ORIGINAL ARTICLE

MJS PUBLISHING

Obesity: A Modulator in Acne Management

Jean Paul CLAUDEL[1], Fabienne BALLANGER[2], Nicole AUFFRET[3], Marie-Thérèse LECCIA[4] and Brigitte DRENO[5]
[1]Private practice, Tours, [2]Private practice, Talence, [3]Private practice, Paris, [4]Department of Dermatology, Allergology and Photobiology, CHU A Michallon, Grenoble, and [5]Nantes Université, INSERM, CNRS, Immunology and New Concepts in ImmunoTherapy, INCIT, UMR 1302/EMR6001, Nantes, France

Acne vulgaris **is an inflammatory and multifactorial skin disease involving the sebaceous gland and the skin microbiome. Different exposome factors, including hormonal and family factors, have been suggested to influence acne. Obesity is an increasingly observed condition worldwide, and is considered as a public health problem by the World Health Organization. Recently, a high body mass index has been identified as an acne severity risk factor in adolescents. A group of 5 dermatologists from different institutions and private practices from France involved in the research and clinical fields of acne analysed recent literature on "obesity and acne" focusing on epidemiology, the pathogenesis of acne and obesity, as well as the management of acne in obese patients. The authors selected, prior to their discussion in November and December 2024 and again in March 2025, and discussed 52 articles concerning acne and obesity published since 2000 and available from the PubMed database. The authors agreed that, considering these common metabolic features, managing both acne and obesity in parallel and helping patients through a global approach including dermatological, endocrinal, psychological and nutrition, as well as lifestyle support is mandatory, and may allow for the improvement of both acne and obesity. Moreover, in order to allow dermatologists to manage acne in obese patients in the most efficient way, the authors developed and propose a decision tree. The authors consider that acne in obese patients is not a fatality, and taking care of acne should not be considered an isolated task in this specific patient population.**

Key words: acne; comorbidities; obesity; polycystic ovary syndrome; hidradenitis suppurativa; management.

Submitted May 23, 2025. Accepted after revision Jul 19, 2025

Published Aug 21, 2025. DOI: 10.2340/actadv.v105.43945

Acta Derm Venereol 2025; 105: adv43945.

Corr: Brigitte Dréno, Nantes Université, INSERM, CNRS, Immunology and New Concepts in ImmunoTherapy, INCIT, UMR 1302/EMR6001, FR-44000 Nantes, France. E-mail: brigitte.dreno@atlanmed.fr

SIGNIFICANCE

- A relationship between acne and obesity exists.
- In addition to adapted treatment, management of acne in obese patients needs specific lifestyle, nutritional, and psychological help.
- Practical and easy to-follow treatment recommendations for acne in obese patients are proposed.

Acne vulgaris (acne) is a chronic and inflammatory disease of the pilosebaceous follicle. The sebaceous gland and the skin microbiome play a crucial role in its evolution. Different exposome factors, including hormonal and family factors, have been suggested to condition its severity and management (1). Epidemiological and basic scientific studies have shown that acne is frequently associated with comorbidities that modulate its severity and evolution, requiring a holistic management approach (2).

Being overweight in adults has been defined as having a BMI between 25 and 29.9 kg/m², and being obese corresponds to having a BMI above 30 kg/m² (3). The World Health Organization reported that in 2016 more than 1.9 billion adults were overweight and, of these, over 650 million were obese. As a result, obesity has become a major public health problem worldwide, contributing to cardiovascular and cerebrovascular disease, diabetes, and hypertension (4). Moreover, obesity was highlighted as increasing the risk of acne, with a high BMI being a risk factor for acne severity in adolescents (5).

Within this context, recently published data and expert experience in the domain of acne will help to increase the understanding of the link between acne and obesity, and their impact on the management of acne. To allow dermatologists to manage acne in obese patients in the most efficient way, a decision tree is proposed.

MATERIAL AND METHODS

A group of 5 dermatologists from different institutions and private practices from France involved in the research and clinical fields of acne analysed recent literature on "obesity and acne" focusing on epidemiology, the pathogenesis of acne and obesity, as well as the management of acne in obese patients.

The authors selected, prior to their discussion in November and December 2024 and again in March 2025, and discussed 52 articles, primarily in English language of any size, including original articles and reviews concerning acne and obesity published since 2000 and available from the PubMed data base. Key words included different combinations of the following: acne, obesity, comorbidities, skin, microbiome, hormones, polycystic (PCOS) syndrome, metabolic syndrome (MetS).

Based on analysed literature data and on their own experience, the experts developed an acne management decision tree for obese patients.

RESULTS

Shared physiopathology features of acne and obesity

In acne, quantitative and qualitative modifications of sebum induce a dysbiosis of the skin microbiome, characterized by the loss of diversity of *Cutibacterium acnes* (*C. acnes*) phylotypes. Phylotype 1A1 becomes the predominant phylotype, characterized by a virulent profile. However, acne is not associated with a proliferation of *C. acnes*. The loss of diversity of phylotypes activates the innate immunity with the secretion of cytokines, mainly I IL-8, IL-17, TNF, IL-1, and MMPs by keratinocytes and sebocytes, resulting in the development of both retentional and inflammatory lesions (6).

Acne is a multi-gene and multi-target disease (7). RETN-420 and IL6-572 gene polymorphisms are closely related to acne susceptibility, and RETN-420G and IL6-572C alleles increase the risk of acne (8). These 2 gene polymorphisms also cause metabolic diseases including obesity and type 2 diabetes, as well as cardiovascular diseases and cancer (9, 10). In addition, tumour necrosis factor (TNF)-α rs1800629 (308 G/A) has been associated with obesity and has been shown to increase susceptibility to acne (11). In obese subjects, adipose tissues secrete pro-inflammatory cytokines including TNF-α and interleukins. As a result, this chronic systemic inflammation may trigger inflammation in acne, and thus worsen the condition.

Rapamycin complex 1 (mTORC1) is involved in the onset and development of metabolic diseases including obesity in inducing lipid synthesis by activating the transcription factor sterol regulatory element-binding protein 1 (SREBP1), which also plays a role in acne (12). In acne, mTORC1 stimulates the expression of the peroxisome proliferator-activated receptor-γ (PPARγ) and sterol response element binding protein-1c (SREBP-1c), triggering the production of sebum. Moreover, SREBP-1c upregulates stearoyl-CoA- and Δ6-desaturase, increasing the proportion of monounsaturated fatty acids in sebum triglycerides. Finally, hyperseborrhoea and dysseborrhoea promote *C. acnes* overgrowth and biofilm formation (13).

Obesity impacts the innate immune function of the white adipose tissue that plays a key role in the differentiation of Th17 cells. In obese compared with non-obese subjects, the number of T-helper (Th) 17 cells in the adipose tissue increases with the Th17 cell signalling pathway, which is also known to be involved in the acne pathway (14).

Obesity is frequently accompanied by insulin resistance, leading to elevated insulin levels (15). Hyperinsulinemia has been reported to stimulate androgen production and increase the bioavailability of insulin-like growth factor 1 (IGF-1), both of which enhance sebaceous gland activity and keratinocyte proliferation, contributing to acne development (16).

Nutrition, including high sugar, carbohydrate, and high dairy intake, triggers both acne and obesity (12). While genetic or family factors may impact acne and obesity differently, nutritional factors increase insulin and IGF-1 levels, leading to an over-activation of mTORC1 signalling, resulting in acne, insulin resistance, and an increased BMI (12, 17) as already described above.

Obese and overweight individuals may produce higher androgen levels, which may also trigger sebum production and, potentially, the formation of acne lesions (18).

Another hypothesis claims that the link between acne and obesity is modulated by increased concentrations of oxidative stress markers, observed for both conditions. An increased level of reactive oxygen species damages cellular components and triggers inflammation, promoting acne and obesity (19).

Dysbiosis of the skin microbiome may be frequently observed in obese patients, which can play a role in the chronic evolution of the inflammatory lesions that are frequent in acne patients (20).

Research currently investigates the relationship between acne and the gut microbiota (21). Available data suggest a potential link between Western diet, a risk factor of obesity, and dysbiosis leading to an increased sebogenesis, providing an optimal environment for the development of *C. acnes* and a low bacterial diversity in the gut microbiota of the Western urban industrialized population (22, 23). Moreover, dysbiosis of the gut microbiota induces inflammation, oxidative stress, substance P secretion, decreases insulin sensitivity, and triggers excessive sebum production. All can be observed in both acne and obesity (24). **Fig. 1** shows shared physiopathology features between acne and obesity.

Relationship between acne and BMI

Four studies and reviews reported that acne severity may worsen with an increasing BMI (25–28). However, these findings were contradicted by data from 2 studies which report that acne is not correlated with an increased BMI (29, 30). Despite these contradictory data, a relationship between acne severity and a high BMI may potentially exist. However, no specific acne profile of acne associated with obesity has been demonstrated.

Acne and obesity as comorbidities

Acne and obesity are frequently observed comorbidities in MetS and PCOS patients. Prior to any decision to treat acne, MetS or PCOS, this should always be confirmed, as it allows practitioners to choose the correct global management of patients (31).

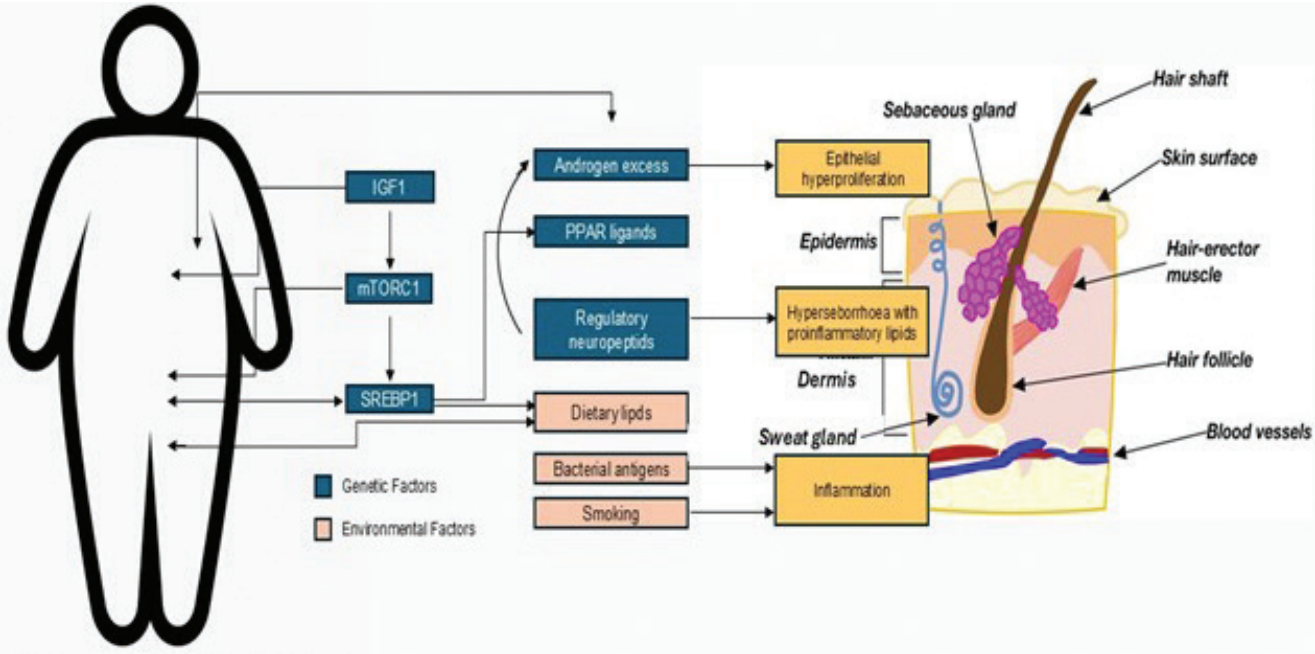

Fig. 1. Shared physiopathology between acne and obesity. IGF1: insulin-like growth factor 1; mTORC1: mammalian target of rapamycin complex 1; SREBP: sterol regulatory element-binding protein; PPAR: peroxisome proliferator-activated receptor.

Metabolic syndrome. MetS is characterized by a range of metabolic risk factors, including central obesity, dyslipidaemia, impaired glucose metabolism, elevated blood pressure, and low levels of high-density lipoprotein cholesterol (HDL-c), associated with chronic low-grade systemic inflammation (32).

MetS is diagnosed according to the International Diabetes Federation (IDF) and includes central obesity (waist circumference criteria), plus 2 of the following: elevated triglycerides, reduced HDL-cholesterol, hypertension, or elevated fasting glucose (≥ 100 mg/dL or diagnosed diabetes) (32).

Polycystic ovary syndrome (PCOS). While acne and obesity may have common causes in both males and females, in females they can be clinical signs of PCOS (33). PCOS is a heterogeneous, reproductive endocrine disorder that is characterized by hyperandrogenism, hirsutism, oligo-anovulation, and metabolic abnormalities (34). Symptoms may vary throughout the life of the patient. PCOS is one of the most common endocrine disorders among reproductive-aged women, affecting 10–15% of this population in whom it is frequently accompanied by insulin resistance and increased cardiovascular risk (35).

To diagnose PCOS, use of the modified Rotterdam criteria is recommended (36). PCOS may be confirmed if any 2 of the following are confirmed: (*i*) clinical or biochemical hyperandrogenism, (*ii*) evidence of oligo-anovulation, (*iii*) polycystic appearing-ovarian morphology on ultrasound, with exclusion of other relevant disorders.

Early identification of menstrual irregularities or hyperandrogenic signs may help to prevent PCOS and PCOS-related comorbidities.

Acne treatment in obese patients

We hereafter propose an algorithm for the management of acne in obese patients.

Induction step. The management of acne in obese patients requires a personalized therapy strategy. This strategy may be grounded in a structured algorithm based on a stratification of the BMI, acne type, and the presence or not of MetS or PCOS. The dermatologist may prescribe specific blood tests (lipides, insulin, as well as hormonal markers) that confirm these metabolic diseases. Moreover, a longitudinal follow-up including lifestyle (nutrition and exercise) changes may allow for the improvement of both acne and obesity. Acne severity should be assessed using current assessment tools that were specifically developed for daily clinical practice, including ECLA, GEA, AFAST, and TRASS (37–40). **Fig. 2** proposes a decision pathway for obese patients consulting for acne.

In patients with a BMI below 30 kg/m² and without metabolic comorbidities, acne management should always follow conventional acne guidelines, without modifying them. In patients with a BMI of at least 30kg / m², or in patients with clinically diagnosed PCOS or diabetes, we recommend systematic metabolic screening, including HbA1c, fasting glucose, and lipid profile, prior to any prescription.

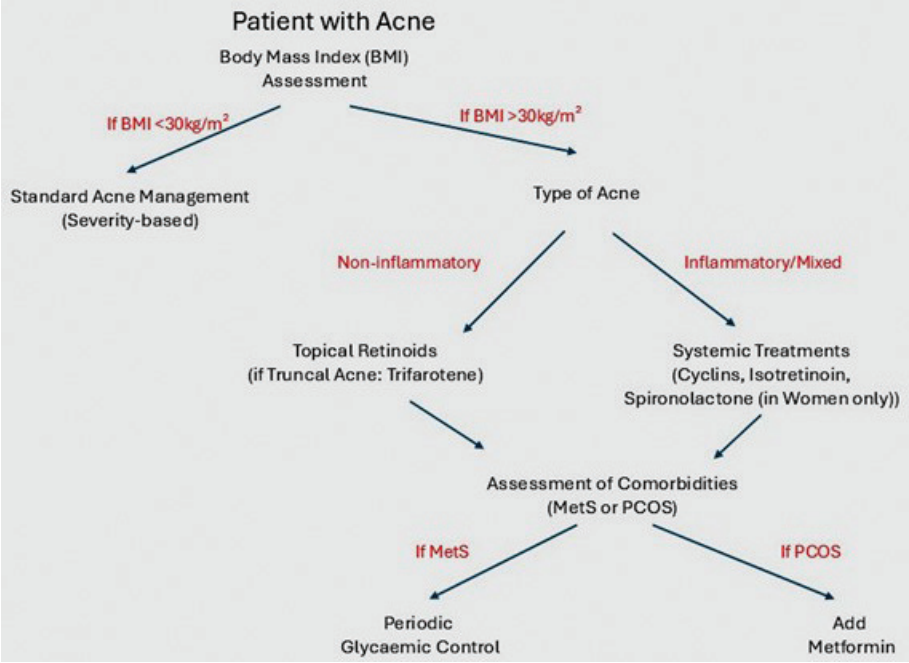

Fig. 2. Proposed treatment pathway for obese patients consulting for acne. All treatment decisions should include adjuvant adapted skin care including the use of specific cleansers and moisturizing creams. Moreover, patients should be advised to avoid exfoliation, masks, scrubs, and essential oils.

In obese patients with mild acne, the use of topical treatment remains first choice. These treatments include retinoids and benzoyl peroxide.

We recommend an early use of systemic treatments for moderate to severe inflammatory acne forms. In obese patients, standard dosing recommendations for both cyclins and isotretinoin should be maintained. To date, there is no scientific ratio to increase doses and, therefore, in order to avoid resistance of *C. acnes* to cyclins, the daily treatment dose of oral cyclins and total duration should respect treatment indications as per guidelines (41). Doxycycline should be prescribed at 100 mg once daily, without a dose escalation. When prescribing isotretinoin (2 mg/kg), current treatment and dose recommendations should be followed (42). Treatment with oral isotretinoin should always be accompanied by regular dosing of triglycerides and assessment of cholesterol levels, to avoid systemic side effects related to treatment.

Truncal acne may be more frequently observed in obese patients (25, 28). Topical retinoids that have been approved for the treatment of truncal acne, such as trifarotene, could be of interest as first-intention treatment (43). In women with diagnosed PCOS, metformin should be considered to treat acne, based on the advice of an endocrinologist. Metformin is an insulin-sensitizing agent, indicated to treat PCOS in overweight or obese women (36) Metformin reduces insulin resistance, as well as circulating androgen levels, and can thus indirectly contribute to reduce acne. Moreover, low-androgenic oral contraceptives may improve acne in patients with PCOS.

Due to its anti-androgen potential, spironolactone at low doses (i.e., 100–150 mg/day) may be indicated as an alternative to oral isotretinoin and oral cyclins as first-line treatment in women with peripheral hyperandrogenism (44). However, currently, there are no published data to support the increase of spironolactone in obese patients.

Long-term management. Long-term monitoring of acne in obese patients should include, at baseline, the assessment of BMI and blood pressure, as well as blood testing of HbA1c, fasting glucose, lipid panel, anti-Müllerian hormone, if PCOS is suspected, as well as lifestyle (i.e., diet, exercise) recommendations (45). Dietary adjustments should always be part of a global management strategy alongside dermatological treatment. A low-glycaemic load diet reduces acne severity by modulating insulin and IGF-1 levels (46). Therefore, nutritional interventions that target insulin resistance can be especially beneficial in overweight and obese patients, contributing to both acne improvement and metabolic health. Obese acne patients should also be advised to reduce high-glycaemic index foods (such as sugary drinks, white bread, processed foods) and should be encouraged to consume fibre-rich vegetables, wholegrain bread, and healthy lipids (47). Dairy products that exacerbate acne through IGF-1 pathways, especially skimmed milk, should also be limited (13).

Follow up management. Currently, there are no specific recommendations for the follow-up of acne treatment

in obese patients. Therefore we propose the following follow-up management.

After 3 months of treatment, acne severity should be reassessed. Moreover, blood lipid and liver enzyme levels should be tested, especially if the patient has received or continues to receive systemic acne treatments (e.g., isotretinoin). The patient's lifestyle should be verified and modifications initiated, if necessary.

Every 6 months, metabolic parameters should be tested and lifestyle modifications adjusted. In addition, we propose an annual follow-up that includes, in addition to the assessments made every 6 months, screening for MetS, especially in patients with persistent acne or with a BMI that has increased despite management.

Contraception in obese patients does not differ from that of the general acne patient population. Combined oral contraceptives (COCs) containing low-androgenic progestins (e.g., drospirenone, desogestrel) should always be preferred, as they offer a synergistic anti-androgen effect, which is beneficial for acne control, while progesterone-only contraceptive methods are not recommended due to their potential to worsen acne (48).

Adjuvant management

To rebalance the natural skin barrier, reduce dysbiosis, and restore the commensal diversity of the skin microbiome of both the face and trunk, the use of specific dermocosmetic cleansers that respect the natural skin pH of 5 should be favoured over soap bars and other unsuitable skin cleansers (i.e., those containing perfume) (49). Non-comedogenic moisturisers should be applied in the morning. Exfoliation, masks, scrubs, and essential oils should be avoided, as they increase dysbiosis.

Table I. Summary guidance for the global management approach of acne in obese patients

Guidance for a holistic management approach of acne in obese patients
1. At the first patient visit, check with the patient if any specific nutritional advice/regimes have been proposed to manage obesity. Following low sugar, carbohydrate, and dairy regimens may not only be beneficial in obesity but may also improve acne. Should the patient not follow any specific regimen, than advice may be given to consult a nutritionist
2. Engage in a discussion to evaluate the mental health status of the patient. This is of importance as the patient may have his/her quality of life heavily impacted by obesity with acne adding a further burden to the obesity. Should the patient's quality of life be heavily impacted and the patient has not asked for any psychological support, then psychological help may be suggested
3. Check with the patient regarding any tobacco consumption. Tobacco impacts on acne onset. Moreover, ask the patient about corporal hygiene routine. The use of comedogenic cleansers and cosmetics should be discussed
4. Prior to any prescription of acne medication, especially systemic acne treatments including antibiotics, hormonal treatments, and oral isotretinoin, please make sure that the patient: • reports all potential treatments that were prescribed to treat his/her obesity or obesity-related comorbidities • has a blood serum and plasma screening to verify blood glycaemic and lipid as well as hormone levels (anti-Müllerian hormone in female individuals only)
5. Once blood glycaemic, lipid, and hormone levels have been confirmed and a differential diagnosis has been made to rule out acne-like conditions that may require different treatment options, adequate treatment should be chosen based on current guidelines and proposed treatment algorithms

Table I provides a summarized take-away regarding guidance tasks for the proposed holistic acne management approach in obese patients

DISCUSSION

Acne is one of the most frequently observed skin diseases worldwide affecting all ages, genders, and phototypes (2). While the link between acne severity and obesity is still not completely confirmed, several indicators signal some mutual disease pathways.

Considering these common metabolic features, managing both acne and obesity in parallel and helping patients through a global approach is mandatory, and may allow for the improvement of both acne and obesity. This approach consists not only in providing medical care for their diseases by prescribing the most suitable treatments according to the severity of their acne and obesity, but also by providing psychological, endocrinological, and psychological support, as well as motivating the patient to do regular physical exercise and follow a suitable diet. Even if lifestyle changes may not help to directly cure acne or obesity, they may help to stimulate the patients' metabolism and improve their physical and mental well-being, and thus encourage them to take care of their acne and obesity.

Moreover, supplementation with probiotics such as *Lactobacillus* and *Bifidobacterium* may be beneficial in both acne and obesity (50, 51). Kwon et al. showed that the generation of regulatory dendritic cells and CD4+Foxp3+ T cells by probiotics administration suppressed immune disorders through the enrichment of CD4(+)Foxp3(+) Tregs in the inflamed regions (52).

Acne in obese patients is not a fatality, and taking care of acne should not be considered an isolated task in this specific patient population.

ACKNOWLEDGEMENTS

The authors acknowledge the writing support of Karl Patrick Göritz, SMWS, France.

Funding: This work was supported by Galderma International, France.

Conflict of interest: The expert board is supported by Galderma International, France.

REFERENCES

1. Dreno B, Bettoli V, Araviiskaia E, Sanchez Viera M, Bouloc A. The influence of exposome on acne. J Eur Acad Dermatol Venereol 2018; 32: 812–819. https://doi.org/10.1111/jdv.14820
2. Wang Y, Zhu M, Wu S, Zheng H. Acne comorbidities. Clin Cosmet Investig Dermatol 2022; 15: 2415–2420. https://doi.org/10.2147/CCID.S392165
3. Jensen MD, Ryan DH, Apovian CM, Ard JD, Comuzzie AG, Donato KA, et al. 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Asso-

ciation Task Force on Practice Guidelines and The Obesity Society. J Am Coll Cardiol 2014; 63: 2985–3023. https://doi.org/10.1161/01.cir.0000437739.71477.ee
4. Alan S, Cenesizoglu E. Effects of hyperandrogenism and high body mass index on acne severity in women. Saudi Med J 2014; 35: 886–889.
5. Rodriguez Baisi KE, Weaver AL, Shakshouk H, Tollefson MM. Acne incidence in preadolescents and association with increased body mass index: a population-based retrospective cohort study of 643 cases with age- and sex-matched community controls. Pediatr Dermatol 2023; 40: 428–433. https://doi.org/10.1111/pde.15223
6. Dréno B. What is new in the pathophysiology of acne, an overview. J Eur Acad Dermatol Venereol 2017; 31 Suppl 5: 8–12. https://doi.org/10.1111/jdv.14374
7. Elsaie ML, Aly DG. The immunogenetics of acne. Adv Exp Med Biol 2022; 1367: 137–154. https://doi.org/10.1007/978-3-030-92616-8_6
8. Chen X, Min S, Chen C, Lin X, Wang D, Jiang G. Influence of RETN, IL-1, and IL-6 gene polymorphisms on the risk of acne vulgaris in the Chinese population. J Cosmet Dermatol 2022; 21: 4965–4973. https://doi.org/10.1111/jocd.14911
9. Rathwa N, Patel R, Palit SP, Ramachandran AV, Begum R. Genetic variants of resistin and its plasma levels: association with obesity and dyslipidemia related to type 2 diabetes susceptibility. Genomics 2019; 111: 980–985. https://doi.org/10.1016/j.ygeno.2018.06.005
10. Harun-Or-Roshid M, Ali MB, Jesmin, Mollah MNH. Statistical meta-analysis to investigate the association between the Interleukin-6 (IL-6) gene polymorphisms and cancer risk. PLoS One 2021; 16: e0247055. https://doi.org/10.1371/journal.pone.0247055
11. AbdElneam AI, Alhajlah S, Al-Dhubaibi MS, Bahaj SS, Mohammed GF, Alantry AK, et al. In severe acne vulgaris, TNF-α gene variants are connected to increased TNF-α gene expression and insulin resistance. Skin Res Technol 2024; 30: e13811. https://doi.org/10.1111/srt.13811
12. Melnik BC. Acne vulgaris: the metabolic syndrome of the pilosebaceous follicle. Clin Dermatol 2018; 36: 29-40. https://doi.org/10.1016/j.clindermatol.2017.09.006
13. Melnik BC. Linking diet to acne metabolomics, inflammation, and comedogenesis: an update. Clin Cosmet Investig Dermatol 2015; 8: 371–388. https://doi.org/10.2147/CCID.S69135
14. Cheng Z, Xiong X, Wu F, Zhao Y, Dong R, Jiang S, et al. Network pharmacology research indicates that Wu-Mei-Wan treats obesity by inhibiting Th17 cell differentiation and alleviating metabolic inflammation. Comb Chem High Throughput Screen 2023; 26: 30–48. https://doi.org/10.2174/1386207325666220221121919
15. González-Saldivar G, Rodríguez-Gutiérrez R, Ocampo-Candiani J, González-González JG, Gómez-Flores M. Skin manifestations of insulin resistance: from a biochemical stance to a clinical diagnosis and management. Dermatol Ther (Heidelb) 2017; 7: 37–51. https://doi.org/10.1007/s13555-016-0160-3
16. Okoro OE, Camera E, Flori E, Ottaviani M. Insulin and the sebaceous gland function. Front Physiol 2023; 14: 1252972. https://doi.org/10.3389/fphys.2023.1252972
17. Danby FW. Turning acne on/off via mTORC1. Exp Dermatol 2013; 22: 505–506. https://doi.org/10.1111/exd.12180
18. Karciauskiene J, Valiukeviciene S, Gollnick H, Stang A. The prevalence and risk factors of adolescent acne among schoolchildren in Lithuania: a cross-sectional study. J Eur Acad Dermatol Venereol 2014; 28: 733–740. https://doi.org/10.1111/jdv.12160
19. Bungau AF, Radu AF, Bungau SG, Vesa CM, Tit DM, Endres LM. Oxidative stress and metabolic syndrome in acne vulgaris: pathogenetic connections and potential role of dietary supplements and phytochemicals. Biomed Pharmacother 2023; 164: 115003. https://doi.org/10.1016/j.biopha.2023.115003
20. Palanivel JA, Millington GWM. Obesity-induced immunological effects on the skin. Skin Health Dis 2023; 3: e160. https://doi.org/10.1002/ski2.160
21. Sánchez-Pellicer P, Navarro-Moratalla L, Núñez-Delegido E, Ruzafa-Costas B, Agüera-Santos J, Navarro-López V. Acne, microbiome, and probiotics: the gut–skin axis. Microorganisms 2022; 10: 1303. https://doi.org/10.3390/microorganisms10071303
22. Deng Y, Wang H, Zhou J, Mou Y, Wang G, Xiong X. Patients with acne vulgaris have a distinct gut microbiota in comparison with healthy controls. Acta Derm Venereol 2018; 98: 783–790. https://doi.org/10.2340/00015555-2968
23. Yan HM, Zhao HJ, Guo DY, Zhu PQ, Zhang CL, Jiang W. Gut microbiota alterations in moderate to severe acne vulgaris patients. J Dermatol 2018; 45: 1166–1171. https://doi.org/10.1111/1346-8138.14586
24. Bowe WP, Logan AC. Acne vulgaris, probiotics and the gut–brain–skin axis: back to the future? Gut Pathog 2011; 3: 1. https://doi.org/10.1186/1757-4749-3-1
25. Sas K, Reich A. High body mass index is a risk factor for acne severity in adolescents: a preliminary report. Acta Dermatovenerol Croat 2019; 27: 81–85.
26. Anaba LE, Ogunbiyi OA, George OA. Adolescent facial acne vulgaris and body mass index: any relationship? West Afr J Med 2019; 36: 129–132.
27. Heng AHS, Chew FT. Systematic review of the epidemiology of acne vulgaris. Sci Rep 2020; 10: 5754. https://doi.org/10.1038/s41598-020-62715-3
28. Witkam W, Dal Belo SE, Pourhamidi S, Raynaud E, Moreau M, Aguilar L, et al. The epidemiology of acne vulgaris in a multiethnic adolescent population from Rotterdam, the Netherlands: a cross-sectional study. J Am Acad Dermatol 2024; 90: 552–560. https://doi.org/10.1016/j.jaad.2023.10.062
29. Snast I, Dalal A, Twig G, Astman N, Kedem R, Levin D, et al. Acne and obesity: a nationwide study of 600,404 adolescents. J Am Acad Dermatol 2019; 81: 723–729. https://doi.org/10.1016/j.jaad.2019.04.009
30. Halvorsen JA, Vleugels RA, Bjertness E, Lien L. A population-based study of acne and body mass index in adolescents. Arch Dermatol 2015; 148: 131–132. https://doi.org/10.1001/archderm.148.1.131
31. Tamer F. Do patients with acne tend to have increased body fat? Comparison of body composition analysis of patients with acne vulgaris and healthy individuals: a prospective case control study. Arch Dermatol Res 2024; 316: 602. https://doi.org/10.1007/s00403-024-03354-w
32. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation 2009; 120: 1640–1645. https://doi.org/10.1161/CIRCULATIONAHA.109.192644
33. Zeng X, Xie YJ, Liu YT, Long SL, Mo ZC. Polycystic ovarian syndrome: correlation between hyperandrogenism, insulin resistance and obesity. Clin Chim Acta 2020; 502: 214–221. https://doi.org/10.1016/j.cca.2019.11.003
34. Rudnicka E, Kunicki M, Calik-Ksepka A, Suchta K, Duszewska A, Smolarczyk K, et al. Anti-Müllerian hormone in pathogenesis, diagnostic and treatment of PCOS. Int J Mol Sci 2021; 22: 12507. https://doi.org/10.3390/ijms222212507
35. Neven ACH, Laven J, Teede HJ, Boyle JA. A summary on polycystic ovary syndrome: diagnostic criteria, prevalence, clinical manifestations, and management according to the latest international guidelines. Semin Reprod Med 2018; 36: 5–12. https://doi.org/10.1055/s-0038-1668085
36. Teede HJ, Misso ML, Costello MF, Dokras A, Laven J, Moran L, et al. Recommendations from the international evidence-based guideline for the assessment and management of polycystic ovary syndrome. Hum Reprod 2018; 33: 1602–1618. https://doi.org/10.1093/humrep/dey256
37. Auffret N, Nguyen JM, Leccia MT, Claudel JP, Dréno B. TRASS: a global approach to assess the severity of truncal acne. J

Eur Acad Dermatol Venereol 2022; 36: 897–904. https://doi.org/10.1111/jdv.18009
38. Dreno B, Bodokh I, Chivot M, Daniel F, Humbert P, Poli F, et al. [ECLA grading: a system of acne classification for every day dermatological practice]. Ann Dermatol Venereol 1999; 126: 136–141.
39. Auffret N, Claudel JP, Leccia MT, Poli F, Farhi D, Dréno B. AFAST – Adult Female Acne Scoring Tool: an easy-to-use tool for scoring acne in adult females. J Eur Acad Dermatol Venereol 2016; 30: 824–828. https://doi.org/10.1111/jdv.13518
40. Dreno B, Poli F, Pawin H, Beylot C, Faure M, Chivot M, et al. Development and evaluation of a Global Acne Severity Scale (GEA Scale) suitable for France and Europe. J Eur Acad Dermatol Venereol 2011; 25: 43–48. https://doi.org/10.1111/j.1468-3083.2010.03685.x
41. Nast A, Dreno B, Bettoli V, Bukvic Mokos Z, Degitz K, Dressler C, et al. European evidence-based (S3) guideline for the treatment of acne: update 2016 – short version. J Eur Acad Dermatol Venereol 2016; 30: 1261–1268. https://doi.org/10.1111/jdv.13776
42. Tallmadge M, Patel A, Liegl MN, Pan A, Barbeau J, Lalor L. Isotretinoin use for acne in obese and overweight young people: a retrospective study. J Am Acad Dermatol 2022; 87: 461–464. https://doi.org/10.1016/j.jaad.2021.10.012
43. Del Rosso JQ, Lain E, York JP, Alexis A. Trifarotene 0.005% cream in the treatment of facial and truncal acne vulgaris in patients with skin of color: a case series. Dermatol Ther (Heidelb) 2022; 12: 2189–200. https://doi.org/10.1007/s13555-022-00788-w
44. Dréno B, Nguyen JM, Hainaut E, Machet L, Leccia MT, Beneton N, et al. Efficacy of spironolactone compared with doxycycline in moderate acne in adult females: results of the multicentre, controlled, randomized, double-blind prospective and parallel Female Acne Spironolactone vs doxyCycline Efficacy (FASCE) study. Acta Derm Venereol 2024; 104: adv26002. https://doi.org/10.2340/actadv.v104.26002
45. Melnik BC. Diet in acne: further evidence for the role of nutrient signalling in acne pathogenesis. Acta Derm Venereol 2012; 92: 228–231. https://doi.org/10.2340/00015555-1358
46. Burris J, Shikany JM, Rietkerk W, Woolf K. A Low glycemic index and glycemic load diet decreases insulin-like growth factor-1 among adults with moderate and severe acne: a short-duration, 2-week randomized controlled trial. J Acad Nutr Diet 2018; 118: 1874–1885. https://doi.org/10.1016/j.jand.2018.02.009
47. Bertolani M, Rodighiero E, Saleri R, Pedrazzi G, Bertoli S, Leone A, et al. The influence of Mediterranean diet in acne pathogenesis and the correlation with insulin-like growth factor-1 serum levels: implications and results. Dermatol Reports 2022; 14: 9143. https://doi.org/10.4081/dr.2022.9143
48. Williams NM, Randolph M, Rajabi-Estarabadi A, Keri J, Tosti A. Hormonal contraceptives and dermatology. Am J Clin Dermatol 2021; 22: 69–80. https://doi.org/10.1007/s40257-020-00557-5
49. Towersey L, Correia P, Fajgenbaum Feiges M, Euzébio Gonçalves Junior J, Sant'Anna B, Kerob D, et al. Assessment of the benefit of a deep cleansing gel containing salicylic acid 2%, zinc gluconate 0.2% and lipohydroxy acids 0.05% in patients with mild to moderate truncal acne: results from an exploratory study. Clin Cosmet Investig Dermatol 2023; 16: 119–123. https://doi.org/10.2147/CCID.S394123
50. Sanchez M, Darimont C, Drapeau V, Emady-Azar S, Lepage M, Rezzonico E, et al. Effect of Lactobacillus rhamnosus CGMCC1.3724 supplementation on weight loss and maintenance in obese men and women. Br J Nutr 2014; 111: 1507–1519. https://doi.org/10.1017/S0007114513003875
51. Uusitupa HM, Rasinkangas P, Lehtinen MJ, Mäkelä SM, Airaksinen K, Anglenius H, et al. Bifidobacterium animalis subsp. lactis 420 for metabolic health: review of the research. Nutrients 2020; 12: 892. https://doi.org/10.3390/nu12040892
52. Kwon HK, Lee CG, So JS, Chae CS, Hwang JS, Sahoo A, et al. Generation of regulatory dendritic cells and CD4+Foxp3+ T cells by probiotics administration suppresses immune disorders. Proc Natl Acad Sci U S A 2010; 107: 2159–2164. https://doi.org/10.1073/pnas.0904055107