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Racial/Ethnic Variations in Skin Barrier: Implications for Skin Care Recommendations in Skin of Color

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ABSTRACT

Background: Genetic and environmental factors influence stratum corneum (SC) barrier properties and function. Researchers increasingly focus on biophysical studies that may help clinicians provide their patients with an informed choice on tailormade skincare. This literature review on skin barrier properties comparing different ethnic populations aims to offer insights into the information's clinical relevance.

Methods: A literature review followed by panel discussions and an online review process aimed to answer the questions: Are there racial/ethnic differences in the SC barrier structure and healthy skin barrier function? Is there a need for specific cleansers and moisturizers?

Results: Ethnic categories based on race and ethnicity are often not well defined and inconsistent across different studies. Studies comparing ethnic groups' physical and biochemical skin barrier properties have reported differences in transepidermal water loss (TEWL), skin lipid levels, pH, and mast cell granule size. However, these studies frequently had methodological flaws, mainly were small, and demonstrated conflicting results. The literature suggests racial/ethnic variations in ceramide content, SC structure, and filaggrin mutations. Furthermore, studies have shown a greater burden of pruritus and atopic dermatitis among Black populations. Data on barrier properties in Hispanic/LatinX and South Asian populations are lacking.

Conclusion: Robust comparative studies are needed to understand these basic concepts to help tailor skincare and skin of color patients' education.

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INTRODUCTION

While multiple studies have identified variations in skin barrier properties between different racial/ethnic populations, the clinical relevance of these findings have not been established.[1-3] This project sought to help clarify the existing published data and provide consensus statements on variations in skin barrier properties that may be observed in populations with skin of color. We assembled a group of dermatologists with expertise in skin of color to examine the data and summarize the findings.

MATERIALS AND METHODS

A panel comprised of seven dermatologists from the US (the authors) convened a virtual meeting on October 10, 2020, to address the following questions using a modified Delphi process: 1) Are there racial/ethnic differences in skin barrier structure and function? 2) Is there a need for specialized approaches to skincare in patients with skin of color? Statements intended for healthcare providers caring for diverse patients and clinician-researchers were developed based on available literature and the panel's expert opinion.

Literature Searches

A dermatologist and a physician/scientist performed literature searches on September 10, 2020, on PubMed and Google Scholar as a secondary source. The review was limited to the English language literature published through September 2020 and used search terms pertaining to racial/ethnic differences in stratum corneum (SC) properties and skincare considerations. Included were original research, clinical guidelines, algorithms, relevant reviews, and evidence-based recommendations describing the current practice. Further excluded were publications that did not specifically address the SC barrier in skin of color, articles covering skincare in specific dermatological conditions, and publications in languages other than English.

Role of the Panel

Selected information from the literature searches, coupled with the panel's opinion and experience, was used to adopt statements and recommendations.

The results of the literature searches were integrated into summary statements, presented, and discussed during a virtual meeting on October 10, 2020. The online conference replaced a face-to-face meeting that was canceled due to COVID-19. In a workshop, advisors divided into two groups to create a final set of summary statements about racial/ethnic differences in SC barrier structure and function and skincare for this population, working with 19 draft messages. The final six statements integrate the combined output from the workshop groups and post-meeting online reviews from individual advisors.

RESULTS

Based on a review of the literature and a modified Delphi process, the expert panel developed the below six consensus statements. A summary of relevant data and expert opinion for each statement is included.

1. ***Attributes contributing to skin hydration, roughness, and other properties can be grouped into genetic (gender, race, ethnicity), environmental (lifestyle, BMI, geography), and individual factors.***

Stratum Corneum Thickness/Desquamation

Several studies have investigated SC differences between Black and White skin. While SC thickness between Black and White individuals has been found to be comparable.[2-8] Black skin has been reported to have a greater number of cell layers that are arranged more compactly.[7,9] Increased cell layers may indicate a stronger SC barrier and faster recovery from barrier damage. White subjects have intermediate barrier strength as evidenced by tape strippings, and Asians have been demonstrated to require the least number of tape "strippings" to disrupt the SC barrier. This finding indicates a weaker barrier strength and slower recovery from barrier damage in the Asian population that supports the observation of sensitive skin seen in Asians.[9]

In one study, corneocyte surface area on the upper-outer arm was similar in Black, White, and Asian subjects, while Black subjects were found to have increased spontaneous desquamation compared to White and Asian subjects.[10]

The increased desquamation seen in this study may explain, at least in part, the observed tendency for xerosis in Black skin. However, in another study, the desquamation index was higher in facial skin (cheeks and forehead) of White subjects compared to Black subjects, whereas dryness scores were higher on the legs of Black subjects compared to White subjects.[11] Another study evaluating the amount of active SCCE enzyme on SC tape strips as a marker of desquamation on ventral forearm samples found evidence for slower desquamation in Black subjects than White and East Asian subjects. In contrast, a different study reported no difference in skin roughness and scaliness between

TABLE 1.

Stratum Corneum Thickness/Desquamation		
Study Subject	**Key Finding**	**References**
Cell layers and density of Black and White skin	The range and average of thickness are nearly the same between Black and White skin. More strips were re-quired for removal of SC and a greater number of cell layers were present in Black vs. White skin.	Weigand DA, et al. *J Invest Dermatol* 1974;62(6):563-8.[7]
Skin thickness of Black and White skin	No statistically significant difference in skin thickness of Black and White skin	Whitmore SE, et al. *J Am Acad Dermatol* 2000;42:76-9.
Barrier strength assessed by tape strippings comparing Asians to Whites	A weaker barrier strength and slower recovery from barrier damage in Asians.	Muizzuddin N, et al. *J Dermatol Sci* 2010;59(2):123-8.[9]
Corneocytes differences between Black, white and East Asian skin	Blacks had increased spontaneous desquamation compared to those with White and Asian skin.	Corcuff P, et al. Acta Derm Venereol 1991;71(2):146-8.[10]
Dryness scores on legs of Blacks versus Whites	Higher dryness scores were observed on Blacks vs. Whites.	Warrier AG, et al. *J Cosmet Sci* 1996(47):229-40.[11]
Influence of age, anatomic site and race on skin roughness and scaliness	Slower desquamation on ventral fore-arm in Black compared to White and East Asian subjects.	Manuskiatti W, et al. *Dermatology* 1998;196(4):401-7.[12]

Black and White patients at multiple anatomical sites.[12] Taken together, the available data support structural and functional variations in the stratum corneum between populations, but these vary by anatomic location or methodology, and therefore, may not be generalizable to the diverse range of populations with skin of color (Table 1).

Skin Barrier: pH

Physiological skin surface pH is acidic (4–6), while the body's internal pH is neutral to slightly alkaline (~7.4).[13-15] Buffer capacity results from free fatty acids and components of natural moisturizing factors (NMF) urocanic acid, carbonic acid, and keratins.[14] Skin surface pH influences skin barrier homeostasis, SC integrity and cohesion, and antimicrobial defense mechanisms. In inflammatory skin diseases, such as atopic dermatitis (AD) and acne, skin surface pH is elevated, and therapeutic measures, alkaline cleansers, and moisturizers may deteriorate the condition.[16] An alkaline skin surface pH leads to disruptions in the skin's acid mantle and may influence skin barrier function.

Few studies have examined pH in skin of color.[13-15] One study demonstrated decreased pH in Black skin after three tape strips but not at baseline or after subsequent tape strips.[14] In contrast, a study of South African nursing students showed increased skin surface pH in Black subjects compared to White subjects.[15] Another study revealed no difference in skin surface pH between Black and White subjects.[13] Thus, the data from these three studies are insufficient to draw any definitive conclusions on pH in skin of color.

2. Skin barrier differences between racial/ethnic populations may contribute to variations in the prevalence and severity of atopic dermatitis, xerosis, and pruritus.

Variations in the prevalence of AD in different racial/ethnic populations have been reported. Several studies have shown a higher prevalence of AD in Black children compared to White children.[16-18] Greater severity of AD in Black children compared to White children was reported in one study after adjusting the erythema score in the Score Atopic Dermatitis index (SCORAD).[19,20] Prevalence and impact of pruritus have also been greater in Blacks than White populations.[20-22] In a cross-sectional study of a middle-aged and elderly population, skin pigmentation (as well as age, female sex, body mass index, outside temperature, eczema, and chemotherapy) were significant determinants for both generalized and localized dry skin. Individuals with Brown-Black skin color were more likely to have generalized dry skin than the reference group of olive to light brown skin color.[23]

Causative factors for observed differences in prevalence and severity of AD, xerosis, and pruritus published in the literature remain unclear, although the aforementioned skin barrier differences mentioned above may be contributory. The role of genetic factors (including those related to barrier structure and

TABLE 2.

Skin Barrier Differences Between Racial/Ethnic Populations and Variations in Prevalence of Various Conditions

Study Subject	Key Finding	References
London-born black Caribbean children are at increased risk of AD	Higher prevalence of AD in Black children compared to White children.	Williams HC, et al. *J Am Acad Dermatol* 1995;32(2 Pt 1):212-7.[16]
AD and sensitization to common aller-gens: a multiethnic, US population-based study	Higher prevalence of AD and sensitization in Black children compared to White children.	Fu T et al. *Pediatr Dermatol* 2014;31(1):21-6.[17]
Prevalence of AD in different racial/ethnic populations in the US	Higher prevalence of AD in the US in Black children compared to White children.	Shaw TE, et al. *J Invest Dermatol* 2011;131(1):67-73.[18]
Erythema scores may mask AD in black children compared to Whites	Greater severity of AD in Black children compared to White children.	Ben-Gashir MA, et al. Br J Dermatol 2002;147(5):920-5.[19]
Pruritus in black skin evaluating molecular characteristics and clinical features.	Greater impact of pruritus in Blacks vs. Whites.	McColl M, et al. *J Nat Med Assn* 2020. doi: 10.1016/j.jnma.2020.07.002.[20]
Racial and gender differences in pruritus	More pruritus in Blacks vs. Whites.	Whang KA, et al. *Medicines (Basel)* 2019;6(4).[21]
Racial disparities in the impact of chronic pruritus	Greater prevalence and impact of pruritus in dark skinned individuals vs. Whites.	Shaw FM, et al. *J Am Acad Dermatol* 2017;77(1):63-9.[22]
Prevalence and determinants for xerosis	Higher prevalence of xerosis in dark skin vs. lighter skin.	Mekic S, et al. *J Am Acad Dermatol* 2019;81(4):963-9 e2.[23]
SOC biology, structure, function, and implications for skin disease	Stratum corneum of equal thickness but possibly a greater number of cell layers in Black skin vs. White skin. Reported TEWL, conductance, pH variations between populations comprehensively summarized.	Taylor SC. *J Am Acad Dermatol* 2002;46 (2 Suppl Understanding):S41-62.[23]

Atopic dermatitis (AD); United States (US); Skin of color (SOC)

function)[24] and environmental, cultural, and socioeconomic factors requires further investigation in future studies (Table 2).

3. Racial/ethnic differences affecting the skin barrier include ethnicity-related variations in ceramide levels and filaggrin null mutations. Certain alterations in skin barrier lipid content correlate with increased trans-epidermal water loss (TEWL) and enhanced barrier permeability.

Filaggrin (filament-aggregating protein) is encoded by the filaggrin (FLG) gene and is first synthesized as a precursor, profilaggrin. It is expressed in the SC where it plays a significant role in barrier function and skin hydration. Loss of function (LOF) mutations in filaggrin are associated with atopic dermatitis (AD) and ichthyosis. Specifically, null mutations in FLG have been associated with epidermal barrier abnormalities, the abnormal architecture of the lamellar bilayer, and increased transepidermal water loss. However, the prevalence of LOF mutations in FLG varies by population, with lower frequencies reported in AD patients of East Asian and African descent. Two LOF mutations were initially discovered in the Northern European Caucasian population with a frequency of 7%–10%.[25] In populations with AD, 27.5% of Caucasian children in the United States, 31.4% of Han Chinese, 20% of Japanese, and 0.6% to 0.9% of Italians have been shown to have FLG mutations.[26-29] Few studies have found FLG mutations in individuals of African descent. Early studies found as little as 0% of patients having an FLG mutation, with subsequent studies ranging from 1.3% to 3.2%.[25,30-32] More recently, Margolis et al evaluated 370 African Americans with AD and found FLG mutations in only 8.1% of subjects.[26] It is important to note that the FLG mutations in different ethnic/racial populations are different mutations in the FLG gene.

Water Content

Water content in the skin can be measured by capacitance, conductance, impedance, and resistance; however, few studies use these methods to compare water content between racial and ethnic groups.

Seven studies examined Black and White skin, with four of these studies showing no significant differences.[12,13,33,34] One study showed increased water content in Black skin while another suggested decreased water content in Black skin.[11,35] Another study showed no statistical difference in skin hydration between African subjects and White subjects except on the palms, which demonstrated a greater level of SC hydration in Caucasians.[15]

The data on water content amongst various ethnic groups remains contradictory and inconclusive.

Transepidermal Water Loss

Transepidermal water loss (TEWL) is one measure of SC barrier function. Five studies of TEWL in Black skin indicate that TEWL is greater in Black skin than White skin.[14, 33,36-38] However, there are nine studies that contradict these findings. Variations in methodology, including the anatomic site of measurement, may account for some of the differences observed between studies. Seven reported no difference in baseline TEWL between the Black and White subjects [5,13,15,34,39-41] and two reported decreased TEWL in Black patients.[9,11] There has been no difference demonstrated in TEWL between Hispanic and White skin.[33,40] Further research is required before any conclusions can be made regarding TEWL in Black skin compared to White skin. Differences in TEWL for Asian skin have also been studied (vide infra).

Lipid Content and Ceramides

The skin lipids play a particularly significant role in barrier function and are produced in the lamellar bodies of the stratum granulosum during keratinocyte differentiation. The intercellular lamellar lipid membrane is primarily composed of roughly equimolar concentrations of ceramides, cholesterol, and free fatty acids, which play a vital role in the physiological maintenance of SC hydration. The physiologic SC lipids comprise approximately twenty percent of the volume of the SC and are composed of ceramides (CERs) (40–50%), cholesterols (25%), and free fatty acids (10–15%).[42,43] Optimal lipid composition is essential for ideal barrier function within the stratum corneum.

Studies have suggested that there is greater lipid content in Black SC when compared to White SC.[42,43] Controversial findings have been reported regarding the lipid levels found in the SC of varying ethnic groups. Although greater overall lipid content has been reported in Black SC, subsequent studies have shown that ceramide levels were lowest in Black skin. Sugino et al found ceramide levels existed in decreasing order in Hispanic and Asian, White, and Black skin. Ceramide levels were inversely correlated with TEWL. Additionally, the ceramide levels are directly correlated with water content of the SC.[37] This was again demonstrated by Hellemans et al, who quantified ceramide levels using hydrolysis and found the lowest level of lipid in the SC in Black skin.[44] In the largest study of its kind, involving 341 healthy subjects in the U.S., Muizzuddin et al found African Americans to have significantly fewer ceramides compared to Caucasian and Asian American subjects.[9]

In a study of 71 healthy student volunteers residing in Denmark, SC lipid profiles in Asian, Black, and White subjects were evaluated by high-performance thin-layer chromatography. The highest ceramide/cholesterol ratio was seen in the Asian group, while the lowest was seen in Africans. However, no significant differences were found in the amount of individual ceramide subgroups.[45]

Based on the various studies discussed, the data regarding racial differences in lipid content consistently point to reduced ceramide levels in Black skin, which has implications for the presence of xerosis. Abnormalities in ceramide composition alter the stratum corneum's physiologic properties and

TABLE 3.

Racial/Ethnic Differences in Filaggrin Null Mutations and Ceramide Levels		
Study Subject	**Key Finding**	**References**
Prevalence of LOF mutations in FLG vary by population	Lower frequencies found of LOF in East Asian and African AD patients vs. Whites.	Palmer CN, et al. *Nat Genet* 2006;38:441-446.25
LOF mutations in FLG in African Americans with AD	Low frequencies and different LOF mutations in FLG found in African Americans with AD.	Margolis DJ, et al. *J Allergy Clin Immunol* 2012; 130:912–917.
LOF mutations in FLG in Han Chinese AD patients	LOF mutations in FLG were found to be less frequent.	Zhang H, et al. *Allergy* 2011;66:420–427.27
FLG mutations in Japanese AD and ichthyosis vulgaris patients	Specific FLG mutations cause AD and ichthyosis vulgaris.	Nomura T, et al. *J Invest Dermatol* 2008;128:1436–1441.28
Full sequencing of the FLG gene in Italian AD patients	Lack of association with AD of detected FLG mutations.	Cascella R, et al. *J Invest Dermatol* 2011;131:982–984.29
SC lipid levels comparing different ethnic groups	African Americans had significantly fewer ceramides compared to Whites and Asian Americans.	Muizzuddin N, et al. *J Dermatol Sci.* 2010;59(2):123-8. 9
Ceramide level differences between ethnic groups	Ceramide levels were found in decreasing order in Hispanic and Asian, White, and Black skin.	Sugino K. *J Invest Dermatol* 1993;100:587-597.37
Ethnic differences in lipid content in the SC	Greater lipid content in Black SC when compared to White SC.	Reinertson RP, et al. J Invest Dermatol 1959;32(1):49-59.42
Histology and physiology of Black skin	Greater lipid content in Black SC.	La Ruche G, et al. Ann Dermatol Venereol 1992;119(8):567-574.43
SC properties differences between Black and White skin	Lowest levels of lipids were found in Black skin.	Hellemans I, et al. *J Invest Dermatol* 2005;124(S4):A62.44
Danish study on differences in ethnic groups in SC lipid content	The Asian showed the highest ceramide/cholesterol ratio and the Africans living in Denmark demonstrated the lowest ratio.	Jungersted JM, et al. *Br J Dermatol* 2010;163(6):1169-1173.45

Filaggrin (FLG); Loss of function (LOF); Atopic dermatitis (AD); Stratum corneum (SC)

contribute to barrier dysfunction and disease.

Additional robust studies with well-defined racial/ethnic groups and phototypes are needed to validate these findings (Table 3).

4. Black patients are disproportionately affected with pruritus and related conditions such as atopic dermatitis and prurigo nodularis. Black skin may have several unique structural properties related to the pathogenesis of pruritus, including decreased ceramide levels, variations in TEWL, and larger mast cell granules.

The published literature suggests that Black patients are more likely to present with pruritus than White patients and are also more likely to be diagnosed with prurigo nodularis and atopic dermatitis.[46] As mentioned previously, data on TEWL in Black skin compared to other racial groups is conflicting. However, data suggesting reduced ceramide content in black skin has been consistent across studies. Both of these factors (TEWL and ceramides) may contribute to xerosis, pruritus, and related conditions. Variations in mast cell composition have also been demonstrated in Black skin, such as larger mast cell granules that may be functional.[47] Notably, pruritus can be associated with malignancy, and in Black patients, these underlying malignancies are more common soft tissue, dermatologic, and hematologic malignancies.[48] With this association, it may be prudent to consider screening Black patients for underlying malignancy when presenting with new-onset pruritus later in life.

5. There is a need for robust clinical studies to understand and quantify ethnic differences in skin properties, including the complex relationship between skin permeability and other characteristics.

While racial/ethnic differences in barrier structure and function have been reported, they are based on a relatively small number of studies with many conflicting results. Interpretation and application of these data are limited by small sample sizes, varying methodologies, heterogeneous definitions of racial/ethnic groups, and lack of standardization of baseline skincare regimens.

Additional, more robust studies with clearly defined comparative populations are needed to better inform optimal skincare recommendations for the diverse spectrum of populations with skin of color. Future research should focus on reducing gaps in our understanding of skin barrier properties across diverse populations and their implications for skin health and disease.

6. Diversity of skin properties and cultural perceptions of skin, such as "ashy skin" in Black populations and sensitive skin in East Asian populations, should be considered in developing and selecting skincare products.

In Black populations, dry skin can be culturally stigmatizing. Xerosis on the background of richly pigmented skin can have a grey or ashen appearance and is often referred to as "ashy skin" in the Black community (Figure 1). Although in all ethnicities dry skin can be present, in Black skin it is more visible and has greater cultural significance due to its aesthetic appearance. Daily moisturization is considered a cultural norm in the personal care practices of Black patients. The frequency and selection of moisturizing products vary between ethnic populations based on cultural and environmental factors (Figure 2a and Figure 2b).

FIGURE 1. Xerosis on the leg of a dark-skinned individual. *(Photograph courtesy of Dr Andrew Alexis)*

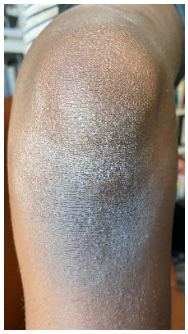
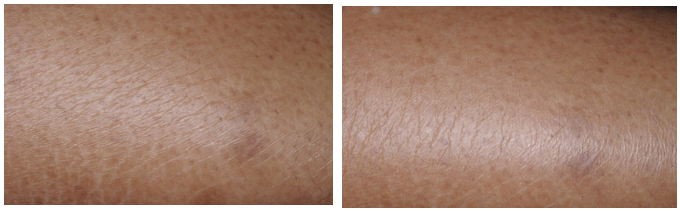


FIGURE 2A AND 2B. Xerosis on the lower leg of a SOC individual (a) before skincare and (b) after four weeks of skincare use. Skincare comprised a ceramide-containing cleanser and moisturizer. *(Photographs are courtesy of Dr Z. Drealos)*

(2A) (2B)



Asian skin is often referred to as more "sensitive",[49] but understanding this perception becomes a bit more challenging. Structural differences do indeed exist that are seeming consistent across multiple studies, but it should be noted that it is difficult to draw generalizations across all East Asian populations, which together encompass a large proportion of the global population.

In multiple studies, it was confirmed that TEWL increased more with tape-stripping in Asian skin versus other groups,[9,36] supporting the relative weakness of the skin barrier, which may lead to a perception of sensitivity. The mechanism for this has been hypothesized to be either the reduced thickness of the stratum corneum or increased sweat gland density.[50] However, another test using a different technique, applying sodium lauryl sulfate to the skin as an irritant, found that TEWL remained the same among Japanese and European women.[51] Interestingly, in this study, Japanese women still reported higher intensity of subjective sensory differences with the application of skin irritants. Overall, most evidence points to Asian skin having higher TEWL and skin reactivity/sensitivity.[52]

All in all, some objective measures support that there may be some structural differences in Asian skin, leading to a perception of sensitivity in this population. However, further studies in larger and better-defined populations in the Asian diaspora are necessary.

Data about cultural variations in skincare or skin dryness among South Asian and Hispanic/LatinX populations are currently lacking.

Different cultural norms on skin cleansing and moisturization are also important to understand and consider when evaluating skin barrier differences and making recommendations for skincare across diverse patient populations.

CONCLUSION

Data on racial/ethnic differences in skin barrier structure and function are limited but suggest variations in some characteristics relevant to skincare. While some data are conflicting and have methodological limitations, the body of literature indicates that there are racial/ethnic variations in ceramide content, stratum corneum structure, filaggrin mutations, and TEWL (albeit varied by study and methodology). Data on barrier properties in Hispanic/LatinX and South Asian populations are notably lacking. Additional, more robust studies with clearly defined comparative populations are needed to better inform optimal skincare recommendations for the diverse spectrum of populations with skin of color.

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