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# Cutaneous biophysical factors related to age and body location

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## ABSTRACT

The biophysical properties of human skin, such as hydration, elasticity, sebum content, and transepidermal water loss (TEWL), are influenced by both age and body location. These factors play a critical role in dermatological health and the efficacy of skincare products. Aging is generally associated with decreased hydration, elasticity, and sebum production, while TEWL increases, indicating a decline in skin barrier function. Additionally, different anatomical locations exhibit distinct biophysical characteristics due to varying densities of sebaceous glands and exposure to environmental factors. For instance, sebaceous gland-rich areas like the forehead show higher sebum content, while the palms exhibit lower hydration levels. This review presents a comprehensive analysis of current research on the effects of age and body location on skin biophysical properties to guide future dermatological studies and skincare product development.

## KEYWORDS

skin biophysical properties, aging, body location, hydration, elasticity

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## 1. INTRODUCTION

Human skin undergoes structural and functional changes with age, varying across anatomical locations due to genetic, hormonal, and environmental influences. These factors collectively impact skin health and appearance, leading to reduced hydration, elasticity loss, increased transepidermal water loss (TEWL), and diminished sebum production. Such changes contribute to clinical signs of aging, including wrinkles, dryness, and sensitivity [1,2,3].

Aging-related hydration decline is primarily due to decreased natural moisturizing factors (NMFs) and lipids in the stratum corneum, impairing moisture retention and resulting in dryness. Collagen and elastin degradation further reduce skin elasticity, causing sagging and wrinkle formation [1]. Environmental factors, such as UV radiation and pollution, accelerate these changes, leading to prem-

ature aging and oxidative stress [3,4]. Increased TEWL with age reflects a weakened epidermal barrier, making skin more vulnerable to irritation and environmental damage. Reduced sebum production, particularly in postmenopausal women, further exacerbates dryness and sensitivity [5,2,6].

Skin properties also differ by anatomical location. Sebaceous gland-rich areas like the forehead and nose have higher sebum production and lower TEWL, while gland-poor regions such as the arms and legs exhibit greater dryness [7]. The palms and soles have a thicker stratum corneum, providing a strong barrier but lower hydration levels [2].

Thinner areas, such as the periorbital region, are more prone to early aging signs due to lower collagen density and greater exposure, while thicker regions, like the back and soles, show better resilience [2,8]. Understanding these variations is crucial for developing targeted dermatological treatments and personalized skincare. Products for aging skin should include humectants to enhance hydration, antioxidants to combat oxidative stress, and peptides to support collagen synthesis. Future research should focus on the interplay of genetic, hormonal, and environmental factors over time to develop more effective skincare solutions. Advancements in non-invasive skin imaging can further enhance personalized treatment strategies [3].

The interplay of aging and anatomical differences necessitates personalized skincare approaches. Recognizing these factors enables dermatologists and cosmetic scientists to create targeted treatments that maintain skin health and appearance throughout life.

## 2. DISCUSSION

Aging has a profound and multifaceted impact on the biophysical properties of the skin. Numerous studies have indicated that with increasing age, skin hydration levels decline due to the reduced presence of natural moisturizing factors (NMFs) and lipid content in the stratum corneum. The diminished levels of these critical components lead to impaired water retention, contributing to the characteristic dryness and rough texture observed in aged skin [2]. This decrease in hydration can also exacerbate other age-related changes, such as skin dullness and reduced suppleness, making hydration maintenance a key aspect of anti-aging skincare interventions. Skin elasticity also declines significantly with age, primarily due to the progressive degradation and fragmentation of dermal collagen and elastin fibers. These structural proteins, essential for maintaining skin firmness and resilience, undergo both intrinsic aging and environ-

mental degradation, such as exposure to ultraviolet (UV) radiation, which accelerates their breakdown. As a result, aging skin exhibits sagging and wrinkle formation, particularly in areas subjected to repetitive facial movements and gravitational forces [1].

Transepidermal water loss (TEWL), a critical indicator of skin barrier function, is also affected by aging. Research suggests that TEWL tends to increase with age, indicating a weakened epidermal barrier that is less effective in preventing water loss and protecting against environmental aggressors. This compromised barrier function makes aged skin more susceptible to irritation, sensitivity, and damage from external factors, such as pollutants and allergens, further contributing to age-related skin concerns [4]. Sebum production, which plays a crucial role in maintaining skin hydration and barrier function, is known to peak during adolescence and gradually decline with advancing age. This decrease is particularly pronounced in post-menopausal women, due to hormonal changes that result in reduced androgen levels. The decline in sebum secretion contributes to drier skin, increased susceptibility to irritation, and a higher likelihood of developing fine lines and wrinkles. Consequently, formulations aimed at mature skin often focus on replenishing lipids and supporting barrier function, as shown in Table 1 [4].

The anatomical location of the skin further influences its biophysical properties, with significant variations observed across different body regions. Sebaceous gland-rich areas, such as the forehead and nose, typically exhibit higher sebum production, leading to an oily appearance and lower TEWL. Conversely, sebaceous gland-poor areas, including the arms and legs, have lower lipid content, resulting in greater dryness and higher susceptibility to environmental stressors [1]. Moreover, the thickness of the stratum corneum varies across different anatomical sites, with the palms and soles exhibiting a significantly thicker layer compared to other areas of the body. This thicker layer provides enhanced protection but also contributes to lower hydration levels and increased TEWL, necessitating targeted moisturizing strategies [1]. Recognizing these age- and location-specific variations is essential for the development of personalized dermatological care and skincare solutions. Products tailored to the unique biophysical needs of different age groups and body regions can enhance their effectiveness by addressing the specific challenges posed by hydration loss, elasticity decline, and barrier dysfunction. Dermatological interventions should be designed to counteract these changes with evidence-based approaches, such as incorporating humectants, emollients, and

barrier-repairing ingredients in skincare formulations [9].

Future research should focus on longitudinal studies that investigate the interaction of environmental factors, intrinsic aging processes,

and anatomical variations in skin properties over time. Such studies would provide valuable insights into how personalized skincare interventions can be optimized to support long-term skin health and resilience across different demographics.

**Table 1:** Skin aging factors and their impact.

Factor	Impact of aging	Variation by body location
<b>Hydration</b>	Declines due to reduced NMFs and lipids, leading to dryness (Li <i>et al.</i> , 2021).	Higher in sebaceous gland-rich areas like the forehead; lower in arms and legs (Farage <i>et al.</i> , 2008).
<b>Elasticity</b>	Decreases due to collagen and elastin degradation, causing wrinkles and sagging (Shin <i>et al.</i> , 2023).	Greater in thicker areas like soles; lower in periorbital region (Shin <i>et al.</i> , 2023).
<b>TEWL</b>	Increases, leading to weakened barrier function and susceptibility to irritation (Farage <i>et al.</i> , 2008).	Lower in sebaceous gland-rich areas, higher in drier regions (Farage <i>et al.</i> , 2008).
<b>Sebum Production</b>	Gradually diminishes, especially in post-menopausal women, causing drier skin (Krutmann <i>et al.</i> , 2017).	Higher in the T-zone; lower in arms and legs (Krutmann <i>et al.</i> , 2017).
<b>Stratum Corneum Thickness</b>	Thinner in aging skin, resulting in reduced barrier protection (Farage <i>et al.</i> , 2008).	Thicker on palms and soles; thinner on periorbital region (Shin <i>et al.</i> , 2023).
<b>Environmental Influence</b>	UV radiation and pollution accelerate skin aging, contributing to oxidative stress (Krutmann <i>et al.</i> , 2017).	More exposed areas experience accelerated aging effects (Krutmann <i>et al.</i> , 2017).

### 3. CONCLUSION

The biophysical properties of human skin are significantly influenced by age and anatomical location. Aging results in reduced hydration, elasticity, and sebum production, along with increased TEWL, leading to the characteristic dryness and fragility of aged skin. Different body sites exhibit distinct biophysical profiles due to variations in sebaceous gland density and environmental exposure. Understanding these variations is critical for dermatological research and the development of tailored skincare products. Future studies should continue to investigate the interplay of age, body location, and environmental factors to enhance personalized skincare solutions.

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#### CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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