

Received: 28 January 2025 | Accepted: 08 April 2025 | Published: 03 May 2025

Paper presented at the **2nd Conference of the Hellenic Scientific Society of Aesthetics**  
30 November-1 December 2024 | University of West Attica, Athens, GreeceOpen Access | **REVIEW**

# Cutaneous biophysical factors related to race and gender

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## ABSTRACT

The biophysical properties of the skin vary significantly across different racial and gender groups, influencing skin health, function, and response to environmental factors. This review explores the impact of race and gender on cutaneous biophysical properties, highlighting differences in skin structure, function, and response to environmental factors. The study synthesizes data from multiple sources to elucidate how genetic, hormonal, and environmental factors contribute to variations in skin properties across different racial and gender groups. Key findings suggest that melanin content, transepidermal water loss (TEWL), sebum production, and skin elasticity exhibit significant variability, impacting dermatological health and cosmetic product development. A comprehensive understanding of these variations can aid in the development of targeted dermatological treatments and skincare products tailored to specific demographic needs.

## KEYWORDS

skin physiology, race, gender, melanin, sebum

**How to cite this article:** Tertipi N., Sfyril E.: Cutaneous Biophysical Factors Related to Race and Gender. *Rev. Clin. Pharmacol. Pharmacokinet. Int. Ed.* 39(Sup1): 37-40 (2025).  
DOI: [10.61873/HJDS2975](https://doi.org/10.61873/HJDS2975)

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## 1. INTRODUCTION

The human skin is the largest organ of the body, serving as a protective barrier against external aggressors, regulating body temperature, and preventing water loss. Skin characteristics such as pigmentation, hydration, lipid content, and barrier integrity are influenced by a variety of intrinsic and extrinsic factors, with race and gender playing a significant role in determining these attributes [1]. Genetic predisposition, hormonal fluctuations, and environmental exposure collectively shape skin properties, resulting in considerable inter-individual and inter-population differences [2]. Race-based differences in skin biology are predominantly attributed to variations in melanin content, stratum corneum structure, and lipid composition. Studies indicate that individuals with higher melanin levels, such as those of African descent, possess enhanced photoprotection but may experi-

ence a greater propensity for hyperpigmentation and keloid formation [3]. Conversely, individuals with lighter skin tones, such as those of European descent, exhibit increased vulnerability to UV radiation-induced damage and premature aging. These differences necessitate race-specific dermatological considerations in both clinical and cosmetic contexts.

Gender-related variations in skin physiology are primarily driven by hormonal influences, with androgens and estrogens exerting significant effects on sebum production, collagen density, and skin thickness [4]. Male skin is typically characterized by a thicker dermis, higher sebaceous gland activity, and increased susceptibility to acne, whereas female skin tends to have greater moisture retention, enhanced elasticity, and a more pronounced tendency for fine lines and wrinkles due to hormonal fluctuations associated with aging.

## 2. DISCUSSION

The biophysical properties of human skin exhibit significant diversity across different racial and gender groups, influenced by a complex interplay of genetic, hormonal, and environmental factors. Understanding these variations is essential for dermatology and skincare, as they provide valuable insights into the development of personalized treatments and cosmetic formulations tailored to diverse populations. This section explores the specific differences observed in skin properties across racial and gender groups, emphasizing key research findings and their implications for clinical and cosmetic applications.

### 2.1. Racial differences in skin properties

Scientific studies have demonstrated that racial variations in skin physiology are primarily governed by differences in melanin production, stratum corneum structure, and sebaceous gland activity [5]. Melanin, the pigment responsible for skin color, plays a critical role in photoprotection by absorbing harmful ultraviolet (UV) radiation. Individuals with darker skin tones, such as those of African or South Asian descent, possess a higher concentration of melanin, which provides superior photoprotection and contributes to a lower incidence of photoaging and skin cancer [6]. Furthermore, their stratum corneum, the outermost layer of the epidermis, is often thicker, enhancing the skin's barrier function and reducing transepidermal water loss. However, despite these protective benefits, individuals with darker skin are more susceptible to specific dermatological conditions such as post-in-

flammatory hyperpigmentation, a condition in which skin trauma or inflammation leads to the development of dark patches. Another common concern is keloid scarring, where the skin forms raised, fibrous scars that extend beyond the initial wound site. In contrast, individuals with lighter skin tones, such as those of European or East Asian descent, generally have lower melanin levels and thinner epidermal layers. The reduced melanin content makes their skin more vulnerable to UV-induced damage, resulting in an increased risk of sunburn, erythema, and premature aging. Additionally, the thinner stratum corneum can lead to a compromised skin barrier, making their skin more prone to dehydration and irritation. These individuals often require enhanced sun protection strategies and targeted skincare regimens that focus on hydration and anti-aging measures to mitigate environmental damage, as shown in Table 1 [7].

### 2.2. Gender differences in skin properties

Gender-related differences in skin physiology are predominantly influenced by hormonal fluctuations, particularly the effects of androgens and estrogens. Testosterone, an androgen hormone, has a significant impact on male skin, leading to increased sebum production, thicker dermis, and a higher density of collagen fibers. As a result, male skin tends to be oilier and more prone to acne and seborrheic conditions. The increased sebaceous gland activity can also contribute to a heightened susceptibility to conditions such as acne vulgaris and seborrheic dermatitis [8]. On the other hand, female skin, which is regulated by estrogen and progesterone, exhibits unique characteristics such as greater hydration, enhanced elasticity, and a finer texture. Estrogen promotes the production of collagen and hyaluronic acid, contributing to a youthful and supple appearance. However, hormonal fluctuations throughout different life stages—such as puberty, pregnancy, and menopause—can lead to changes in skin texture and hydration levels. For example, during menopause, a decline in estrogen levels often results in reduced skin elasticity, dryness, and an increased tendency for fine lines and wrinkles [8]. Additionally, female skin typically has lower sebaceous gland activity compared to male skin, which contributes to a lesser tendency for acne but a higher propensity for dryness and sensitivity. Women also tend to experience more pronounced age-related changes in skin, including thinning and decreased structural integrity, necessitating targeted skincare interventions that support hydration and elasticity.

2.3. Implications for dermatological care and cosmetic science

The racial and gender-based differences in skin properties have far-reaching implications for dermatological care and cosmetic science. Addressing these differences requires a personalized approach to skincare that considers individual genetic, hormonal, and environmental factors. For instance, dermatological treatments for individuals with darker skin tones should focus on preventing and managing hyperpigmentation, reinforcing barrier function, and selecting appropriate cosmetic formulations that do not exacerbate oiliness or lead to breakouts. In contrast, skincare solutions for in-

dividuals with lighter skin tones should prioritize sun protection, anti-aging ingredients, and barrier-enhancing formulations to counteract the effects of environmental exposure. Gender-specific skincare approaches are equally important. Products designed for men should target excess oil production, support collagen integrity, and address common concerns such as acne and post-shaving irritation. Conversely, formulations for women should emphasize hydration, skin firming, and the prevention of fine lines, particularly in response to hormonal changes associated with aging [9]. Personalized dermatological strategies based on these considerations not only improve treatment outcomes but also enhance consumer satisfaction by addressing the unique skin care needs of diverse populations.

**Table1.** Impact of racial and gender differences on skin properties.

Factor	Racial differences	Gender differences
<b>Skin structure</b>	Darker skin tones have a thicker stratum corneum; lighter skin tones have a thinner epidermis.	Male skin is generally thicker than female skin.
<b>Pigmentation</b>	Higher melanin content in darker skin provides enhanced UV protection; lighter skin has lower melanin levels.	No significant difference between genders; influenced more by racial background.
<b>Transepidermal water loss (TEWL)</b>	Darker skin generally has lower TEWL, contributing to better moisture retention; lighter skin exhibits higher TEWL, leading to dryness.	Female skin has lower TEWL, leading to better hydration; male skin tends to lose more water.
<b>Sebum production</b>	Darker skin tends to produce more sebum; lighter skin has lower sebaceous activity.	Male skin produces more sebum due to androgens; female skin has lower sebum production.
<b>Skin elasticity</b>	Darker skin shows greater elasticity; lighter skin is more prone to wrinkles and fine lines.	Female skin is more elastic due to estrogen; male skin is less elastic but firmer.
<b>Photo protection</b>	Darker skin is less prone to UV-induced damage; lighter skin is highly susceptible to sun damage.	Male skin is more resistant to UV damage; female skin may show early signs of sun-related aging.
<b>Aging susceptibility</b>	Darker skin ages more slowly; lighter skin experiences premature aging due to lower collagen density.	Female skin is more prone to fine lines due to hormonal fluctuations; male skin shows delayed signs of aging.
<b>Dermatological conditions</b>	Darker skin is more prone to hyperpigmentation and keloid formation; lighter skin is more prone to erythema and sun damage.	Male skin is prone to acne and seborrheic conditions; female skin is prone to dryness and hormonal acne.

3. CONCLUSION

A thorough understanding of the biophysical properties of the skin in relation to race and gender is crucial for advancing personalized dermatological treatments and cosmetic product formulations. Recognizing and addressing the distinct character-

istics of different racial and gender groups will facilitate more effective and inclusive approaches to skincare. Future research should continue to explore the interplay of genetic, hormonal, and environmental influences to develop innovative and customized skincare solutions that cater to the diverse needs of individuals worldwide.

## ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to the Hellenic Scientific Society of Aesthetics for their valuable support and contribution to completing this work. This research was financially supported by the Hellenic Scientific Society for Aesthetics.

## CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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