Publisher
Maharshi Charaka Ayurveda
www.maharshicharaka.in

E-ISSN:2456-3110

Journal of Ayurveda and Integrated Medical Sciences

2025 Volume 10 Number 2 FEBRUARY

Review Article

Acne Vulgaris

Check for updates

Exploring the relationship between Gut Dysbiosis and Acne Vulgaris in Adolescence and Young Adults: A Narrative Review

Sanjita K[1*], Lakshmeesha DR[2], Prajna[3], Swathi S[4]

DOI:10.21760/jaims.10.2.24

[1*] Konsam Sanjita, Post Graduate Scholar, Department of Naturopathy, Alva's College of Naturopathy and Yogic Sciences, Moodabidri, Dakshina Kannada, Karnataka, India.

[2] Lakshmeesha DR, Associate Professor, Alva's College of Naturopathy and Yogic Sciences, Moodabidri, Dakshina Kannada, Karnataka, India.

[3] Prajna, Associate Professor, Alva's College of Naturopathy and Yogic Sciences, Moodabidri, Dakshina Kannada, Karnataka, India.

[4] Swathi S, Assistant Professor, Alva's College of Naturopathy and Yogic Sciences, Moodabidri, Dakshina Kannada, Karnataka, India.

Acne vulgaris is a common skin condition, particularly in adolescents and young adults, resulting from clogged hair follicles due to excess sebum and dead skin cells. While its causes include genetic, hormonal, and environmental factors, recent research suggests gut dysbiosis plays a significant role in acne development. This review examines the connection between gut microbiota imbalance and acne, focusing on the gut-skin axis, where disruptions in the gut microbiome can trigger systemic inflammation and affect skin health. Dysbiosis may compromise both the gut and skin barriers, contributing to acne through inflammation, altered lipid metabolism, and immune dysfunction. Factors like diet, antibiotics, and stress can worsen this imbalance. Interventions such as probiotics, prebiotics, and dietary changes show promise in managing acne by restoring gut health and reducing inflammation. This review also highlights the importance of understanding the gut-skin axis in acne treatment and alternative therapies such as acupuncture, herbal medicine, and naturopathic approaches in managing acne vulgaris. Further research is needed to elucidate the exact mechanisms and therapeutic potentials of gut-skin interactions in acne management.

Keywords: Acne vulgaris, Gut Dysbiosis, Gut - skin axis, Naturopathy treatment

Corresponding Author

Konsam Sanjita, Post Graduate Scholar, Department of Naturopathy, Alva's College of Naturopathy and Yogic Sciences, Moodabidri, Dakshina Kannada, Karnataka, India.

Email: sanjitakonz@gmail.com

How to Cite this Article

Sanjita K, Lakshmeesha DR, Prajna, Swathi S, Exploring the relationship between Gut Dysbiosis and Acne Vulgaris in Adolescence and Young Adults: A Narrative Review. J Ayu Int Med Sci. 2025;10(2):171-178.

Available From
https://jaims.in/jaims/article/view/3990/

To Browse

Manuscript Received	Review Round 1	Review Round 2	Review Round 3	Accepted
2025-01-08	2025-01-18	2025-01-28	2025-02-08	2025-02-25

Conflict of Interest	Funding	Ethical Approval	Plagiarism X-checker	Note
None	Nill	Not required	12.75	

Introduction

Acne vulgaris is the most common dermatological condition, occurring when hair follicles are blocked by dead skin cells and sebum, leading to pimples, oily skin, comedones, and scars.**[1]** It is a chronic inflammatory condition of the pilosebaceous unit, often affecting sebaceous-rich areas like the face, chest, and back. Its causes include hormone-induced sebum production, follicular hyperkeratinisation, and inflammation from *P. acnes*.**[2]**

The gut microbiota may influence acne onset and development through the gut-skin axis, which impacts the inflammatory immune response.**[3]** Dysbiosis of both skin and gut microbiota is linked to autoimmune and inflammatory conditions.**[4]**

The skin, as the body's largest organ and first line of defence, is inhabited by bacteria, viruses, fungi, and mites, these microorganisms that usually coexist harmlessly with skin cells.**[5,6]** The gastrointestinal tract is a major interface between the host and environment.**[7]** The gut microbiome impacts both gut and skin tissue function and balance.**[8]**

From birth, it plays key roles in protection, metabolism, and immune regulation.**[9,10]** Several skin diseases are linked to gut disorders, with studies showing a bidirectional relationship between gut dysbiosis and skin imbalance, particularly in inflammatory diseases.**[11]**

Acne affects over 85% of adolescents, with moderate to severe cases impacting 20%, and continues to affect 64% of individuals in their 20s and 43% in their 30s, especially in adult women. **[12,13]** Acne is one of the top three most common skin conditions globally, with scars prevalent in 52% of Asia, 51% of Europe, and 31% of Africa.**[14,15]**

In alternative and complementary medicine, J.H. Tilden suggested that the accumulation of toxins in the body continues until the body's nerve energy is restored and the causes are removed. He viewed all diseases as crises of toxaemia, a result of the body's effort to eliminate toxins from the bloodstream. According to naturopathy, acne vulgaris is caused by a disruption in nature's balance, which can be triggered by various factors such as poor lifestyle choices, a high-fat diet, bowel toxaemia, stress, and anxiety.

These factors lead to hormonal imbalances, increased glandular activity, and a build-up of dead skin cells that clog pores. The clogged pores create an environment for bacterial growth, causing inflammation. Naturopathy also emphasizes the role of detoxification, proper diet, stress management, and balancing the body's natural processes to treat acne. It proposes that restoring the body's natural functions and promoting internal harmony are key to healing and preventing acne.**[16]**

Aims and Objectives

This narrative review aims to explore the relationship between gut dysbiosis and acne vulgaris in adolescents and young adults and the objectives is to see the role of gut dysbiosis to acne vulgaris.

Methodology

Relevant data were gathered using terms such as "acne vulgaris" and "gut dysbiosis" through electronic databases like Google Scholar, PubMed, and various books for pertinent citations. A total of 1,140 references from these databases, covering the period from inception to 2022, were reviewed. The focus was on case studies, review papers, and case series published in English, specifically those addressing the gut-skin axis in relation to natural treatment approaches for acne vulgaris. The collected information was then analysed to explore the underlying pathogenesis associated with the condition.

Pathophysiology of Acne Vulgaris

The pathogenesis of acne vulgaris is multifactorial involving environmental factors, diet, smoking, stress, and lifestyle,**[17]** characterized by excess sebum production, sebaceous gland hyperplasia, keratinocyte obstruction, Cutibacterium acnes (*C. acnes)* proliferation, and immune cell dysfunction. **[18]**

Excess sebum is triggered by elevated androgen and IGF-1 levels, activating mTORC1, which enhances sebaceous gland and keratinocyte activity. Leucine a common amino acid found in meat and dairy proteins also activates mTORC1.**[19,20]** IGF-1 also amplifies androgen production, creating a feedback loop that boosts sebum. Insulin and growth factors influence keratinocyte changes and sebum production.**[21]**

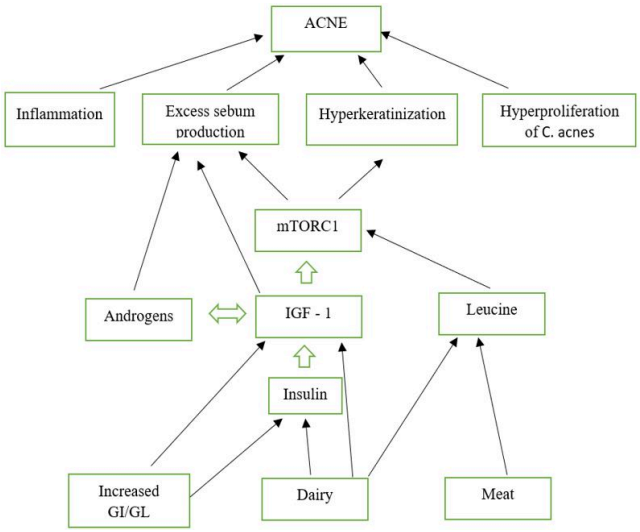

Figure 1: Dietary impact on mammalian target of rapamycin complex 1 (mTORC1)[22]

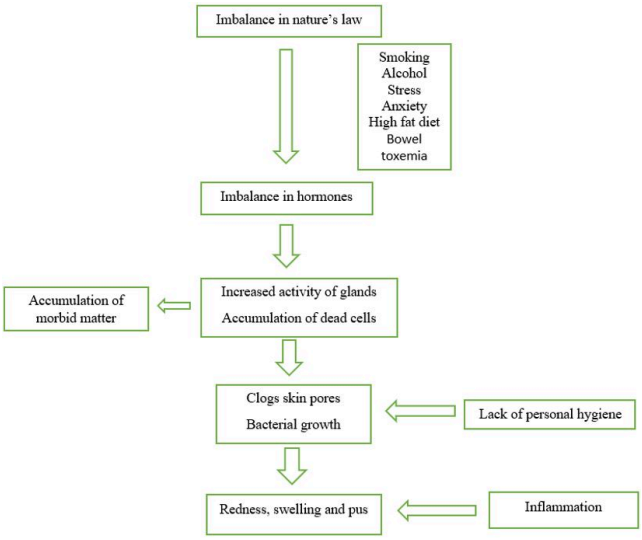

Figure 2: Naturopathic understanding of acne[23]

Skin Microbiota in Acne Vulgaris

C. acnes triggers innate and adaptive immune responses by interacting with pattern recognition receptors (PRRs), especially Toll-like receptors (TLR-2 and TLR-4). TLR-2 activation activates the NF-κB pathway, releasing proinflammatory cytokines like IL-1, IL-6, and TNF. IL-1 and IL-6 promote keratinocyte proliferation and sebum production, while IL-1 decreases linoleic acid levels, causing inflammation and follicular blockage. C. acnes also secretes lipases, proteases, hyaluronidase, and neuraminidases, contributing to inflammation.**[24]** Malassezia hydrolyzes triglycerides into free fatty acids, promoting hyperkeratinization and comedones.**[15]**

Gut Dysbiosis and Acne Vulgaris

The gut microbiome helps break down indigestible complex polysaccharides and produce essential nutrients like vitamin K. Dysbiosis, an imbalance in gut flora, is linked to various conditions, including metabolic, neurodegenerative, and neoplastic diseases. Altered gut flora can lead to an overregulation of T cells, contributing to autoimmune disorders.**[3]** Gut microbiota influences acne through interactions with the mTOR pathway, affecting cell proliferation, lipid metabolism, and other metabolic processes. Disruptions in the gut barrier and dysbiosis create a positive feedback loop of inflammation, leads to aggravate acne.**[25]**

Gut - skin axis interaction with Acne Vulgaris

The gut-skin axis refers to the interaction between the gut and skin,**[11]** where the microbiome helps regulate inflammation by interacting with the immune system. Gut microbes maintain the intestinal barrier and produce essential nutrients like vitamins K and B12 and short-chain fatty acids (SCFAs) like butyrate.**[26,27]**

Factors such as antibiotics, diet, lifestyle, and illness can alter the gut microbiome, leading to dysbiosis. This disrupts the gut barrier, allowing toxins and harmful metabolites to enter the bloodstream, impairing immune function and promoting skin inflammation. Disruption of the gut microbiome can lead to imbalances in microbial communities, affecting overall skin homeostasis. Dysbiosis can contribute to skin disorders such as acne, psoriasis, alopecia, and atopic dermatitis.**[3,28]**

Current Understanding Linking Gut Dysbiosis to Acne Research Summary

Author and Study Year	Research Conclusion
Hui- Min Yan et al., 2018	We hypothesize that changes in gut microbiota and reduced butyrate production impair the intestinal barrier and anti-inflammatory mechanisms, exacerbating acne vulgaris. Butyrate, crucial for gut barrier integrity and inflammation regulation, is reduced in acne, along with a decrease in beneficial bacteria like Coprobacillus and Allobaculum.
Britta De Pessemier et al., 2021	The gut and skin are interconnected through the bloodstream and lymphatic system, with both maintaining health through intact barriers. In dysbiosis, both barriers are compromised—marked by an imbalanced gut microbiome, weakened gut barrier, and impaired skin barrier—leading to inflammation and immune imbalance, particularly a Th2 response. This creates potential bidirectional crosstalk between the gut and skin.

Md. Rayhan Mahmud et al., 2022	The gut epithelium, influenced by the immune system, diet, and microbial metabolites, releases bioactive compounds like hormones, neurotransmitters, and short-chain fatty acids into the bloodstream, affecting the skin's microbiota and health. Therefore, dietary substances can directly impact skin appearance and health.
Pedro Sanchez-Pellicer et al., 2022	A high-fat or high-glycemic diet can alter gut microbiota, increasing intestinal permeability and worsening acne. This suggests that gut microbiota changes, along with factors like proinflammatory lipids from Cutibacterium acnes and genetic variations, may influence acne onset and progression.
Karolina Chilicka et al.,2022	The gut microbiota influences acne development and immune function, with studies suggesting probiotics may help reduce outbreaks. The growing markets for probiotic supplements and skincare products offer potential benefits for improving acne.
Spela Suler Baglama et al., 2022	The skin and gut microbiomes are key to studying autoimmune and inflammatory skin disorders, with dysbiosis linked to immune system dysfunction. Advanced techniques have revealed that bacterial dysbiosis, alongside viruses and fungi, may influence the pathogenesis of these conditions.
Cao Q. et al., 2023	Acne is linked to Allisonella and Bacteroides, while Ruminococcus torques may offer protection. Additionally, Eubacterium soleaferrea, coliform bacteria, Fusicatenibacter, and Lactobacillus are also associated with acne.

Discussion

Acne vulgaris is a multifactorial condition influenced by genetic, metabolic, and hormonal factors, with both the skin and gut microbiota playing key roles. C. acnes are increasingly recognized in acne development, alongside the gut-skin axis. While acne is often linked to elevated androgen levels, insulin and IGF-1, which are nutrition-dependent, also significantly impact it.**[29]** Changes in the gut microbiome can affect skin conditions, as microbial by-products directly influence health. Factors like environmental elements, host factors (e.g., pH and bile acids), and bacterial elements (like microbial enzymes and adhesion capacity).**[7]** The gut's mucosal layer acts as a primary defense, activating immune responses and preventing microbial invasion.**[30]** Cathelicidins like LL-37 maintain the epithelial barrier and have immune-modulatory effects. Tight junction proteins and AMPs protect the gut from harmful bacteria and maintain skin homeostasis.**[31]** Gut-derived neurotransmitters, such as GABA, acetylcholine, serotonin and dopamine, affect skin function and collagen production.**[32]** GABA promotes collagen production and skin elasticity, while dopamine can inhibit hair growth by stimulating collagen.**[33]** Research by Guo et al. found that a high-fat diet in mice led to dysbiosis and inflammation, with reduced AMP release, altered cytokine levels, and gut permeability. Low stomach acid in some acne patients may also contribute to skin irritation. **[34,35]** A Western diet high in ultra-processed foods, refined carbs, saturated fats, dairy, fatty meals, and chocolate is linked to aggravated acne. High glycemic foods worsen acne, while fruits and vegetables offer protection.**[36,37]** High-fat diets reduce gut microbiota diversity, increasing endotoxemia and proinflammatory cytokines, which contribute to acne.

Meat-heavy diets, high in leucine, activate mTOR, worsening acne, while plant-based diets improve gut diversity and reduce inflammation.**[38,39]** A study found 66% of acne sufferers aged 13-18 reported chocolate worsened their acne, though other studies found minimal correlation.**[40]** A low-glycemic load diet reduced acne severity,**[41,42]** while ketogenic diets lowered IGF-1 and inflammation markers.**[43]** A case series found whey protein worsened acne in five patients, likely due to leucine activating mTORC1.**[44,45]** Probiotics, found in cosmetics and supplements, reduce inflammation, protect against infections, and support skin health.**[1,5]** A study by GW Jung et al. explored combining probiotics with antibiotics for acne, showing probiotics may reduce antibiotic side effects and offer anti-inflammatory benefits.**[46]** Dall'Oglio F et al. found that prebiotics improved glycemic and lipid levels in women with mild to moderate adult acne.**[47]** A 2021 study showed green tea-derived compounds inhibited skin pathogens, including S. aureus and C. acnes, suggesting a potential alternative to antibiotics.**[48]** Korean research found Curcuma longa extract and probiotics helped combat C. acnes, indicating promise for acne treatment.**[49]** A 10-week study showed omega-3s and γ-linoleic acid reduced acne lesions.**[50]**In complementary and alternative medicine (CAM), they are concerned about the side effects of drugs, the choice of treatment in CAM, which includes herbal treatment, acupuncture, cupping therapy and dietary adjustments. From Naturopathic perspective, management of skin conditions requires an investigation and understanding the underlying issue that cause psychological imbalance this may leads to dietary intolerance or psychological factor. Skin is considered as the third elimination organ in naturopathy as it acts as both eliminative and absorbs toxins.

Common interventions used are herbal medicine, hydrotherapy, acupuncture, naturopathic diet, mud therapy, and fasting therapy and massage therapy. (51) Acupuncture, a common treatment in Traditional Chinese Medicine, is increasingly used for acne vulgaris. It involves inserting needles into specific acupoints to unblock Qi energy channels, which is believed to improve health and skin conditions. Acupuncture can also boost nitric oxide levels; reduce heat toxicity, balance androgen levels, and lower sebum production. While studies show acupoint stimulation technique-such as acupuncture, moxibustion, cupping, acupoint injection, and acupoint catgut embedding for treatment of moderate acne vulgaris can reduce inflammatory acne lesions, more large-scale research is needed for conclusive evidence. Herbal medicine and facial masks are quite popular, mostly due to less cost and a common belief that medicines made out of natural herbs have lesser risk of side effects.**[52]** In one of the single case studies, conclude that fasting therapy with other naturopathy treatment modalities has shown changes in reducing inflammatory response in acne vulgaris.**[53]**

Conclusion

In conclusion, this narrative review highlights the complex, multifactorial nature of acne vulgaris, emphasizing the significant role of gut dysbiosis in its pathogenesis. The gut-skin axis, which links changes in gut microbiota to skin health, has been shown to influence inflammation, immune responses, and metabolic processes that contribute to acne development. Dysbiosis, particularly an imbalance in gut microbiota and its interactions with the immune system, can exacerbate acne by disrupting both the gut and skin barriers. Environmental factors, such as diet, play a crucial role in acne progression, with high-glycemic and high-fat diets linked to worsening symptoms. Conversely, dietary changes, such as incorporating low-glycemic foods, probiotics, and reducing processed foods, can potentially alleviate acne. Complementary and alternative treatments, including acupuncture, herbal medicine, and naturopathy, offer promising adjuncts to conventional therapies, although further research is required to validate their effectiveness. Ultimately, a holistic approach that integrates gut health management, dietary adjustments, And complementary treatments alongside traditional acne therapies may provide more comprehensive and sustainable acne care, improving both skin health and overall well-being.

References

1. Chilicka K, Dzieńdziora-Urbińska I, Szyguła R, Asanova B, Nowicka D. Microbiome and probiotics in acne vulgaris—A narrative review. Life. 2022 Mar 15;12(3):422. *[Crossref][PubMed][Google Scholar]*

2. Salem I, Ramser A, Isham N, Ghannoum MA. The gut microbiome as a major regulator of the gut-skin axis. Front Microbiol. 2018 Jul 10;9:1459. *[Crossref][PubMed][Google Scholar]*

3. Baglama ŠŠ, Trčko K. Skin and gut microbiota dysbiosis in autoimmune and inflammatory skin diseases. Acta Derm Alp Pannonica Adriat. 2022 Sep;31:105-9. *[Crossref][PubMed][Google Scholar]*

4. Belkaid Y, Hand TW. Role of the microbiota in immunity and inflammation. Cell. 2014 Mar 27;157(1):121-41. *[Crossref][PubMed][Google Scholar]*

5. Helander HF, Fändriks L. Surface area of the digestive tract—revisited. Scand J Gastroenterol. 2014 Jun 1;49(6):681-9. *[Crossref][PubMed][Google Scholar]*

6. Mahmud MR, Akter S, Tamanna SK, Mazumder L, Esti IZ, Banerjee S, Akter S, Hasan MR, Acharjee M, Hossain MS, Pirttilä AM. Impact of gut microbiome on skin health: gut-skin axis observed through the lenses of therapeutics and skin diseases. Gut Microbes. 2022 Dec 31;14(1):2096995. *[Crossref][PubMed][Google Scholar]*

7. Guarner F, Khan AG, Garisch J, Eliakim R, Gangl A, Thomson A, Krabshuis J, Lemair T, Kaufmann P, De Paula JA, Fedorak R. World Gastroenterology Organisation global guidelines: probiotics and prebiotics October 2011. J Clin Gastroenterol. 2012 Jul 1;46(6):468-81. *[Crossref][PubMed][Google Scholar]*

8. Renz H, Brandtzaeg P, Hornef M. The impact of perinatal immune development on mucosal homeostasis and chronic inflammation. Nat Rev Immunol. 2012 Jan;12(1):9-23. *[Crossref][PubMed][Google Scholar]*

9. Grice EA, Segre JA. The skin microbiome. Nat Rev Microbiol. 2011;9(4):244-53. *[Crossref][PubMed][Google Scholar]*

10. De Pessemier B, Grine L, Debaere M, Maes A, Paetzold B, Callewaert C. Gut-skin axis: current knowledge of the interrelationship between microbial dysbiosis and skin conditions. Microorganisms. 2021 Feb 11;9(2):353. *[Crossref][PubMed][Google Scholar]*

11. Mohiuddin AK. Acne protection: measures and miseries. Dermatol Clin Res. 2019;5(1):272-311. *[Crossref][PubMed][Google Scholar]*

12. 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 Oct;45(10):1166-71. *[Crossref][PubMed][Google Scholar]*

13. Vos T, Flaxman AD, Naghavi M, Lozano R, Michaud C, Ezzati M, Shibuya K, Salomon JA, Abdalla S, Aboyans V, Abraham J. Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012 Dec 15;380(9859):2163-96. *[Crossref][PubMed][Google Scholar]*

14. Katsuta Y, Iida T, Inomata S, Denda M. Unsaturated fatty acids induce calcium influx into keratinocytes and cause abnormal differentiation of epidermis. J Invest Dermatol. 2005 May 1;124(5):1008-13. *[Crossref][PubMed][Google Scholar]*

15. Suh DH, Kwon HH. What's new in the physiopathology of acne? Br J Dermatol. 2015 Jul;172:13-9. . *[Crossref][PubMed][Google Scholar]*

16. 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 Jun 27;10(7):1303. *[Crossref][PubMed][Google Scholar]*

17. Grice EA, Kong HH, Conlan S, Deming CB, Davis J, Young AC, Bouffard GG, Blakesley RW, Murray PR, Green ED. Topographical and temporal diversity of the human skin microbiome. Science. 2009 May 29;324(5931):1190-2. *[Crossref][PubMed][Google Scholar]*

18. Zaenglein AL, Pathy AL, Schlosser BJ, Alikhan A, Baldwin HE, Berson DS, Bowe WP, Graber EM, Harper JC, Kang S, Keri JE. Guidelines of care for the management of acne vulgaris. J Am Acad Dermatol. 2016 May 1;74(5):945-73. *[Crossref][PubMed][Google Scholar]*

19. Melnik B. Dietary intervention in acne: attenuation of increased mTORC1 signaling promoted by Western diet. Dermatoendocrinol. 2012 Jan 1;4(1):20-32. *[Crossref][PubMed][Google Scholar]*

20. Smith TM, Gilliland K, Clawson GA, Thiboutot D. IGF-1 induces SREBP-1 expression and lipogenesis in SEB-1 sebocytes via activation of the phosphoinositide 3-kinase/Akt pathway. J Invest Dermatol. 2008 May 1;128(5):1286-93. *[Crossref][PubMed][Google Scholar]*

21. Wolkenstein P, Misery L, Amici JM, Maghia R, Branchoux S, Cazeau C, Voisard JJ, Taïeb C. Smoking and dietary factors associated with moderate-to-severe acne in French adolescents and young adults: results of a survey using a representative sample. Dermatology. 2015 Nov 19;230(1):34-9. *[Crossref][PubMed][Google Scholar]*

22. Baldwin H, Tan J. Effects of diet on acne and its response to treatment. Am J Clin Dermatol. 2021 Jan;22:55-65. *[Crossref][PubMed][Google Scholar]*

23. Nair PMK, Salwa H, Satyalakshmi K. Clinical naturopathy: a manual for physicians and students. Pune: National Institute of Naturopathy; 2017. ISBN:978-81-9326-72-0-6. *[Crossref][PubMed][Google Scholar]*

24. Noureldein MH, Eid AA. Gut microbiota and mTOR signaling: insight on a new pathophysiological interaction. Microb Pathog. 2018 May 1;118:98-104. *[Crossref][PubMed][Google Scholar]*

25. Vojvodic A, Peric-Hajzler Z, Matovic D, Vojvodic P, Vlaskovic-Jovicevic T, Sijan G, Dimitrijevic S, Stepic N, Wollina U, Badr BA, Badawi A. Gut microbiota and the alteration of immune balance in skin diseases: from nutraceuticals to fecal transplantation. Open Access Maced J Med Sci. 2019 Sep 9;7(18):3034. *[Crossref][PubMed][Google Scholar]*

26. LeBlanc JG, Milani C, De Giori GS, Sesma F, Van Sinderen D, Ventura M. Bacteria as vitamin suppliers to their host: a gut microbiota perspective. Curr Opin Biotechnol. 2013 Apr 1;24(2):160-8. *[Crossref][PubMed][Google Scholar]*

27. Mahmud MR, Akter S, Tamanna SK, Mazumder L, Esti IZ, Banerjee S, Akter S, Hasan MR, Acharjee M, Hossain MS, Pirttilä AM. Impact of gut microbiome on skin health: gut-skin axis observed through the lenses of therapeutics and skin diseases. Gut Microbes. 2022 Dec 31;14(1):2096995. *[Crossref][PubMed][Google Scholar]*

28. Deepa Y. Integrative yoga and naturopathy approach to managing acne vulgaris. a single case study. . *[Crossref][PubMed][Google Scholar]*

29. Belkaid Y, Harrison OJ. Homeostatic immunity and the microbiota. Immunity. 2017 Apr 18;46(4):562-76. *[Crossref][PubMed][Google Scholar]*

30. Goto Y, Panea C, Nakato G, Cebula A, Lee C, Diez MG, Laufer TM, Ignatowicz L, Ivanov II. Segmented filamentous bacteria antigens presented by intestinal dendritic cells drive mucosal Th17 cell differentiation. Immunity. 2014 Apr 17;40(4):594-607. *[Crossref][PubMed][Google Scholar]*

31. Lyte M. Microbial endocrinology and the microbiota-gut-brain axis. Microbial Endocrinol. 2014 Jun 9:3-24. *[Crossref][PubMed][Google Scholar]*

32. Langan EA, Lisztes E, Bíró T, Funk W, Kloepper JE, Griffiths CE, Paus R. Dopamine is a novel, direct inducer of catagen in human scalp hair follicles in vitro. Br J Dermatol. 2013 Mar 1;168(3):520-5. *[Crossref][PubMed][Google Scholar]*

33. Guo X, Li J, Tang R, Zhang G, Zeng H, Wood RJ, Liu Z. High-fat diet alters gut microbiota and the expression of Paneth cell-antimicrobial peptides preceding changes of circulating inflammatory cytokines. Mediators Inflamm. 2017;2017(1):9474896. *[Crossref][PubMed][Google Scholar]*

34. Lee YB, Byun EJ, Kim HS. Potential role of the microbiome in acne: a comprehensive review. J Clin Med. 2019 Jul 7;8(7):987. *[Crossref][PubMed][Google Scholar]*

35. Dall'Oglio F, Nasca MR, Fiorentini F, Micali G. Diet and acne: review of the evidence from 2009 to 2020. Int J Dermatol. 2021 Jun;60(6):672-85. *[Crossref][PubMed][Google Scholar]*

36. Dreno B, Gollnick HP, Kang S, Thiboutot D, Bettoli V, Torres V, Leyden J. Global Alliance to Improve Outcomes in Acne. Understanding innate immunity and inflammation in acne: implications for management. J Eur Acad Dermatol Venereol. *2015 Jun;29:3-11 [Crossref][PubMed][Google Scholar]*

37. Melnik B. Dietary intervention in acne: attenuation of increased mTORC1 signaling promoted by Western diet. Dermatoendocrinol. 2012 Jan 1;4(1):20-32. *[Crossref][PubMed][Google Scholar]*

38. Ansaldo E, Farley TK, Belkaid Y. Control of immunity by the microbiota. Annu Rev Immunol. 2021 Apr 26;39(1):449-79. *[Crossref][PubMed][Google Scholar]*

39. Spencer EH, Ferdowsian HR, Barnard ND. Diet and acne: a review of the evidence. Int J Dermatol. 2009 Apr 1;48(4). *[Crossref][PubMed][Google Scholar]*

40. Block SG, Valins WE, Caperton CV, Viera MH, Amini S, Berman B. Exacerbation of facial acne vulgaris after consuming pure chocolate. J Am Acad Dermatol. 2011 Oct 1;65(4):e114-5. *[Crossref][PubMed][Google Scholar]*

41. Costa A, Lage D, Moisés TA. Acne and diet: truth or myth? An Bras Dermatol. 2010;85:346-53. . *[Crossref][PubMed][Google Scholar]*

42. Kaymak Y, Adisen E, Ilter N, Bideci A, Gurler D, Celik B. Dietary glycemic index and glucose, insulin, insulin-like growth factor-I, insulin-like growth factor binding protein 3, and leptin levels in patients with acne. J Am Acad Dermatol. 2007 Nov 1;57(5):819-23. *[Crossref][PubMed][Google Scholar]*

43. Forsythe CE, Phinney SD, Fernandez ML, Quann EE, Wood RJ, Bibus DM, Kraemer WJ, Feinman RD, Volek JS. Comparison of low-fat and low-carbohydrate diets on circulating fatty acid composition and markers of inflammation. Lipids. 2008 Jan;43(1):65-77. *[Crossref][PubMed][Google Scholar]*

44. Silverberg NB. Whey protein precipitating moderate to severe acne flares in 5 teenaged athletes. Cutis. 2012 Aug 1;90(2):70-2. *[Crossref] [PubMed][Google Scholar]*

45. Melnik B. Dietary intervention in acne: attenuation of increased mTORC1 signaling promoted by Western diet. Dermatoendocrinol. 2012 Jan 1;4(1):20-32. *[Crossref][PubMed][Google Scholar]*

46. Jung GW, Tse JE, Guiha I, Rao J. Prospective, randomized, open-label trial comparing the safety, efficacy, and tolerability of an acne treatment regimen with and without a probiotic supplement and minocycline in subjects with mild to moderate acne. J Cutan Med Surg. 2013 Mar;17(2):114-22. *[Crossref][PubMed][Google Scholar]*

47. Dall'Oglio F, Milani M, Micali G. Effects of oral supplementation with FOS and GOS prebiotics in women with adult acne: The "SO Sweet" study: A proof-of-concept pilot trial. Clin Cosmet Investig Dermatol. 2018 Oct 8:445-9. *[Crossref][PubMed] [Google Scholar]*

48. Chae M, Kim BJ, Na J, Kim SY, Lee JO, Kim YJ, Lee E, Cho D, Roh J, Kim W. Antimicrobial activity of Lactiplantibacillus plantarum APsulloc 331261 and APsulloc 331266 against pathogenic skin microbiota. Front Biosci Elite. 2021 Dec 20;13(2):237-48. *[Crossref][PubMed][Google Scholar]*

49. Kim J, Kim H, Jeon S, Jo J, Kim Y, Kim H. Synergistic antibacterial effects of probiotic lactic acid bacteria with Curcuma longa rhizome extract as synbiotic against Cutibacterium acnes. Appl Sci. 2020 Dec 15;10(24):8955. *[Crossref][PubMed] [Google Scholar]*

50. Jung JY, Kwon HH, Hong JS, Yoon JY, Park MS, Jang MY, Suh DH. Effect of dietary supplementation with omega-3 fatty acid and gamma-linolenic acid on acne vulgaris: a randomized, double-blind, controlled trial. Acta Derm Venereol. 2014 Jan 29;94(5):521-5. *[Crossref][PubMed][Google Scholar]*

51. Steel A. Acne vulgaris. Clin Naturopathy Evid-Based Guide Pract. 2010 May 4:463. *[Crossref] [PubMed][Google Scholar]*

52. Kaur I. Complementary and alternative medicine (CAM) in acne vulgaris. Res Clin Dermatol. 2018;1(1):18-19. *[Crossref][PubMed][Google Scholar]*

53. Ameya P, Nair PM. Role of therapeutic fasting along with other naturopathy and yoga modalities in addressing acne vulgaris—A single case report. J Nutr Fast Health. 2017 Sep 1;5(3):103-6. *[Crossref] [PubMed][Google Scholar]*