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How obesity impacts the skin microbiome - Literature review

Marta Opalińska-Kubowicz

Provincial Specialist Hospital No. 3 in Rybnik, Poland

https://orcid.org/0009-0006-4125-8966

Kinga Popieralska

Private practice Gdańsk, Poland

https://orcid.org/0009-0009-7797-5301

Zuzanna Musialska

University Clinical Centre in Gdańsk, Poland

https://orcid.org/0009-0000-7916-614X

Yuliia Protsenko

Private practise

https://orcid.org/0009-0001-3356-7332

Marta Kowalska

University Hospital of Cracow, Poland

https://orcid.org/0009-0001-6676-5765

Magdalena Barczewska

Medical University of Lublin

https://orcid.org/0009-0004-1990-6096

Dominika Bieszczad

Medical University in Lublin, Poland

https://orcid.org/0009-0005-1475-617X

Anna Marczak

Private practice Gdańsk, Poland

https://orcid.org/0000-0003-2107-5469
Olga Stadnicka
Central Clinical Hospital in Łódź, Poland
https://orcid.org/0009-0008-9058-0868
Marzena Swojnóg
Private practice, Lodz, Poland
https://orcid.org/0009-0002-4363-7389
Adam Mazurek
Vizja University, Warsaw, Poland
https://orcid.org/0009-0007-9563-0468

Abstract

Background. Obesity is becoming an increasingly serious problem in society and affects an entire human body including skin. It potentially affects barrier integrity, immune responses and susceptibility to dermatoses.

Aim. This review aims to examine how obesity changes the composition and function of the skin microbiome and what are the possible consequences.

Material and methods. A research was performed in the PubMed and Google Scholar based on peer-reviewed studies published between 2017 – 2025 and focusing on phrases "skin microbiome", "obesity", and "skin diseases".

Results. Available studies indicate reduced microbial diversity, increased colonisation by opportunistic pathogens and overgrowth of yeasts on the skin of obese patients. Mechanical factors such as friction, sweating and elevated skin-fold temperature promote dysbiosis and inflammation. These changes are associated with dermatoses such as atopic dermatitis, intertrigo, folliculitis, seborrhoeic dermatitis and hidradenitis suppurativa. Treatment strategies include weight reduction, targeted skincare, antimicrobial treatment and new microbiome-modulating therapies.

Conclusions. Obesity significantly influences the skin microbiome, contributing to a higher risk of infections and inflammatory dermatoses. Although the understanding of these mechanisms is improving, further research, particularly involving metagenomics and metabolomics is needed to develop more precise preventive and therapeutic approaches.

Key words: obesity, skin microbiome, skin diseases, bacteria

1. Introduction

Obesity is one of the biggest public health challenges in the XXI century and its prevalence is steadily increasing in both developed and developing countries [1]. In 2022, one in eight people worldwide was obese. A study published in The Lancet estimates that by 2050, more than half of the population will be at least overweight [2]. Obesity is defined as an excessive accumulation of adipose tissue that has a negative impact on health [2]. It is recognised as a chronic disease with a complex etiology, involving interactions between genetic, metabolic, environmental and behavioural factors [3].

Emerging research emphasises the importance of the body's microbiome in physiological processes and in the pathogenesis of chronic diseases [4]. Although the gut microbiome remains the most intensively studied, an increasing number of empirical investigations examines the skin microbiome, which includes bacteria, fungi, viruses and mites [3]. Studies suggest that obesity affects the functioning of the epidermal barrier, inflammatory response and susceptibility to infections and dermatoses. At the same time, the skin of obese individuals is exposed to specific environmental conditions, namely increased sweating, higher skin fold temperature and a different lipid profile, which may further affect the composition and activity of the microbiome [5]. Understanding these mechanisms is important because many skin diseases can affect the quality of life. Recurrent infections or chronic dermatoses contribute to

physical discomfort, reduce self-confidence, limit daily activities and negatively influence overall well-being [6].

This paper aims to synthesise what is currently known in relation to the impact of obesity on the skin microbiome, discuss its potential clinical implications, and indicate directions for future research in this area. This analysis will contribute to a better understanding of the links between metabolic status and skin condition, as well as have a positive impact on personalized preventive and management strategies.

2. Research materials and methods

The literature for this review was collected using the PubMed and Google Scholar database. Publications were searched using combinations of the following keywords: obesity, skin microbiome, skin diseases, dysbiosis, skin barrier, fungal microbiome, probiotics and postbiotics. Filters were applied to include articles published between 2017 and 2025. Only studies addressing the relationship between obesity and skin microbiome composition, microbial dysbiosis, skin physiology or dermatological consequences were selected. Additional references were identified manually from the bibliographies of relevant papers to ensure proper coverage of the topic.

3. Research results

3.1 The skin microbiome

The microbiome is a collection of microorganisms that occur in a given habitat [7]. In the human body, we distinguish the following environments: the oral cavity, the digestive tract, the urogenital tract, the respiratory tract and the skin [8]. The skin microbiome includes microorganisms that colonise the surface of the epidermis, sebaceous glands and hair follicles [9]. The specific structure of the skin includes dry, exfoliating epidermis and a hydrolipid coat enriched with substances with antimicrobial properties (lysozyme, sebum). These factors create conditions that are unfavourable for the colonisation and multiplication of microorganisms. In addition, keratinocytes, mast cells and sweat gland cells produce a variety of antimicrobial peptides (AMPs) that limit the growth of microorganisms [10]. As a result, only a few species are able to permanently colonise this environment, which means that the composition and size

of the skin microbiome remain relatively constant [11]. It is primarily composed of four groups of bacteria: Actinobacteria, Firmicutes, Bacteroidetes and Proteobacteria. The dominant species is Staphylococcus epidermidis, which is approximately half of the entire microflora. There are also other coagulase-negative Staphylococci, as well as Corynebacterium, Propionibacterium and Micrococcus. Pathogenic bacteria, such as Staphylococcus aureus, Streptococcus pyogenes and Pseudomonas aeruginosa, may also be present on the skin. Infections may occur in cases of immunosuppression, antibiotic therapy or the presence of foreign bodies in the skin (e.g. a catheter). Fungi - dermatophytes (e.g. Microsporum, Trichophyton) and yeasts (e.g. Candida), viruses (Papillomaviridae, Polyomaviridae and Circoviridae) and mites also play a significant role [12]. The composition of the microbiome depends on skin type, moisture, anatomical location, age, gender, environmental factors and health status. Numerous studies have shown that Propionibacteria dominate in sebum-rich areas. In moist regions (armpits, popliteal fossae, navel) Corynebacterium and Staphylococcus are dominant. On the other hand, Proteobacteria colonise areas where the skin is dry [11,13]. Skin microbiome takes part in proper functioning of the skin barrier as it is a competition to pathogens. Other functions are lipid metabolism, protection from infections and maintaining proper skin pH [12]. Microbiological imbalance (dysbiosis) is associated with many dermatoses, such as atopic dermatitis, acne and psoriasis, and may also be an intermediary factor in the impact of systemic diseases on skin condition [10,15].

3.2 Obesity

Obesity is a chronic metabolic disorder resulting from a persistent imbalance between energy intake and expenditure. The etiology involves genetic, environmental, behavioural and neurohormonal factors. Mechanisms regulating appetite and energy metabolism play an important role. Disorders related to leptin dysfunction, insulin or ghrelin lead to the dysregulation of hunger and satiety, promoting excessive calorie consumption [16]. Obesity is also associated with neuroendocrine disorders, including hyperinsulinemia and changes in the hypothalamic-pituitary-adrenal axis [17]. Behavioural factors include high-calorie diet and sedentary lifestyle, psychosocial stress, disrupted sleep patterns [18]. When the amount of adipose tissue increases, it undergoes remodelling and dysfunction. Adipocytes enlarge and the local environment becomes a source of low-grade inflammation. Fat cells secrete excess pro-

inflammatory adipokines, such as TNF-α and IL-6, which promote insulin resistance and metabolic disorders [19]. The role of the gut microbiota is also an important aspect of pathogenesis. Reduced bacterial diversity and increased intestinal barrier permeability exacerbate inflammatory processes.

3.3 The changes in the skin microbiome in obese patients

Studies indicate that obese patients experience numerous changes in the composition of their skin microbiome, although these changes may vary between anatomical locations. The most consistent correlations noted include a decrease in microbial diversity, which can lead to colonisation of the skin by opportunistic pathogens. Studies have reported excessive growth of Staphylococcus aureus and Corynebacterium spp. in skin folds and moist areas [20]. When their numbers rise, the skin becomes more reactive and more vulnerable to inflammation. This helps explain why bacterial problems such as folliculitis, superficial infections, or persistent irritation are seen more often in these regions. In addition, reduced microbial diversity and S. aureus dominance may also exacerbate atopic dermatitis in individuals with obesity, contributing to more frequent flares and impaired barrier function [14]. Mechanical factors amplify these issues - overheating of skin folds, increased friction and maceration of the epidermis, all together can lead to abrasions and slow-healing wounds [21,22]. The altered structure of adipose tissue impairs microcirculation, which causes oedema and ulcers [23]. Changes in the skin microbiome are not limited to bacteria. Yeasts such as Candida and Malassezia also tend to flourish when moisture and occlusion are present [20]. Their overgrowth is connected with conditions including intertrigo, which manifests as redness, pruritus and sometimes painful erosions [24]; pityriasis versicolor, that can be identified by yellow-brown spots located mainly on the chest, caused by Malassezia spp.; and various other fungal infections. Obesity can also influence sweat and sebum production. Excess sebum can clog pores and disturb the balance of microbes living around hair follicles, supporting the development of acne. Changes in skin lipids and microbial activity may also play a role in seborrhoeic dermatitis, which presents with redness and flaking in oily areas [25]. At the same time, altered sweating patterns may lead to hyperhidrosis, and the extra moisture can worsen irritation and provide an even richer environment for microbes to grow [11]. Moreover, dysbiosis within the pilosebaceous unit is probably contributing to hidradenitis suppurativa, a condition associated with obesity, where

follicular occlusion and chronic inflammation are driven in part by microbial imbalance and impaired immune responses [26].

4. Discussion

As the relationship between obesity, dysbiosis and cutaneous inflammation becomes clearer, various prophylactic and therapeutic strategies should be considered to support the skin's microbial balance and improve its overall condition. Weight reduction seems to be one of the most fundamental interventions. The logical consequence of weight loss is reduction of the mechanical irritation within skin folds, more effective microcirculation and as a further result improvement in the composition of the skin microbiome. Complementary to systemic changes, daily hygiene and adequate skincare play a significant role. Regular cleansing with gentle cosmetics, careful drying of the skin and the use of emollients can limit moisture accumulation, enhance the skin barrier and promote a more stable microbial environment [27]. Products enriched with prebiotic or probiotic ingredients may further support the growth of beneficial microorganisms [28]. In cases where dysbiosis leads to active dermatoses, targeted treatment such as antibiotics for bacterial infections, becomes essential. Looking ahead, new treatment strategies are moving toward more targeted ways of adjusting the skin's microbiome. These include topical probiotics designed to introduce beneficial species [28] and experimental methods such as skin microbiome transplantation [29,30]. Another promising direction involves postbiotic preparations containing metabolites that are able to inhibit a pathogen colonization and as a consequence reintroduce a healthy microbiome [31]. Altogether, these approaches highlight the growing potential of microbiome-oriented strategies in preventing and managing skin conditions associated with obesity.

Despite growing interest in the skin microbiome in obese patients, several issues remain understudied and require further investigations. It is important to better understand the role of microorganisms other than bacteria, especially fungi and viruses [11], and how the interactions between species influence the development and severity of dermatoses in obesity. There is also a lack of data on the impact of various interventions, such as dietary changes, weight loss or the use of specific medications, on the microbial balance of the skin [10]. Such findings would help determine whether improving metabolic health can directly restore microbial balance or reduce susceptibility to skin disorders. In addition, modern research techniques, including

metagenomics and metabolomics, are only partially being used in this area, even though they have the potential to reveal detailed relationships between microorganisms, their metabolic activity and skin function in obese patients.

5. Conclusions

Obesity significantly changes both the composition and activity of the skin microbiome, contributing to a wide range of cutaneous disorders. The studies indicate that obese patients frequently exhibit reduced microbial diversity, increased colonisation by opportunistic pathogens and an environment that favours microbial overgrowth due to excess moisture, higher temperature in the skin folds and changes in lipid secretion. These alterations weaken the skin barrier, enhance inflammatory responses and increase susceptibility to bacterial, fungal and inflammatory dermatoses, including atopic dermatitis, intertrigo, seborrhoeic dermatitis and hidradenitis suppurativa. Understanding the mechanisms linking metabolic status, immune responses and microbial imbalance is essential for improving dermatological care in this population. Current therapeutic strategies focus on weight reduction, optimisation of hygiene practices, targeted treatment of infections and the use of skincare products supporting microbial balance. Emerging approaches aim to modulate the microbiome more precisely through topical probiotics, postbiotics or experimental interventions such as microbiome transplantation. However, several issues warrant further investigations. Firstly, the role of fungal and viral communities remains insufficiently researched. Secondly, it is necessary to assess how lifestyle modifications, dietary patterns and pharmacological interventions influence the skin microbiome, particularly in patients undergoing weight-loss therapies. Finally, further development of advanced analytical techniques, including metagenomics and metabolomics, will be crucial for creating more personalized strategies to prevent and manage skin conditions in obese individuals.

Disclosure

Supplementary Materials

Not applicable.

Author Contributions

Conceptualization: Marta Opalińska-Kubowicz, Olga Stadnicka
Methodology: Marta Opalińska-Kubowicz, Kinga Popieralska, Zuzanna Musialska, Marzena Swojnóg
Software: Anna Marczak
Check: Marta Kowalska, Yuliia Protsenko, Adam Mazurek
Formal analysis: Zuzanna Musialska, Magdalena Barczewska
Investigation: Marta Opalińska-Kubowicz, Adam Mazurek, Anna Marczak, Dominika Bieszczad
Resources: Marta Opalińska-Kubowicz, Marzena Swojnóg, Anna Marczak
Data Curation: Yuliia Protsenko
Writing - rough preparation: Marta Opalińska-Kubowicz, Marta Kowalska, Olga Stadnicka
Writing - review and editing: Marta Opalińska-Kubowicz, Marzena Swojnóg, Kinga Popieralska
Visualization: Dominika Bieszczad
Supervision: Dominika Bieszczad, Magdalena Barczewska
Project administration: Magdalena Barczewska
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