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Racial differences in sodium lauryl sulphate induced cutaneous irritation: black and white

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The different reactivity of black and white skim after exposure to sodium lauryl sulphate (SLS) has been investigated 9 white and 10 black male volunteers entered the study. The tests were performed on the back at 3 sites: untreated skin, skin pre-treated with occlusion and skin pre-delipidized. Irritant reactions were elicited applying 0.5% and 2.0% SLS via Finn chamber patch tests and monitored by means of laser Doppler velocimetry (LDV), transperdermal water loss (TEWL) and stratum corneum water content (WC). Higher TEWL, LDV, and WC values were recorded for 2.0% SLS when compared to 0.5% SLS and **baselines. Pre - treatment** with short-term occlusion generally increased values, while delipidization produced flattening of the data more detectable in whites than in blacks. Significant TEWL differences for the two concentrations were recorded in whites for the occluded site (P<0.02) while in blacks in the untreated (P<0.04) and delipidized (P<O.O3) sites. LDV revealed significant changes in the untreated and pre-occluded white skin (P<0.05 and 0.01, respectively). In blacks, the values were significantly different only in the prem-occluded skin (P<0.01). Water content correlated with the visual score and was greatly increased in **sites** with strongly positive reactions (P<0.01). It appears that there are significant differences in the modulation of irritation in the behavior of water barrier function and of the erythematous response between **blacks and whites.** Clinical correlations are discussed.

Key *words:* TEWL - LDV - sodium lauryl sulphate - irritation - races

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To determine the proclivity of black and white skin to react to an irritant, investigators have applied chemicals to black and white skin and monitored the induced erythematous reactions. Weigand & Mehrson (1) documented the racial variable in skin reactivity with patch test exposures to orthochlorobenzylidene malonitrile, reporting decreased susceptibility of black skin to develop erythema. Exposure to dinitrochlorobenzene (DNCB) produced lower minimal perceptible erythema (MFE) values in blacks, while the removal of the stratum corneum rendered more nearly equal that 2 groups (2). However, the difficulty of perceiving erythema in black skin raised questions regarding the interpretation of such studies.

The availability of modern bioengineering techniques allowing the non-visual detection and quantification of erythema, vasodilatation and damage of the skin barrier after exposure to irritants, leads us to utilize them to investigate racial responses to skin irritants.

The present study evaluates by means of laser Doppler velocimetry (LDV), transepidermal water loss (TEWL), and measurements of the water content of the stratum corneum (WC), the sodium lauryl sulphate (SLS) induced irritant reactions in

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blacks and whites. These objective methods have been used to assess skin irritancy in man (3, 4). To assess the modulation of the irritant reaction produced by water and skin surface lipids, SLS was applied to normal untreated skin, to skin with previously removed lipids, and pre-occluded for 30 min. Short-term occlusion appears to increase percutaneous penetration (5).

Material and Methods

9 healthy white (age 30.6 f 8.8) and 10 healthy black male (age 29.9 f 7.2) volunteers entered the study.

Finn chamber patch tests of 12 mm diameter (Epitest Ltd, Helsinki, Finland) containing 0.5% and 2.0% SLS in aqueous solution were applied for 24 h to the back of the subjects in 3 anon (a) untreated skin; (b) skin pre-treated with impermeable plastic occlusion for 30 min; an occlusive dressing with plastic film (Parafilm, American Can Co. Greenwich CT, USA) was applied to a 100 cm' surface; after 30 min, the tape was removed and the patches applied; (c) skin pre-delipidized. Skin surface lipids were solubilized applying ethyl acetate (Baker analyzed, Phillipsburg, NJ) for 3 min via cotton swab without scrubbing the skin surface. To assess for satisfactory delipidization, casual sebum levels were determined prior to and after ethyl acetate treatment using a Sebumeter (Schwarzhaupt, Kolhn, West Germany) (6).

Table 1. TEWL, LDV and WC baselines in the 2 groups.
Normal skin without SLS application or pre-treatment

	TEWL	LDV	WC
whites	2.7+/-0.7	44.2+/-9.8	6.1+/-2.8
blacks	3.3+/-0.9	37.6+/-12.8	7.8+/-4.8

Values are expressed in g/h (TEWL), in mV (LDV) and in facial-aqua meter units (WC). There are no significant differences between the black and white groups.

After 24 h exposure to 0.5% and 2.0% SLS, the patches were removed. Readings were performed 30 min after the removal at room temperature. The skin temperature, recorded with a telethermometer (Yellow Spring Instruments Co, USA), ranged between 3 1.5 and 33°C. Skin irritation was monitored as follows.

(i)Visual scoring (VS): VS was evaluated as follows: - negative reaction, 7 + doubtful, + positive (erythema), + f (erythema, microvesiculation), + + + strongly positive edematous reaction.

(ii)Laser Doppler velocimetry (LDV). LDV is a well-known objective technique for monitoring cutaneous microcirculation (7): A He-Ne laser source (Medpacific Corp. Seattle, USA) is applied to the skin via a small probe, The wavelength of the light is 632 nm and the amount of light scattered by erythrocytes is displayed in mV.

(iii) Transepidermal water loss (TEWL). The measurements were performed using an evaporimeter (Servo-Med, Stockholm, Sweden) (8).

(iv) Water content (WC). WC was measured by a capacitance device (Facial aqua-meter, IBS Co. Ltd, Japan). The technique measured the stratum corneum water content in few seconds by applying a 1 cm diameter probe on the skin surface (9).

The recordings were taken 30 min after patch removal. The baseline TEWL values were subtracted from the recordings to attenuate the great inter-individual variability in skin water loss. Statistical analysis was performed by means of the Student t-test (two-tailed). Casual sebum level was 121 pg (rt79) in whites and 72 pg (*31) in blacks. Delipidization produced a significant lowering of casual levels (38.5 f 5.7 in whites, 43.2 If 12 in blacks) (P<0.007 in whites; P<0.009 in blacks). Occlusion increased the water content of the stratum corneum from 5.9 f 2.8 to 25.1+/-1.3 in whites (P<0.01) and from 7 f 3.4 to 20.4 ± 16.5 in blacks (P<0.02).

Results

Values for skin not treated with SLS or not modified with any pre-treatment showed no significant difference between blacks and

whites (Table 1).

Higher TEWL, LDV, and WC values were recorded for 2.0% SLS when compared to 0.5% SLS and baselines both in blacks and whites (Table 2). A good correlation between visual scoring and instrumental data was found. Pre-treatment with occlusion generally caused an increase in the values, while delipidization produced flattening of the data, more detectable in whites than blacks (but not statistically significant).

TEWL

Higher values were detected in blacks (untreated, occluded, delipidized) but were only statistically significant (when compared to the white group) for 0.5% SLS in the pre-occluded area ($P \leq 0.04$). The reactions to the 2 concentrations differed significantly in whites in the occluded site ($P<0.02$). In the black group, the values were significantly different in the not pre-treated ($P<0.04$) and delipidized sites ($P<0.03$).

LDV

The comparison between black and white values didn't reveal significant changes, but the comparison between the 2 concentrations revealed in whites significant differences in not pre-treated skin ($P<0.05$) and more signiticative ($P<0.01$) in pre-occluded skin. In blacks, the values were significantly different in pre-occluded skin ($P<0.01$).

WC

The stratum corneum WC was decreased when irritation was low on the basis of visual scoring (-, +/-) and greatly increased in sites where the score + or + + was assigned ($P<0.01$) both in blacks and whites (Table 3).

***Table* 2. TEWL and LDV** values in **blacks** and **whites**

	Not pre-treated		Pre-occluded		Pre-delipidized	
TEWL (mg/cm²/h)	0.5%	**2.0%**	**0.5%**	**2.0%**	**0.5%**	**2.0%**
whites	**4.5i4.4**	8.3±8.1	4.7±3.9	14.7±13.2	7.4±4.7	8.5±4.8
	N.S		P<0.02		**N.S.**	
blacks	7.7±6.5	16.11±17.0	12.9±9.9	20.3±15.2	8.4±5.8	24.1±23
	P<0.04		**N.S.**		P<0.03	
LDV (mV)						
whites	73.2±35	174.2±140	73.6±34	179±128	8.6±74	122±73
	P<0.05		P<0.01		**N.S.**	
blacks	81±63	151.6±139	58.9±25	234±194	78.6±40	183.6±120
	N.S.		P<0.01		**N.S.**	

P-values refer to the comparison between 0.5% and 2% SLS concentrations. In the black group, TEWL increases significantly ($P<0.04$) for the 0.5% concentration in the occluded site when compared to the white. All 0.5% and 2.0% sites were significantly different from baseline control sites as recorded by LDV, except for 0.5% in not pre-treated black skin.

*$P \leq 0.04$ for blacks versus whites.

***Table* 3. Relationship between water content and visual score**

Water content (aqua meter units) Visual Score	—	?+	+	++
blacks	4.4±1.1	14.5±13	56±62	95.2±26
whites	5.1rt8.5	12.6±13	37.3±31	113.7±22.8
	N.S.	**N.S.**	**N.S.**	**N.S.**

Differences between negative, doubtful reactions and positive reactions is **highly significant** ($P<0.001$) **in the 2** groups. **There was no significant difference between** the **black and white responses.**

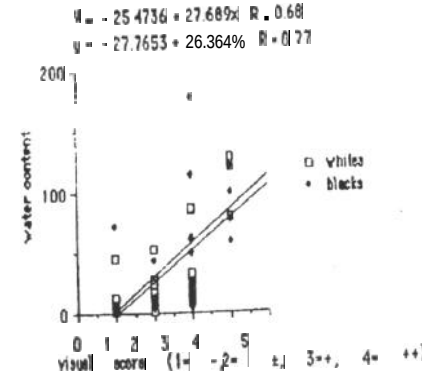

Fig. **I. The water content of the stratum corneum is plotted versus the visual score. There is a highly significant linear correlation ($P<0.001$) in whites and in blacks.**

Discussion

Marshall et al. (10) believed that dark 'skin is less susceptible to irritancy than light skin. This could be explained on the basis of physiological differences in the stratum corneum and barrier function, but also on the difficulty in visualizing erythema in black skin. Although the stratum corneum of blacks and whites has the same thickness, Weigand et al. (11) demonstrated that stratum corneum from blacks contained more cell layers and required more tape strips for removal. This could be due to an increase in lipid molecules within the comeocytes (12) resulting in an increased intercellular cohesion. On the other hand, epidemiologic data (13) show no significative differences in the black/white ratio of allergic contact dermatitis. Fisher (14) reported an approximately equal incidence of **contact** dermatitis in blacks and whites in North America, while Olumide (15) reports a higher rate of sensitization in Nigerian blacks.

Our data reveal a different susceptibility to SLS-induced irritation in whites and blacks, mainly related to a different response of the **water barrier** function and of the microcirculation after chemical injury. Blacks had an increased TEWL **than** the whites in the entire study, although significantly in the pre-occluded site.

In the white group, the comparison between the 2 concentrations of SLS revealed higher values for **2.0% SLS.** The values differ significantly in the pre-occluded area ($P<0.02$). Increasing hydration with the occlusion presumably enhanced the penetration of the irritant, producing a greater damage of the skin water barrier detected mainly with 2.0% SLS (8.3 untreated site, 14.7 occluded site). Lipid removal didn't produce significant changes in comparison with the control site. Even the differences between the responses elicited by the 2 concentrations were small. It seems that the removal of lipids renders the skin less susceptible to irritation and capable of differentiating and modulating the irritant response between the 2 SLS concentrations. This data is confirmed by the LDV values.

In blacks, the 2 SLS concentrations elicited significantly different reactions in the control area ($P<0.04$) and in the delipidized area ($P<0.03$). Pre-treatment with occlusion increased **the 0.5% SLS response** ($P<0.04$) and produced a non-significant difference with 2% SLS. These data suggest that black skin has **a** more sensitive TEWL response to SLS than white skin; different concentrations produce significantly different irritant reactions. Increasing the **penetration** in blacks with occlusion caused an increased response mainly for the lower SLS concentration. 2% SLS did not produce this effect, presumable since TEWL levels were already high. In white subjects, the differences are detectable mainly in the occluded site, possibly because of the increased penetration, but not in the other areas. When the TEWL baselines are plotted versus the TEWL values induced after SLS application, there is a significant linear correlation in the 2 groups for the 0.5% SLS concentration and for the **2.0%** SLS in blacks ($P \leq 0.05$). This data is not significant in the white group, meaning that even if there is a high baseline value, **there is not** necessarily a high TEWL after exposure to the irritant. This is a further demonstration that blacks have a more sensitive response

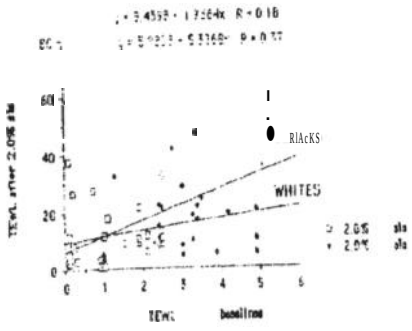

Fig 2. **TEWL** baselines are plotted versus the **values recorded after 2.0% SLS irritation. The** straight line is significant only **for** black skin ($P \leq 0.05$).

to transepidermal water loss (Fig. 2).

Cutaneous blood flow revealed an increased response for the higher SLS concentration in all subjects. The comparison between black and white values didn't show significative changes, but the difference in the responses elicited by the 2 concentrations was statistically significant in whites in the control site ($P<0.05$) and in the pre-occluded skin ($P<0.01$). Delipidization in whites, even for the blood flow as with the TEWL, minimized the diierences, making the data similar (98.6 in 0.5% and 122 in 2% SLS). In blacks, the levels were significantly different in the preoccluded ($P<0.01$) and delipidized area ($P<0.02$). In the untreated skin, the values didn't differ and the comparison between 0.5% SLS and basal blood flow in skin not exposed to irritant was not significant. The interpretation of this data is difficult. Without pretreatment, in blacks, at the lower SLS concentration, changes in blood flow are minimally detectable (or black skin produces less erythema than white skin?). This could explain the findings of decreased minimal perceptible erythema in blacks (2).

The water content of the stratum comeum was decreased when irritation was low on the basis of the visual scoring (-, ?+), and greatly increased in the sites where + or + + was assigned, ($P<0.01$) both in whites and blacks. No significant differences between the 2 groups was recorded because of the inter-individual variability and of the bi-modal response of the values. The 2 concentrations demonstrated insignificant changes in whites, while blacks differ in control ($P<0.05$) and occluded sites ($P<0.03$). As shown in Fig. 1, a good correlation between VS and increase of WC was detected ($P<0.00$ 1) in blacks and whites. This finding was independent of the SLS concentration applied and of the pre-treatment, since some subjects had stronger reactions at low concentration and vice versa.

In conclusion, the SLS-induced irritation showed different responses in blacks and whites depending on the parameters investigated and on the pre-treatment. Pre-occlusion increased TEWL and blood flow in blacks and whites, while delipidization elicited similar responses for the 2 concentrations in the white group but not in blacks. The reason why removal of lipids causes different reactions in the 2 races is not known. Furthermore, sebum causal levels after delipidization were equal in the 2 groups. The TEWL and WC responses demonstrated a higher suscep tibility of black skin to SLS and a different modulation of irritant reactions after exposure to different amounts of irritant. On the other hand, there was less erythema in black than in white skin, and significant differences were appreciable only after the pre-treatments. Probably, not only is it more difficult to perceive erythema in black skin, but black skin reacts with lower increases of skin blood flow (at lower SLS concentration, namely 0.5%), as long as this can be detected with LDV.

Further investigations are needed to elucidate with more detail the TEWL sensitivity of black skin to various chemicals in order to increase the amount of data available. This work could have great implications in terms of occupational dermatitis, topical drug and cosmetic formulations and could lead to the development of specific race-oriented products.

References

1. Weigand D A, Mershon M *M. The cutaneous irritant reaction to* **agent** *o-chlorobenzylidene malonitrile (CS)* **(I),** *Quantification and racial influence* **in** *human subjects.* Edgewood Arsenal Technical **Report 4332,** February 1970.
2. Weigand D A, Gaylor G **R. Irritant reaction in Negro and Caucasian skin.** *South Med Jour* **1974: 67: 548-55 1.**
3. Nilsson G E, **Otto U, Wahlberg J E.** Assessment of skin irritancy in man by laser Doppler **flowmeby. Contact** *Dermatitis* **1982: 8:** 401-**406.**
4. Malten **K** E, Thiele F **A J.** Evaluation of skin *damage (II). Brit J Dermatol* **1973: 89: 565-600.**
5. Ryatt K S, Stevenson J **M,** Maibach H I, Guy **R H. Pharmacodynamic measurement of percutaneous penetration enhancement in vivo.** *J Pharm Sci* **1986: 75: 374-377.**
6. Dikstein **S, Harzshtark A, Bercovici R, Orgad A Distribution of sebum measurement in normal adult woman.** *IV Int Symp* **on** *Bioengineering and the* ***Skin.*** Besancon, **France, September 1983.**
7. **Stevenson J M, Maibach H I, Guy R H. Laser Doppler photoplethysmographic assessment of cutaneous microvasculature. In: Maibach H I, Lowe N U, (eds): Model in dermatology 1987. Basel: Karger, 1987: 121.**
8. Miller D L, **Brown A M, Artz E J. Indirect measures of transepidermal water loss. In: Marks R, Payne P A (eds):** ***Bioengineering*** *and the skin.* **Lancaster: MTP Press, 198 1: 161-171.**
9. Tagami **H, Ohi M,** Iwatsuki K, Kanamaru Y, Yamada **M, Ichijo** B. Evaluation of skin surface hydration in vivo by electrical measurement. *J* ***Invest*** *Dermatol* **1980: 75: 500-507.**
10. **Marshall E K, Lynch V, Smith H W.** Variations in susceptibility of the skin to dichloroethylsulphide. *J Pharmacol Exp Ther* **1919: 12: 291-301.**
11. **Weigand D A, Haygood C, Gaylor J A Cell layers and density of negro and Caucasian stratum corneum.** *J Invest Dermatol* **1974: 62: 563-568.**
12. Reinertson R **P, Wheatley V R. Studies** on the **chemical composition of human epidermal lipids.** *J Invest Dermatol* **1959: 32: 49-59.**
13. ***North*** **American Contact Dermatitis Group. Epidemiology of contact dermatitis in North America.** *Arch Dermatol* **1973: 108: 537-540.**
14. **Fisher A A Contact dermatitis in black patients.** *Cutis* **1977: 20: 303-320.**
15. Olumide **Y M. Contact dermatitis in Nigeria.** *Contact Dermatitis* **1985: 12: 241-246.**

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