

# The Influence of Water, Glycerin, Paraffin Oil and Ethanol on Skin Mechanics

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Moisturizers and emollients do not only smooth the skin but also make it more supple. To clarify this effect, the short-term influence of tap water, paraffin oil, ethanol and glycerin on skin mechanics was studied. These substances are all common ingredients in moisturizers and emollients. Significant changes were seen already after 10 min of application. The distensibility and hysteresis (creep phenomenon) showed the most pronounced changes. Water and paraffin oil application caused significant ( $p < 0.03$ ) increases after 10 min of application. The changes persisted for at least 10 min following paraffin oil application, while they disappeared sooner following water application. Application of ethanol had a negative effect on distensibility ( $p < 0.03$ ). Glycerin appears to have a slow onset of action, but with the changes continuing even after application was stopped. The changes induced by glycerin appear to be similar to those induced by water and paraffin oil. The study shows that some of the most common ingredients in moisturizers and emollients are capable of inducing significant changes in the mechanical properties of human skin *in vivo* even after a 10-min application, suggesting that the outermost layers of the epidermis play an important role in skin mechanics.

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Moisturizers and emollients are generally thought to make the skin not only smoother but also softer, i.e. influence its mechanical properties. It has previously been shown (1-3) that ordinary tap water changes the skin mechanics substantially, increasing the distensibility, resilient distensibility and hysteresis even after short-term exposure. The main ingredients of moisturizers are often water and glycerin, while emollients often have a high content of paraffin oil. The effects of these substances on skin mechanics are poorly described in the dermatological literature. In continuation of the above-mentioned studies, we have found it interesting to compare

changes in skin mechanics after application of not only water but also glycerin and paraffin oil. In addition the effects of ethanol were tested, because of its presence in cosmetic and dermatological products (4).

The study of the short-term (minutes) effects of these substances on the mechanical properties of skin under standardized conditions increases our knowledge not only of the relative importance of these substances in moisturizers and emollients but also of the possible role of the outermost layers of the epidermis on parameters of skin mechanics.

## MATERIALS AND METHODS

This study was carried out in 16 healthy volunteers, 11 women and 5 men, with a mean age of 34 years (range 24-48). None of the volunteers had a history of previous or current generalized skin disease, and none had skin diseases in the area studied.

A Dermaflex<sup>®</sup> machine was used for all measurements. The machine measures the elevation of the skin within a sealed chamber during suction. It operates in repeated cycles, each cycle lasting 4 s and applying 0.3 bar of suction. After 6 cycles the following parameters of skin mechanics are presented: hysteresis, reflecting the creep phenomenon (mm); distensibility, the maximum distension achieved (mm); elasticity, the ability of the skin to return to its original position after being stretched (given as a percentage); and resilient distensibility, any remaining elevation at the end of the first suction period (mm).

The flexor side of the forearm was used for the study. On each forearm two areas of 5 × 5 cm were marked, giving a total of four marked areas. For the measurement of skin mechanics no single site was measured more than once in order to avoid any possible artefacts due to repeated suction and subsequent deformation of the skin. Initially untreated skin was measured in all four areas to find baseline values. The test-substances were then applied to the four areas by soaking a 5 × 5 cm big gauze pad in the test substance, e.g. water, ethanol, glycerin or paraffin oil. The site of application was rotated, so that all sites were equally represented in the final result. The forearms were then covered with an occlusive plastic film (Gladwrap<sup>®</sup>) for 10 min. After 10 min any surplus test substance was gently removed, and skin mechanics were measured immediately. A final measurement was made 10 min after the removal of the test substance. Each measurement consisted of two readings in two different places within the test area, and the average value was used for further calculations. The

Table I. Changes in the measured parameters following application of tap water to the skin

Note the appearance of significant changes which disappear after 10 min of drying.

Parameter	Baseline value (range)	10 min of hydration (range)	10 min after hydration (range)	p value		
				I-II	II-III	I-III
Elasticity	0.65 (0.54-0.74)	0.66 (0.52-0.85)	0.66 (0.55-0.78)	0.22	0.75	0.37
Resilient distensibility	0.60 (0.44-0.79)	0.64 (0.42-0.84)	0.59 (0.49-0.78)	0.07	0.05	0.46
Distensibility	1.73 (1.52-2.13)	1.99 (1.41-2.99)	1.77 (1.35-2.36)	0.01	0.02	0.16
Hysteresis	0.19 (0.13-0.36)	0.30 (0.13-0.48)	0.19 (0.12-0.31)	0.005	0.004	0.55



Table II. Changes in the measured parameters following application of ethanol

Note that the significant changes appear only after the skin has been left to dry.

Parameter	Baseline value (range)	10 min of hydration (range)	10 min after hydration (range)	p value		
				I-II	II-III	I-III
Elasticity	0.65 (0.54-0.81)	0.66 (0.55-0.81)	0.64 (0.53-0.81)	0.73	0.09	0.42
Resilient distensibility	0.63 (0.42-0.97)	0.61 (0.39-0.81)	0.58 (0.42-0.69)	0.33	0.35	0.03
Distensibility	1.78 (1.42-2.52)	1.81 (1.12-2.84)	1.67 (1.22-2.46)	0.61	0.003	0.03
Hysteresis	0.19 (0.10-0.44)	0.18 (0.09-0.29)	0.17 (0.07-0.27)	0.82	0.16	0.16

Wilcoxon paired rank sum test was used for statistical analysis. The protocol was approved by the Copenhagen Ethical Committee.

## RESULTS

Considerable changes in skin mechanics occurred in the study. The results are presented in Tables I-IV. Notable differences were found between the different substances tested. Water and paraffin oil showed the most pronounced increases in hysteresis and distensibility, while it would appear that glycerin had a similar but slower effect. Ethanol seems to have the opposite effect, reducing hysteresis and distensibility. No significant effects were found concerning elasticity and resilient distensibility.

## DISCUSSION

The mechanical properties of human skin are of considerable interest (5-8), and the ability of different substances to modify these properties is not only of direct practical interest but may offer additional important information on the nature of the underlying mechanisms governing skin mechanics.

Aging induces changes in skin elasticity, hydration, skin surface and blood flow. Impairment or degeneration of elastic and collagen networks is responsible for some of these changes, while changes in blood flow and water binding in the stratum corneum reduce the hydration of the skin and cause an increased transepidermal water loss (9). Moisturizers or emollients are often perceived as being able to temporarily reverse at least some of these changes.

Dermal collagen is generally considered to be the most important factor determining skin mechanics (7, 9, 10). This is in clear contrast to the extensive global use of moisturizers to make the skin more moist or supple (11). It is unlikely that the

topical application of simple chemical substances can influence dermal collagen significantly in short-term use. This strongly suggests that the epidermis plays a role in skin mechanics. It has previously been shown that water influences the mechanical properties of skin after only 10 min of exposure, and the present study shows that some of the substances commonly contained in moisturizers and emollients may have similar effects (1, 2). Changes were induced both by substances freely miscible with water such as water, ethanol and glycerin, as well as paraffin oil, which is not miscible with water.

The greatest and most reliable changes occurred in hysteresis and distensibility. Both these parameters relate to the ease with which mechanical movement takes place, i.e. lubrication. The study found an immediate lubricating effect of both water and paraffin oil. For ethanol and glycerin no early effects were seen, which may either be due to differences in permeation or inherent different effects of these substances. Water appears to have only a short-term effect, as values return to baseline values in only 10 min (see Table I). In contrast, glycerin and paraffin oil appear to have a more prolonged effect, lasting at least 10 min after application, suggesting that the outermost layers of the skin have been altered or influenced more substantially.

The changes seen can be the result of either a direct influence on the intercellular matrix, or an epiphenomenon due to regulatory mechanisms, e.g. a physiological shift of water between the tissues aimed at maintaining homeostasis. It is possible that glycerin and paraffin oil attract water by osmosis from the deeper layers of the epidermis, softening the skin, while ethanol displaces water already present in the stratum corneum, thereby stiffening the skin. The rapid onset of changes, however, speaks in favour of a more direct action but may be due to the ability of each substance to penetrate the stratum corneum (12).

The study shows that both hydrophilic and hydrophobic

Table III. Changes following application of paraffin oil, suggesting that a more lasting increase of the hysteresis has occurred

Parameter	Baseline value (range)	10 min of hydration (range)	10 min after hydration (range)	p value		
				I-II	II-III	I-III
Elasticity	0.67 (0.56-0.82)	0.66 (0.51-0.76)	0.67 (0.55-0.81)	0.28	0.53	0.31
Resilient distensibility	0.58 (0.42-0.97)	0.67 (0.49-1.03)	0.62 (0.40-0.86)	0.004	0.01	0.17
Distensibility	1.85 (1.40-3.09)	2.08 (1.47-2.91)	1.98 (1.16-3.36)	0.03	0.18	0.18
Hysteresis	0.19 (0.07-0.43)	0.28 (0.15-0.43)	0.25 (0.14-0.45)	0.004	0.14	0.008



Table IV. Changes following application of glycerin showing a pattern similar to that seen after the application of paraffin oil

Parameter	Baseline value (range)	10 min of hydration (range)	10 min after hydration (range)	p value		
				I-II	II-III	I-III
Elasticity	0.66 (0.51-0.80)	0.67 (0.59-0.80)	0.66 (0.55-0.82)	0.74	0.80	0.32
Resilient distensibility	0.61 (0.44-0.76)	0.60 (0.45-0.85)	0.58 (0.36-0.77)	0.88	0.28	0.07
Distensibility	1.81 (1.47-2.32)	1.87 (1.52-2.30)	1.81 (1.40-2.80)	0.31	0.21	0.24
Hysteresis	0.19 (0.06-0.30)	0.22 (0.10-0.33)	0.23 (0.12-0.36)	0.10	0.29	0.01

substances affect skin mechanics, suggesting that both the elements of the intercellular matrix in the stratum corneum play a role in skin mechanics.

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