

Association Between Digestive Health, Lifestyle Factors And Skin Health Among Young Adults: A Cross-Sectional Study Of The Gut–Skin Axis

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ABSTRACT

Background: The gut-skin axis represents a bidirectional communication pathway between the gastrointestinal tract and the skin, mediated through immune, metabolic, hormonal, and inflammatory mechanisms. Dietary patterns, physical activity, sleep quality, hydration status, and psychological stress are critical modulators of both digestive and skin health. Young adulthood represents a transitional period characterized by significant changes in eating behaviors and lifestyle practices that may influence long-term health outcomes. **Objective:** The present study was undertaken to explore the relationship between digestive health, lifestyle factors, and skin health among young adults aged 18–26 years. **Methods:** A cross-sectional study was conducted among 100 participants using a convenience sampling method. Data were collected through a structured questionnaire encompassing socio-demographic characteristics, anthropometric parameters, digestive health indicators, lifestyle practices, and skin health parameters. Statistical analysis was performed using JASP software (Version 0.16.4), with the Chi-square test employed to determine associations between variables. A p -value < 0.05 was considered statistically significant. **Results:** The findings revealed statistically significant associations between lifestyle factors and skin health ($\chi^2 = 10.88$, $p = 0.027$), lifestyle factors and digestive health ($\chi^2 = 11.85$, $p = 0.002$), and digestive health and skin health ($\chi^2 = 13.87$, $p = 0.0009$). Participants adhering to healthier lifestyle practices demonstrated superior digestive health outcomes and better skin conditions compared to those with suboptimal lifestyle behaviors. **Conclusion:** The findings substantiate the concept of the gut-skin axis and underscore the importance of maintaining healthy dietary and lifestyle practices for promoting digestive and skin health among young adults. The study emphasizes the need for targeted awareness programs regarding the influence of lifestyle choices on overall health and provides a foundation for further mechanistic investigations in this emerging research domain.

Keywords: Gut-Skin axis, Digestive health, Lifestyle factors, Skin health, Gut microbiota.

INTRODUCTION

The human body functions as an intricately interconnected system wherein various organs communicate through complex signaling networks to maintain physiological homeostasis and overall health. Among these inter-organ interactions, the relationship between the gastrointestinal tract and the skin has garnered substantial scientific interest in recent years. This connection, termed the gut–skin axis, represents a bidirectional communication pathway linking the gut and skin through immune, metabolic, hormonal, and inflammatory signaling cascades.¹

The gastrointestinal tract harbors trillions of microorganisms collectively known as the gut microbiota, which play an indispensable role in digestion, nutrient absorption, immune regulation, maintenance of intestinal barrier integrity, and protection against pathogenic colonization.² The composition and functional capacity of the gut microbiome are influenced by numerous factors including dietary habits, host genetics, medication use, stress, and environmental exposures.³ Disruption in the balance of these microbial communities, termed gut dysbiosis, has been implicated in various pathological conditions affecting both gastrointestinal function and distal organ systems, including the skin.

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The gut microbiota contributes to host health through multiple mechanisms, including the fermentation of indigestible dietary components to produce short-chain fatty acids (SCFAs) such as acetate, propionate, and butyrate, which serve as energy sources for colonocytes and modulate immune responses.⁴ Additionally, gut microbes regulate intestinal barrier function, compete with pathogens for ecological niches, synthesize essential vitamins, and metabolize xenobiotics. However, factors including Western dietary patterns characterized by high fat and refined sugar content, chronic psychological stress, insufficient sleep duration, physical inactivity, and medication use—particularly antibiotics—may disturb microbial homeostasis, compromising intestinal barrier integrity and promoting systemic low-grade inflammation.⁵

Skin health is influenced by a complex interplay of genetic predisposition, hormonal regulation, nutritional status, environmental exposures, and lifestyle practices. Emerging evidence indicates that internal factors, particularly gut health and microbial composition, may significantly contribute to skin conditions through immune and inflammatory mechanisms. Dysbiosis of the gut microbiota has been associated with various dermatological conditions including acne vulgaris, atopic dermatitis, psoriasis, and rosacea, potentially through promotion of systemic inflammation and modulation of immune responses.^{6,7} The gut–skin axis operates through multiple pathways including the immune system, neuroendocrine system, and metabolic regulation, creating a complex network of interactions that influence skin homeostasis and pathology.⁸

Lifestyle factors including dietary patterns, physical activity levels, sleep quality, hydration status, and psychological stress play pivotal roles in maintaining both gut and skin health. Diets rich in fruits, vegetables, whole grains, and dietary fiber increase the growth of beneficial gut microorganisms, whereas frequent consumption of processed foods, refined sugars, and saturated fats may adversely affect microbial diversity and metabolic function.⁵ Similarly, chronic sleep deprivation and psychological stress can compromise intestinal barrier function, increase pro-inflammatory cytokine production, and exacerbate dermatological conditions through activation of the hypothalamic–pituitary–

adrenal (HPA) axis.⁹ Regular physical activity has been associated with enhanced gut microbial diversity, reduced inflammatory markers, and improved overall health outcomes.¹⁰

Young adulthood represents a critical developmental period during which lifestyle behaviors are often significantly influenced by academic demands, occupational responsibilities, and social factors. Irregular meal patterns, increased consumption of energy-dense nutrient-poor foods, inadequate sleep, and elevated stress levels are commonly observed among young adults and may negatively impact both digestive and skin health. While previous investigations have explored the relationship between gut microbiota and specific dermatological disorders, limited research has comprehensively examined the combined influence of digestive health, lifestyle factors, and overall skin health among healthy young adult populations.^{11,12}

Therefore, the present study was undertaken to explore the relationship between digestive health, lifestyle factors, and skin health among young adults aged 18–26 years. The findings of this investigation may contribute to increasing awareness regarding the importance of maintaining digestive balance and adopting healthy lifestyle practices for promoting optimal skin health, potentially informing future public health interventions and educational programs targeting this demographic.

MATERIALS AND METHODS

Study Design and Population:

The present study employed a cross-sectional research design to investigate the relationship between digestive health, lifestyle factors, and skin health among young adults. The study was conducted among 100 participants aged 18–26 years, selected using a convenience sampling method from the student population of Veeranari Chakali Iamma Women's University, Hyderabad, India. Individuals who met the inclusion criteria and provided written informed consent were enrolled in the study.

Inclusion Criteria:

- Age between 18 and 26 years

- Willingness to participate and provide informed consent
- Ability to comprehend and respond to the questionnaire
- Currently enrolled as a student at the university

Exclusion Criteria:

- Individuals with diagnosed chronic gastrointestinal disorders (e.g., inflammatory bowel disease, celiac disease, irritable bowel syndrome)
- Individuals with diagnosed chronic skin conditions requiring ongoing medical treatment (e.g., severe psoriasis, eczema)
- Pregnant or lactating women

Data Collection Tool:

Data were collected using a structured questionnaire specifically developed for the study after review of relevant literature. The questionnaire comprised five sections: socio-demographic characteristics, anthropometric assessment, digestive health indicators, lifestyle factors, and skin health parameters. The questionnaire was administered online through Google Forms, and responses were collected following receipt of informed consent from all participants.

Questionnaire Validation

The questionnaire was prepared after reviewing relevant published literature on digestive health, lifestyle factors, and skin health. Before the main study, it was pilot-tested among 10 participants to evaluate the clarity, sequence, and understanding of the questions. Based on their feedback, minor changes were made to improve the wording and overall clarity of the questionnaire. The revised questionnaire was then used to collect data from the final sample of 100 participants. The responses from the pilot study were not included in the final analysis.

Assessment of Digestive Health:

Digestive health was assessed using questions pertaining to bowel habits (frequency and consistency), bloating, gastric acidity, abdominal discomfort, constipation, diarrhea, and other

commonly reported gastrointestinal symptoms experienced over the preceding three months. Each symptom was scored on a Likert scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always). Total scores were calculated and categorized as follows: good (score ≤ 15), average (score 16–25), or poor (score ≥ 26) based on composite scores and distribution tertiles.

Assessment of Lifestyle Factors:

Lifestyle factors were evaluated using questions on dietary habits (frequency of consumption of fruits, vegetables, whole grains, processed foods, sugary foods, fiber-rich foods, and fermented foods), daily water intake (<2 L, 2–3 L, >3 L), physical activity levels (sedentary, moderate, vigorous based on weekly frequency and duration), sleep duration (<6 hours, 6–8 hours, >8 hours), perceived stress levels (low, moderate, high), and meal-skipping behavior (never, sometimes, often). Responses were scored and categorized to evaluate the overall lifestyle pattern of participants, classified as good, average, or poor based on composite scores.

Assessment of Skin Health:

Skin health was assessed using self-reported information on common skin concerns, including acne (frequency and severity), dryness, pigmentation, skin sensitivity, and overall skin condition over the preceding three months. Participants rated the severity and frequency of these concerns on a Likert scale. Responses were analyzed to assess skin health status, categorized as good, average, or poor based on composite scores and distribution tertiles.

Anthropometric Assessment:

Body Mass Index (BMI) was calculated using self-reported height and weight measurements using the formula: $BMI = \text{weight (kg)} / \text{height (m}^2\text{)}$. Participants were classified according to the World Health Organization (WHO) BMI classification: underweight (<18.5 kg/m²), normal weight (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), and obese (≥ 30.0 kg/m²).

Statistical Analysis:

The collected data were entered into Microsoft Excel and analyzed using JASP software (Version 0.16.4).

Descriptive statistics were used to summarize the socio-demographic characteristics, anthropometric measurements, digestive health, lifestyle factors, and skin health of the participants. Categorical variables were expressed as frequencies and percentages. The Chi-square test of independence was performed to assess the association between lifestyle factors and skin health, lifestyle factors and digestive health, and digestive health and skin health. The Chi-square statistic (χ^2), degrees of freedom (df), and corresponding p-values were reported for each analysis. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations:

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Participation in the study was entirely voluntary. All participants were informed about the purpose, objectives, and procedures of the study before data collection, and informed consent was obtained from each participant. Participants were assured that their responses would remain confidential and anonymous, and that the information collected would be used solely for research purposes. They were also informed that they were free to withdraw from the study at any stage without providing a reason and without any consequences.

RESULTS

VARIABLES	CATEGORY	NO. OF SUBJECTS
Age	18-20	29
	21-23	54
	24-26	17
	Total	100
Gender	Male	7
	Female	93
	Total	100
Educational Status	Undergraduate	43
	Post Graduate	53
	Others	4
	Total	100

Table 1: Socio-demographic characteristics

Interpretation: Table 1 presents the socio-demographic characteristics of the study participants. A total of 100 young adults were included in the study, with the majority belonging to the 21–23 years age group (n = 54, 54%), followed by the 18–20 years age group (n = 29, 29%) and the 24–26 years group (n = 17, 17%). The study population was predominantly

female (n = 93, 93%), reflecting the institutional demographic of the women's university. Regarding educational status, the majority were postgraduate students (n = 53, 53%), followed by undergraduate students (n = 43, 43%), with a small proportion falling into the "others" category (n = 4, 4%).

BMI CATEGORY	n	%
Underweight	23	23%
Normal	50	50%
Overweight	27	27%
TOTAL	100	100%

Table 2: Distribution of participants based on Body Mass Index (BMI)

Interpretation: Table 2 depicts the distribution of participants according to BMI classification. The majority of participants had normal BMI (n = 50, 50%), followed by overweight (n = 27, 27%) and underweight (n = 23, 23%). No participants were classified as obese.

	Skin Health				
Lifestyle factors	Good	Average	Poor	Total	P-value
Good	18	9	1	28	0.027
Average	29	29	7	65	
Poor	-	5	2	7	
Total	47	43	10	100	

Table 3: Association between Lifestyle factors and skin health

Chi-square Test: $\chi^2 = 10.88$, df = 4, p-value = 0.027

Interpretation: Table 3 presents the association between lifestyle factors and skin health among the study participants. It was observed that participants with good lifestyle practices tend to have a good skin health, whereas those with poor lifestyle practices were more likely to have average or poor skin health. Participants with average lifestyle practices showed a

mixed distribution across all categories of skin health. The Chi-square value was 10.88 with 4 degrees of freedom, and the p-value was 0.027, indicating a statistically significant association between lifestyle factors and skin health. These findings suggest that maintaining healthy lifestyle practices may contribute to better skin health among young adults.

	Gut Health				
Lifestyle factors	Good	Average	Poor	Total	P-value
Good	3	25	-	28	0.002
Average	30	35	-	65	

Poor	4	3	-	7	
Total	37	63	-	100	

Table 4: Association between Lifestyle factors and Gut health

Chi-square Test: $\chi^2 = 11.85$, $df = 2$, $p\text{-value} = 0.002$

Interpretation: Table 4 shows the association between lifestyle factors and gut health among the study participants. Participants with healthier lifestyle practices demonstrated better gut health, while those with poorer lifestyle practices were more likely to have average gut health. No participants were classified under the poor gut health category based on the predefined scoring criteria; therefore, this

category contained no observations in the final analysis. Overall, the findings indicate a positive relationship between healthy lifestyle behaviours and digestive health. The Chi-square value was 11.85 with 2 degrees of freedom, and the p-value was 0.002, indicating a statistically significant association between lifestyle factors and gut health. These findings suggest that healthy lifestyle habits play an important role in maintaining good digestive health among young adults.

	Skin Health				
Gut Health	Good	Average	Poor	Total	P-value
Good	10	19	8	37	0.0009
Average	37	24	2	63	
Poor	-	-	-	-	
Total	47	43	10	100	

Table 5: Association between Gut health and Skin health

Chi-square Test: $\chi^2 = 13.87$, $df = 2$, $p\text{-value} = 0.0009$

Interpretation: Table 5 presents the association between gut health and skin health among the study participants. The Chi-square value was 13.87 with 2 degrees of freedom, and the p-value was 0.0009. Since the p-value is less than 0.05, a statistically significant association was observed between gut health and skin health. However, considerable overlap among the different gut health and skin health categories suggests that additional factors may also influence skin health. Therefore, the findings indicate an association between gut health and skin health rather than a direct cause-and-effect relationship among the study participants.

DISCUSSION

The present study explored the relationship between digestive health, lifestyle factors, and skin health among young adults. The findings demonstrated significant associations between lifestyle factors and skin health, lifestyle factors and digestive health, and digestive health and skin health. These findings support the growing evidence that healthy lifestyle behaviors contribute to maintaining both digestive and skin health through the gut-skin axis.

The majority of the participants belonged to the 21–23-year age group, indicating that the study population represented young adults, a stage of life often characterized by changing dietary habits, irregular sleep patterns, academic or occupational stress, and other lifestyle modifications. These factors

may influence both digestive and skin health, making this population relevant for studying the gut–skin axis.

A significant association was observed between lifestyle factors and skin health ($p = 0.027$). Participants with healthier lifestyle practices generally reported better skin health. Dietary habits, adequate sleep, regular physical activity, and stress management are known to influence inflammatory responses and immune function, which play important roles in maintaining healthy skin. Similar findings have been reported in previous studies, which suggest that gut microbiota and lifestyle behaviors play an important role in maintaining skin homeostasis and regulating inflammatory skin conditions.^{1,2}

The present study also demonstrated a significant association between lifestyle factors and gut health ($p = 0.002$). Participants who followed healthier lifestyle practices were more likely to have better digestive health. Lifestyle behaviors, particularly a balanced diet rich in dietary fiber, adequate hydration, regular physical activity, and sufficient sleep, have been shown to support gut microbial diversity and normal gastrointestinal function. Conversely, unhealthy dietary patterns and chronic stress may contribute to gut dysbiosis and digestive disturbances. These findings are consistent with previous reports highlighting the influence of lifestyle factors on gut microbiota and digestive health.^{3,4}

Another important finding of the present study was the significant association between digestive health and skin health ($p = 0.0009$). Participants with better digestive health generally reported healthier skin, supporting the concept of the gut–skin axis. The gut microbiota contributes to immune regulation, maintenance of intestinal barrier integrity, and the production of microbial metabolites that influence inflammatory pathways. Alterations in these mechanisms may contribute to the development or worsening of common skin conditions such as acne, eczema, psoriasis, and rosacea. Similar findings have been reported in previous studies investigating the relationship between gut microbial balance and skin health.^{5,6}

The relationship between digestive health and skin health may be explained through several biological mechanisms involved in the gut–skin axis. Beneficial

gut microorganisms produce short-chain fatty acids (SCFAs), which help maintain intestinal barrier integrity, regulate immune responses, and reduce inflammation. In contrast, gut dysbiosis may increase intestinal permeability, allowing microbial metabolites and other inflammatory substances to enter the circulation and stimulate the release of inflammatory cytokines. These changes can alter immune function and contribute to skin inflammation, potentially influencing the development or progression of skin conditions such as acne, eczema, psoriasis, and rosacea. Although these mechanisms were not directly assessed in the present study, they provide a biological explanation for the significant associations observed between digestive health and skin health.

The findings of the present study highlight the importance of adopting healthy lifestyle practices for promoting digestive and skin health among young adults. Increasing awareness regarding balanced nutrition, regular physical activity, adequate sleep, hydration, and stress management may contribute to improved overall well-being and support a healthy gut–skin relationship.

Limitations of the Study

- The cross-sectional study design limits the ability to establish a causal relationship between digestive health, lifestyle factors, and skin health.
- The study findings were based on self-reported responses, which may be affected by recall bias and reporting bias.
- The study included a convenience sample of 100 participants, which may limit the generalizability of the findings to the broader population.
- The study was conducted among young adults from a single university, which may not represent individuals from different age groups, regions, or socio-demographic backgrounds.
- The study did not include objective clinical assessments or laboratory investigations to evaluate gut health or skin health.

Recommendation for Future Research

- Future studies should include larger and more diverse populations to improve the generalizability of the findings.
- Longitudinal or prospective studies are recommended to better establish causal relationships.
- Further research incorporating clinical assessments and gut microbiome analysis is needed to better understand the underlying mechanisms of the gut–skin axis.
- Additional studies should evaluate the influence of dietary patterns, stress, sleep, and physical activity in greater detail to strengthen the evidence on the gut–skin relationship.

CONCLUSION

The findings of the present study indicate that digestive health, lifestyle factors, and skin health are closely interrelated among young adults, providing evidence supporting an association consistent with the gut–skin axis. Participants adhering to healthier lifestyle practices demonstrated superior digestive health and better skin conditions compared to those with suboptimal lifestyle behaviors. The highly significant association observed between gut health and skin health suggests that maintaining optimal digestive function may be a critical factor in promoting dermatological health among young adults.

The study highlights the importance of creating awareness among young adults regarding the influence of lifestyle choices on both digestive and skin health. Targeted interventions promoting balanced nutrition, adequate sleep, regular physical activity, proper hydration, and effective stress management may contribute to improved health outcomes through modulation of the gut–skin axis. The findings provide a foundation for further research in this emerging area and underscore the need for integrated approaches to health promotion that recognize the interconnectedness of physiological systems.

While the present study provides valuable insights into the relationship between digestive health, lifestyle factors, and skin health among young adults, further investigations involving larger, more diverse populations and incorporating objective measures are needed to better elucidate the underlying mechanisms of the gut–skin axis. Such research will inform the development of evidence-based interventions to promote optimal health and well-being among young adults and may contribute to the prevention and management of common skin conditions through modulation of gut health and lifestyle factors.

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REFERENCES

1. O'Neill CA, Monteleone G, McLaughlin JT, Paus R. The gut–skin axis in health and disease: a paradigm with therapeutic implications. *Bioessays*. 2016;38(11):1167-1173.
2. Singh RK, Chang HW, Yan D, Lee KM, Ucmak D, Wong K, et al. Influence of diet on the gut microbiome and implications for human health. *J Transl Med*. 2017;15:73.
3. Valdes AM, Walter J, Segal E, Spector TD. Role of the gut microbiota in nutrition and health. *BMJ*. 2018;361:k2179.
4. Makki K, Deehan EC, Walter J, Bäckhed F. The impact of dietary fiber on gut microbiota in host health and disease. *Cell Host Microbe*. 2018;23(6):705-715.
5. Salem I, Ramser A, Isham N, Ghannoum MA. The gut microbiome as a major regulator of the gut–skin axis. *Front Microbiol*. 2018;9:1459.
6. Kho ZY, Lal SK. The human gut microbiome: A potential controller of wellness and disease. *Front Microbiol*. 2018;9:1835.

7. Hills RD Jr, Pontefract BA, Mishcon HR, Black CA, Sutton SC, Theberge CR. Gut microbiome: Profound implications for diet and disease. *Nutrients*. 2019;11(7):1613.
8. 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;9(2):353.
9. Mahmud MR, Akter S, Tamanna SK, Mazumder L, Esti IZ, Banerjee S, et al. Impact of gut microbiome on skin health: Gut-skin axis observed through the lenses of therapeutics and skin diseases. *Gut Microbes*. 2022;14(1):2096995.
10. Bowe WP, Logan AC. Acne vulgaris, probiotics and the gut-brain-skin axis: From anecdote to translational medicine. *Benef Microbes*. 2011;2(3):185-199.
11. Lee SY, Lee E, Park YM, Hong SJ. Microbiome in the gut-skin axis in atopic dermatitis. *Allergy Asthma Immunol Res*. 2018;10(4):354-362.
12. Scher JU, Ubeda C, Artacho A, Attur M, Isaac S, Reddy SM, et al. Decreased bacterial diversity characterizes the altered gut microbiota in patients with psoriatic arthritis, resembling dysbiosis in inflammatory bowel disease. *Arthritis Rheumatol*. 2015;67(1):128-139.
13. Arck P, Handjiski B, Hagen E, Joachim R, Klapp BF, Paus R. Is there a gut-brain-skin axis? Experimental and clinical perspectives. *Exp Dermatol*. 2010;19(5):401-405.
14. Gao T, Wang X, Li Y, Ren F. The role of probiotics in skin health and the gut-skin axis: A review. *Nutrients*. 2023;15(14):3123.
15. Pedroza Matute SP, Iyavoo SI. Exploring the gut microbiota: Lifestyle choices, disease associations, and personal genomics. *Front Nutr*. 2023;10:1225120.
16. Fan Y, Pedersen O. Gut microbiota in human metabolic health and disease. *Nat Rev Microbiol*. 2021;19(1):55-71.
17. Byrd AL, Belkaid Y, Segre JA. The human skin microbiome. *Nat Rev Microbiol*. 2018;16(3):143-155.
18. Chai J, Deng F, Li Y, Wei X, Zhao J. Editorial: The gut-skin axis: interaction of gut microbiome and skin diseases. *Front Microbiol*. 2024;15:1427770. doi:10.3389/fmicb.2024.1427770.
19. Chen M, Wang R, Wang T. Gut microbiota and skin pathologies: Mechanism of the gut-skin axis in atopic dermatitis and psoriasis. *Int Immunopharmacol*. 2024;135:112658. doi:10.1016/j.intimp.2024.112658.
20. Millman JF, Kondrashina A, Walsh C, Busca K, Karawugodage A, Park J, et al. Biotics as novel therapeutics in targeting signs of skin ageing via the gut-skin axis. *Ageing Res Rev*. 2024;102:102518. doi:10.1016/j.arr.2024.102518.
21. Guo J, Luo Q, Li C, Liang H, Cao Q, Li Z, et al. Evidence for the gut-skin axis: Common genetic structures in inflammatory bowel disease and psoriasis. *Skin Res Technol*. 2024;30(2):e13611. doi:10.1111/srt.13611.

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