skin. For product attributes of creams, not only is the ratio between oil and water important, but also the type of oil as well as the amount and type of other ingredients (emulsifiers, humectants, etc.). The combination of substances influences the initial feel, how the formulation spreads on the skin, whether and how fast it is absorbed, and how the skin feels after use. To evaluate such product differences a variety of test methods are needed.

Tactile perception involves a contact and a movement of a fingertip across the skin surface. The relative movement of the two surfaces is restricted by friction. Thus friction of skin plays an important role in the objective evaluation of consumer-perceptible skin attributes. Quantitative measurements of skin friction can generate valuable guidelines in the course of product development, aimed at producing desirable tactile feel.

The aim of the present study was to develop a set of techniques to measure the frictional response of skin following application of moisturizing creams. The friction was measured objectively with a newly developed sliding friction instrument, as well as subjectively using sensory analysis. A consumer test was also undertaken in which we evaluated the subjective attitudes to the perceived skin feel.

MATERIALS AND METHODS

PREPARATIONS USED

Five moisturizing creams (A–E) with variations in type and amount of oils, humectants, and emulsifiers were tested. The composition and viscosity of the creams are given below. The viscosity (mPas) was determined with Haake Viscosimeter RV 12 (Haake Mess-Technik GmbH u. Co., West Germany). The measurements were performed under the same conditions at 20°C.

A. 5000 mPas; urea, lactic acid, betaine, diethanolamine, cetylphosphate, cholesterol, lanolin, glyceryl monostearate, sodium chloride, water.

B. 7000 mPas; pyrollidone carboxylic acid, isopropyl myristate, peanut oil, mineral oil, alcohol, PEG-2 stearate/stearic acid, cetylphosphate/DEA cetylphosphate, diethanolamine, butylhydroxitoluene, parabens, water.

C. 8000 mPas; pyrollidone carboxylic acid, glycerine, cetearyl octanoate, dimethicone, mineral oil, isopropyl myristate, myristyl myristate, cetyl phosphate/DEA cetyl phosphate, PEG-2 stearate/stearic acid, diethanolamine, parabens, butylhydroxitoluene, alcohol, water.

D. 10,000 mPas; glycerine, peanut oil, mineral oil, glyceryl stearate, stearic acid, triethanolamine, parabens, water.

E. 45,000 mPas; mineral oil, cetearyl alcohol, ceteth-20, sodium citrate, citric acid, methylparaben, water.

INSTRUMENTAL ASSESSMENT OF FRICTION

Seven healthy volunteers were included in the study, two males and five females, with a mean age of 39 years (range 19–57). The creams (A–E) were tested once on the volunteers. The creams were also tested seven times on one volunteer (male, 28 years) during a time period of six months, with at least one day passing between each evaluation. This was done in order to study the inter- and intraindividual variation in the skin response.

Before application of the creams, a basal value of the skin friction was registered. The products were dispensed by a volumetric syringe to the inner forearm of the volunteers. The application rate was about 5 mg/cm^2. The friction was measured immediately after application of the product and then every fifth minute up to 30 minutes. Between each measurement the probe was cleaned.

The computerized friction instrument consists of a probe with an oscillating steel plate that permits objective measurements of the surface slide friction (1,2). The operating principles of the instrument have been described in detail previously (1). The probe is applied perpendicular to the surface and the friction is measured at an axial load of approximately 0.1 N. At this low load no twisting or wrinkling of the skin occurs. The topographical features of the steel probe were determined using profilometry, according to a previously described method (3). The surface of the probe was much smoother than normal skin (data not shown).

SENSORY ASSESSMENT OF FRICTION

Eleven females constituted the panel for sensory evaluation of the creams. They were all familiar with tactile measurements. Their mean age was 46 years, range 41–50.

The perceived degree of friction was marked on a 15-cm visual analogue scale, where the endpoints of the line reflect a continuum from very low to very high friction. Before application of the creams, the panelists were "calibrated" by estimating the basal level of the skin friction. They were instructed that the basal level was anchored 6 cm from the left end of the line, and that the scale values emanated in two directions from this normalized point. The key benefit to the use of the line comes from its ability to diminish the variation in the panelists' rating and that it gives the panelists the opportunity to use the scale in a way they found comfortable.

The products were submitted to the panelists in random order. They were dispensed from coded volumetric syringes to the inner surface of the panelists' forearms. The application rate was 5 mg/cm^2. The panel members were asked to spread the product over and into the skin with fingertips. The ease of moving the fingertip over the surface during 10 s was evaluated as friction. The sensory magnitude of friction was estimated at product application and every fifth minute thereafter during 15 minutes. The fingertips were cleansed between each evaluation.

CONSUMER TEST

Fifteen users of skin care products were selected among subjects with no apparent connection to any of the tested creams. Their mean age was 41 year, range 29–57. Three products (A, B, and E) were dispensed to the arms of the volunteers as described above. The subjects were asked to spread the products on the skin surface and assess the degree of liking during spreading. Fifteen minutes later they were again asked to assess the degree of liking of the skin resistance. The results were marked on an analogue scale, where the left end reflected very unpleasant friction and the right very pleasant friction. The subjects were also asked to mark on a five-point hedonic scale the term that best represented their attitude about the feeling:

Score	Sensation
1	Much too slippery
2	Too slippery
3	Pleasant
4	Too stiff
5	Much too stiff and tacky

CALCULATIONS AND STATISTICS

The results from creams A and E were compared statistically with the results from cream B.

In the subjective evaluation, the distance from the left end to the marker on the analogue scale yielded numerical values used for statistical analysis. These results and the results from the five-point hedonic scale were evaluated statistically using the Wilcoxon signed rank test. Student's t-test was used to compare the values from the instrumental measurements. Probability values less than 0.05 were regarded as significant.

RESULTS AND DISCUSSION

The friction of the skin following application of five moisturizing creams was studied. The friction was evaluated with a new friction instrument as well as by panelists trained in sensory evaluation.

During application of the products the friction of the skin was lower than that of untreated skin. This result was obtained with instrumental as well as with sensory

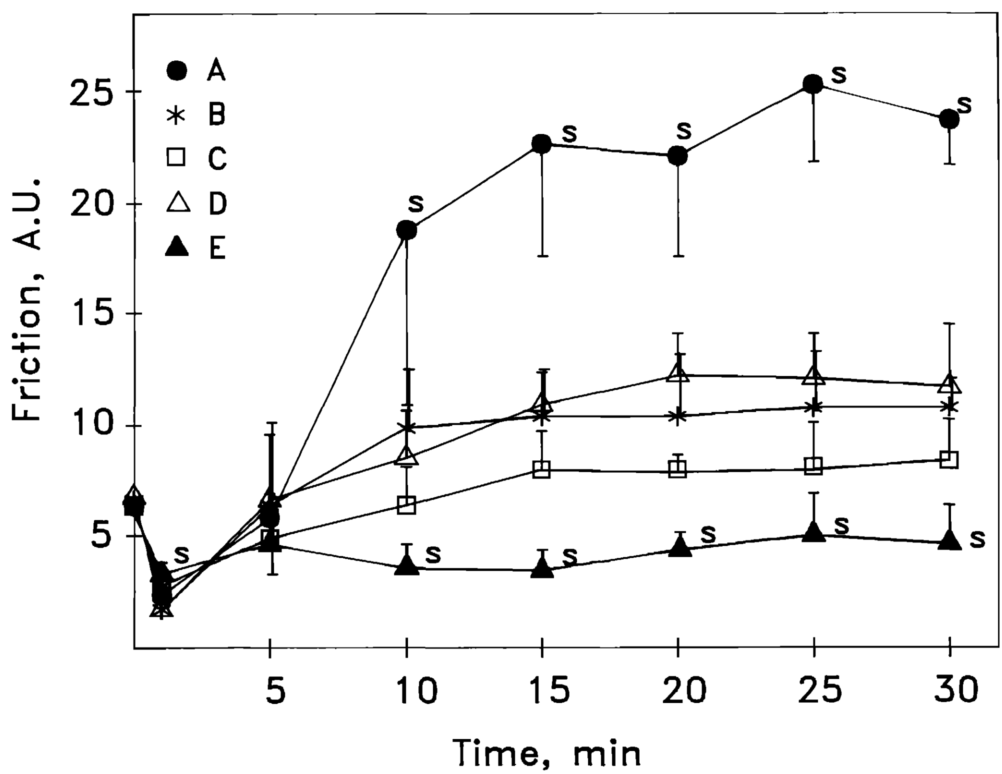

Figure 1. Instrumental evaluation of the frictional resistance of the skin following application of five moisturizing creams. The results are the mean from seven subjects ± S.D. s = Significantly different from cream B.

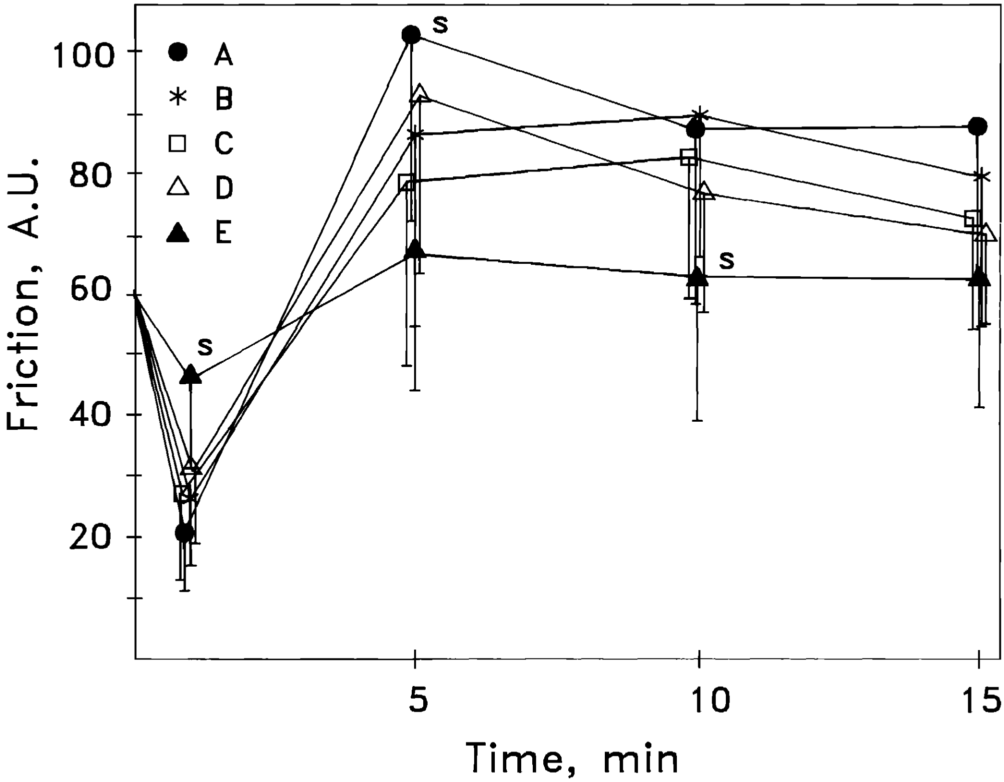

Figure 2. Sensory evaluation of the frictional resistance of the skin following application of five moisturizing creams. The results are the mean from 11 panelists ± S.D. s = Significantly different from cream B.

evaluation (Figures 1 and 2). The viscosity of the creams (see Materials and Methods) was lowest for cream A (5000 mPas) and highest for cream E (45,000 mPas). The instrumental and sensory evaluations showed that cream E gave higher frictional resistance during application than did cream A (Figure 1 and 2). The panelists ranked the creams in the same order as could be expected from their viscosity (Figure 2, c.f. Materials and Methods). This indicates that during application of a cream, the frictional resistance depends on the viscosity of the product. Similar results have been reported following application of silicone oils to the skin (4). The consumer test also indicates that the creams differed in viscosity. The subjects preferred the application of cream B to that of cream E, which was considered to be too stiff (Figures 3 and 4).

As water and other volatile agents evaporate, a marked rise in friction followed for the products, except for cream E. The area treated with cream E gave about the same resistance as did the untreated skin. The time course of the change in friction was almost the same for the two types of measurements. Product E gave the lowest friction and product A the highest. However, there was a tendency for the panelists to consider the friction to decrease after five minutes, whereas the instrumental measurements indicated a higher and more persistant friction after five minutes.

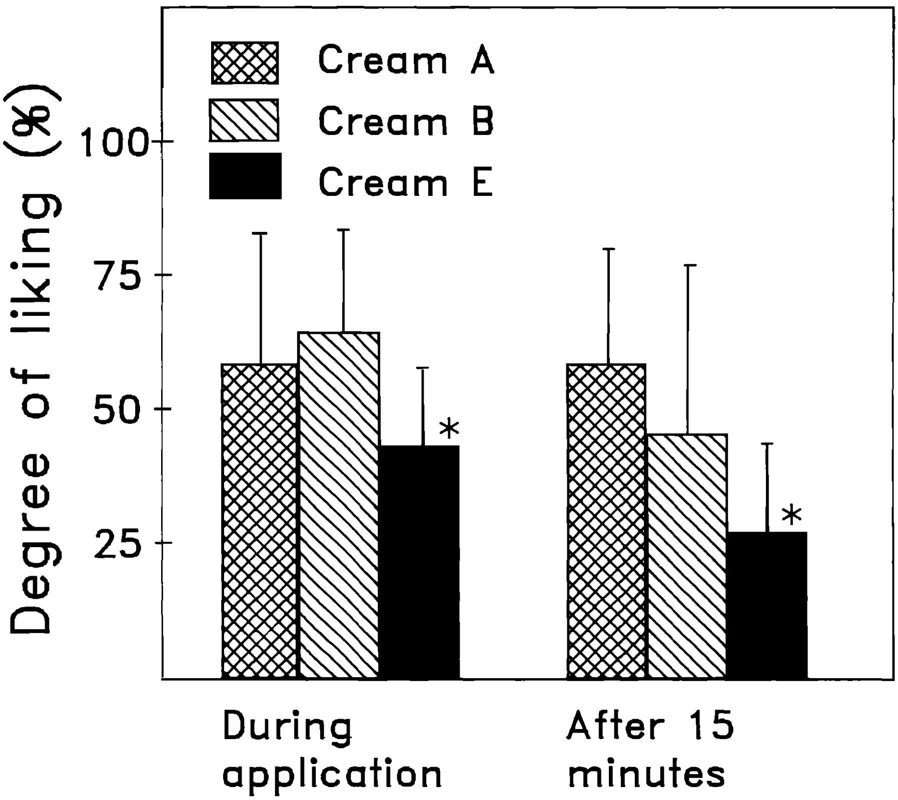

Figure 3. Degree of liking of the perceived skin feel during application and 15 minutes following application of creams A, B, and E. The results are the mean from 15 subjects ± S.D. * = Significantly different from cream B.

In general, the intraindividual variation between the measurements was lower than the interindividual one, (Table I). However, the difference was not very high and consistent, suggesting that the surface topography of the skin and the possible presence of endogenous substances on the surface had only a minor impact on the friction.

The consumers rated the application of product B to be significantly more pleasant than the application of cream E (Figure 3). The consumers considered product A more slippery than product B at application (Figure 4). Fifteen minutes after application of the creams, the consumers rated the skin area treated with the cream B to be significantly more pleasant than the area treated with product E (Figure 3). This was explained by the individuals to be due to the slippery feeling of the latter area (Figure 5). This is probably due to the higher concentration of oils in that cream than in the other tested products. A large amount of nonabsorbed oil residue on the skin surface may give a lower friction. These findings support earlier observations concerning greasiness and skin friction (5). The more greasy and unpleasant the products were perceived as being, the lower the skin friction that was obtained (5).

We have demonstrated significant differences in the influence on skin friction between the tested moisturizers, despite their similarities to a novice as oil-in-water emulsions.

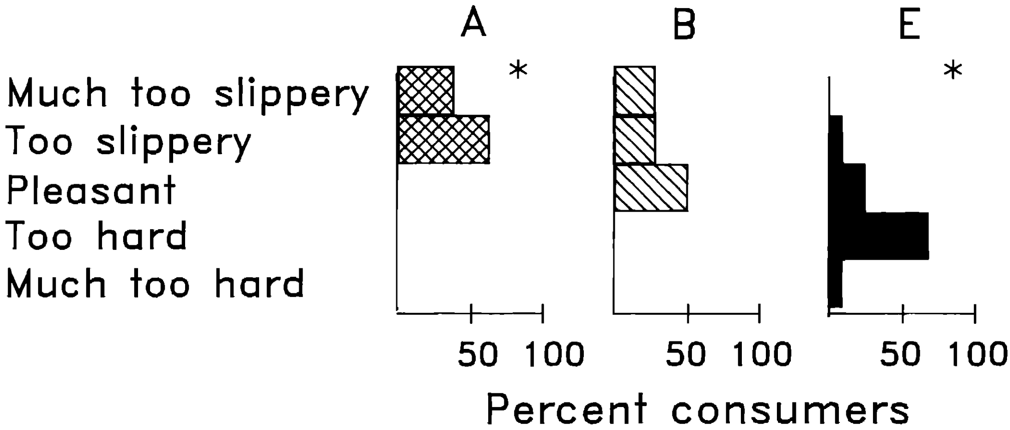

Figure 4. Sensation of the skin feel during application of creams A, B and E. The results are the mean from 15 subjects. * = Significantly different from cream B.

Formulation differences, such as the presence of humectants, may well account for some of the differences, but the type and amount of oils may also contribute to the obtained frictional response. Cream A caused the highest skin friction after evaporation of volatile compounds. This cream is marketed as an efficient moisturizer because of its high content of urea (10%). Since hydrated skin exhibits a higher frictional resistance than does normal skin (4–7), one might conclude that the obtained frictional values are excellent measures of the moisturizing properties of the creams. However, one must bear in mind that the observed changes in friction are the combined results of the lubricating and adhesive effects of the creams' components and the moisture content of the skin. Efficient moisturizers may also cause a reduction in the friction for hours (4).

In order to determine which part of the sensory evaluation can be most satisfactorily accomplished by the use of an instrumental approach, correlative research between instruments and panelists' evaluation is important. This study shows that the friction instrument gives readily quantifiable data of the frictional response following application of creams. The data also correlate well with those obtained in sensory evaluation. Hence, successful correlation between consumer tests and instrumental data would be a key to introducing new quantitative measures of product performance.

Table I
Examples of Single Person's and "Between Persons'" Standard Deviation, Expressed as a Percentage of the Friction Value From the Instrumental Assessment (n = 7)

	Single person's	"Between persons'"
Control skin	15	18
Cream A, 1 min	28	45
15 min	17	25
Cream B, 1 min	54	19
15 min	8	21
Cream E, 1 min	20	26
15 min	16	23

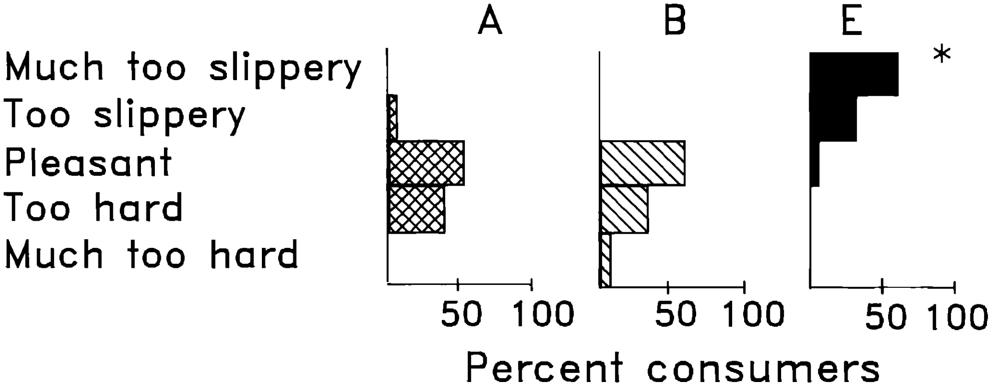

Figure 5. Sensation of the skin feel 15 minutes after application of creams A, B, and E. The results are the mean from 15 subjects. * = Significantly different from cream B.

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