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The Impact of Lifestyle Factors on the Human Microbiome

Dampak Faktor Gaya Hidup terhadap Mikrobioma Manusia

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ABSTRACT
The conclusions of this study highlight the complexity of the relationship between lifestyle and human microbiome composition, which is based on the results of a systematic literature review. Findings from the literature show that lifestyle factors such as diet, physical activity, and sleep habits have a significant impact on the composition and diversity of the human microbiome, both in the digestive system, skin, and oral cavity. These factors interact and influence each other, forming a complex network of relationships that influence the health and balance of the human microbiome. The implications of these findings are very important in the context of preventing and treating various microbiome-related diseases, such as obesity, diabetes, and inflammatory bowel disease. By understanding the relationship between lifestyle and the human microbiome, we can develop more effective and targeted intervention strategies, both in terms of behavior change and the development of therapies focused on modulating the microbiome. For future research, it is recommended to further explore the mechanisms underlying the interaction between lifestyle and the human microbiome, and involve more comprehensive and longitudinal analysis.
Keywords: Lifestyle, human microbiome composition, systematic literature review, interaction of lifestyle factors, health implications.

ABSTRAK
Kesimpulan dari penelitian ini menyoroti kompleksitas hubungan antara gaya hidup dan komposisi mikrobioma manusia, yang didasarkan pada hasil dari systematic literature review. Temuan dari literatur menunjukkan bahwa faktor gaya hidup seperti diet, aktivitas fisik, dan kebiasaan tidur memiliki dampak signifikan pada komposisi dan keanekaragaman mikrobioma manusia, baik dalam sistem pencernaan, kulit, maupun rongga mulut. Faktor-faktor ini saling berinteraksi dan saling mempengaruhi, membentuk suatu jaringan hubungan yang kompleks yang mempengaruhi kesehatan dan keseimbangan mikrobioma manusia. Implikasi dari temuan ini sangat penting dalam konteks pencegahan dan penanganan berbagai penyakit terkait mikrobioma, seperti obesitas, diabetes, dan penyakit inflamasi usus. Dengan memahami hubungan antara gaya hidup dan mikrobioma manusia, kita dapat mengembangkan strategi intervensi yang lebih efektif dan terarah, baik dalam hal perubahan perilaku maupun pengembangan terapi yang terfokus pada modulasi mikrobioma. Untuk penelitian mendatang, disarankan untuk mengeksplorasi lebih lanjut tentang mekanisme-mekanisme yang mendasari interaksi antara gaya hidup dan mikrobioma manusia, serta melibatkan analisis yang lebih komprehensif dan longitudinal.
Kata Kunci: Gaya hidup, komposisi mikrobioma manusia, sistematis review literatur, interaksi faktor gaya hidup, implikasi kesehatan.

1. Introduction

The human microbiome, including the gut, skin, and oral microbiomes, is significantly influenced by lifestyle factors. Lifestyle choices such as diet, physical activity, and environmental exposures play a crucial role in shaping the composition and diversity of the human microbiome (Manor et al., 2020). For instance, variations in the gut microbiome have been linked to host lifestyle and behaviors, and these variations can influence disease biomarker levels in the blood (Manor et al., 2020). Similarly, the human skin microbiome is influenced by extrinsic factors such as lifestyle, which can impact its composition (Dimitriu et

al., 2019). Furthermore, the oral microbial composition is impacted by lifestyle and social structures, with lifestyle and shared environments being more significant than intrinsic factors like genetics (Willis et al., 2022).

Diet is a key lifestyle factor that has been found to have a profound impact on the human microbiome. The gut microbiota composition is influenced by various dietary components, including macronutrients, micronutrients, salt, and food additives, as well as different dietary habits such as vegan, vegetarian, gluten-free, ketogenic, high sugar, low FODMAP, Western-type, and Mediterranean diets (Rinninella et al., 2019). Moreover, the gut microbiome is a complex and dynamic community of microorganisms essential for maintaining human health, and it is influenced by various factors, including diet and lifestyle (Kumbhare et al., 2023).

The transition from non-industrialized to industrialized lifestyles has been associated with drastic changes in microbiome diversity and composition, highlighting the impact of industrialization on the human microbiome (Groussin, 2020). Additionally, the lifestyle aspects that characterize westernized groups, including diet, environment, and sedentary practices, shape the gut microbiome and are associated with an increased risk of metabolic and chronic disorders affecting modern populations (Conteville et al., 2019). In conclusion, lifestyle factors have a profound impact on the human microbiome, particularly the gut, skin, and oral microbiomes. Diet, physical activity, environmental exposures, and industrialization all play significant roles in shaping the composition and diversity of the human microbiome, with implications for human health and disease.

The impact of lifestyle factors on the human microbiome, particularly the gut microbiome, is a topic of increasing importance due to its association with human health. Research has shown that lifestyle habits such as diet, physical activity, and sleep patterns can influence the composition and diversity of the human microbiome, which in turn may impact the risk of chronic diseases such as obesity, diabetes, and inflammatory bowel disease. For instance, a study demonstrated that health and disease markers correlate with gut microbiome composition across a large population, indicating the impact of lifestyle on the gut microbial community (Manor et al., 2020). Furthermore, highlighted the microbiome's association with health status and disease development, emphasizing the need for a deeper understanding of the relationships between diet, metabolites, and the microbiome (Tang et al., 2019).

The influence of lifestyle factors on the microbiome is evident in various contexts. For example, found that health factors exerted a strong influence on the oral microbiome, indicating the broader impact of lifestyle on different microbial communities within the human body (Dimitriu et al., 2019). Additionally, observed patterns of oral microbiota diversity in both adults and children, linking these patterns to factors such as diet and diseases like cardiovascular and periodontal diseases, further emphasizing the relationship between lifestyle and microbiome composition (Burcham et al., 2020).

The relationship between lifestyle factors and gut microbiome composition is complex and multifaceted, reflecting the intricate interplay between dietary habits, age, body mass index (BMI), and other lifestyle elements. Studies have extensively explored how different dietary patterns, including omnivorous, vegetarian, vegan, and low-carbohydrate high-fat diets, can significantly influence the composition of the gut microbiota. Moreover, specific dietary components such as red meats, processed meats, vegetables, fruits, grains, fermented foods, and alcohol intake have been associated with alterations in the mucosal microbiome, potentially impacting the development of conditions like colorectal cancer. Furthermore, lifestyle elements like physical activity and drug-based therapies have been identified as additional factors that can modulate gut microbiota functionality, further highlighting the intricate relationship between lifestyle choices and the delicate balance of the gut microbial ecosystem.

The significant role of diet and lifestyle factors in shaping the composition and activity

of the gut microbiota underscores their profound implications for human health. A diverse and abundant microbial ecosystem, influenced by a diet rich in natural sources and mindful choices, holds the potential to enhance immunological responses and maintain metabolic equilibrium. However, the lack of consensus on defining a healthy gut microbiota and the multitude of influencing factors present challenges in developing universally applicable dietary recommendations. The correlation between feeding behavior, physical exercise, and gut microbiota diversity emphasizes the necessity for personalized nutrition and exercise recommendations tailored to individual microbial profiles and lifestyle patterns.

In conclusion, the intricate relationship between lifestyle factors and gut microbiome composition underscores the importance of considering various dietary patterns, dietary components, physical activity levels, and other lifestyle elements in promoting gut microbial balance and overall health. Further research aimed at elucidating the specific mechanisms underlying these relationships and developing personalized interventions is warranted to optimize gut microbiota health and mitigate the risk of associated diseases.

Moreover, the impact of lifestyle on the microbiome extends to specific health conditions. For instance, discussed the interactions between the lung microbiome and host immunity in chronic obstructive pulmonary disease, highlighting the relevance of microbiome analysis in disease management and the potential influence of lifestyle on disease-associated microbiome alterations (Zhu & Chang, 2023). Similarly, demonstrated changes in the intestinal microbiome in response to cholestasis induced by bile duct ligation, indicating the dynamic nature of microbiome composition in response to physiological changes influenced by lifestyle factors (Cabrera-Rubio et al., 2019). In conclusion, the references provide comprehensive insights into the impact of lifestyle factors on the human microbiome. They underscore the intricate relationships between diet, physical activity, sleep habits, and the composition and function of the human microbiome, emphasizing the need for further research to improve human health and well-being.

Although there have been a number of studies investigating the relationship between lifestyle factors and the human microbiome, there is still a need for a deeper understanding of the complex interactions between the two. There is a knowledge gap in the literature regarding the specific mechanisms through which lifestyle factors influence the human microbiome, as well as how these interactions can be directed to improve human health.

The aim of this systematic literature review is to investigate and synthesize existing evidence regarding the interaction between lifestyle factors, such as diet, physical activity, and sleep habits, with the composition of the human microbiome. Through this approach, we aim to provide a more comprehensive understanding of how these lifestyle factors may influence the human microbiome and their implications for health.

The research question that will be answered in this study is: "What is the interaction between lifestyle factors, such as diet, physical activity, and sleep habits, with the composition of the human microbiome?"

One of the unique elements of this study is its holistic approach to the relationship between lifestyle factors and the human microbiome. We will investigate the evidence from a variety of scientific disciplines, including biology, nutrition, and medical science, to provide a comprehensive picture of the complexity of these interactions.

The results of this study are expected to provide new contributions to our understanding of the relationship between lifestyle and the human microbiome. The information obtained from this literature analysis can be the basis for developing more effective interventions or recommendations in an effort to improve the health of the human microbiome and prevent diseases associated with modern lifestyle changes.

2. Research Methods

The article collection process was carried out through searches in several international

databases recognized in related scientific fields, such as PubMed, Web of Science, and Scopus. Searches are carried out using certain combinations of keywords that are relevant to the research topic.

Keywords used in the article search included terms such as “lifestyle factors,” “human microbiome,” “diet,” “physical activity,” “sleep habits,” and other variations. The use of broad and inclusive keywords is designed to ensure comprehensive coverage in the article collection.

Inclusion and exclusion criteria have been established to ensure that the selected articles meet the research objectives and are relevant to the topic under study. Articles that meet the inclusion criteria will be considered for further analysis, while articles that do not meet these criteria will be excluded from the study.

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method was used as the main guide in carrying out this review. This method provides a structured framework for conducting systematic research, including article collection, selection and data analysis. By following PRISMA guidelines, it is hoped that this research can be carried out transparently and systematically, resulting in reliable and reproducible results.

3. Results and Discussion

3.1. Lifestyle Factors and Composition of the Human Microbiome

The human microbiome, including the gut, skin, and oral microbiota, is significantly influenced by various lifestyle factors. Manor et al. (2020) demonstrated associations between gut microbiome composition and host clinical markers and lifestyle factors, emphasizing the impact of lifestyle on the microbiome (Manor et al., 2020). Similarly, Dimitriu et al. (2019) highlighted the influence of extrinsic factors, such as lifestyle, on the human skin microbiome, indicating the need to understand these influences (Dimitriu et al., 2019). Furthermore, discussed the shifts in gut microbiome composition across different human lifestyles, underscoring the consequences for human health (Rosas-Plaza et al., 2022; . Salosensaari et al., 2021) and Scorrano et al. (2021) also linked microbiome composition to lifestyle factors and diet, emphasizing the pivotal role of lifestyle in shaping the microbiome (Salosensaari et al., 2021; Scorrano et al., 2021).

Moreover, Johnson et al. (2019) emphasized the dynamic and complex nature of the gastrointestinal microbiome, which varies widely across healthy individuals, further highlighting the impact of lifestyle on microbiome composition (Johnson et al., 2019; . Olm et al., 2022) provided insights into the inheritance of lifestyle-shaped microbiomes, indicating the long-term impact of lifestyle on microbiome assembly (Olm et al., 2022). Additionally, Willis et al. (2022) and Callewaert et al. (2020) discussed the changes in the oral and skin microbiomes influenced by lifestyle and cultural habits, further supporting the role of lifestyle factors in shaping microbiota (Willis et al., 2022; Callewaert et al., 2020).

Furthermore, Goffau et al. (2021) and highlighted the influence of lifestyle and environmental factors on the gut microbiome, emphasizing the need to consider these factors in understanding microbiome compositions (Goffau et al., 2021; McDonough et al., 2020; . Burcham et al., 2020) also suggested that oral microbiome composition is affected by variables including diet, age, and cohabitation, further emphasizing the multifaceted influence of lifestyle on microbiota (Burcham et al., 2020). In conclusion, the human microbiome, including the gut, skin, and oral microbiota, is intricately linked to lifestyle factors such as diet, geography, and industrialization. These references collectively underscore the significant impact of lifestyle on the composition and diversity of the human microbiome, highlighting the need for further research to comprehensively understand these associations.

The human microbiome is influenced by various lifestyle factors such as diet, physical activity, and sleep habits. Diet, in particular, has been extensively studied and is known to significantly impact the composition of the gut microbiome. Research has shown that a diet rich in fiber is associated with greater microbiome diversity and better overall health

(Blackmer-Raynolds & Sampson, 2023). Furthermore, physical activity has also been identified as an important factor that may influence microbiome composition, although the exact mechanisms are not yet fully understood (Holzhausen et al., 2022). There is evidence suggesting that the relationship between physical activity and the gut microbiome is bidirectional (Knoll et al., 2022). However, the exact nature of this relationship and its implications are still being explored. Additionally, good sleep habits are believed to influence the balance of the human microbiome, although the supporting evidence is currently limited.

The bidirectional relationship between the microbiome and host physiological processes has been highlighted in recent literature, indicating that the microbiome also influences various physiological functions within the host (Blackmer-Raynolds & Sampson, 2023). Moreover, a scoping review has summarized evidence addressing the relationship between the intestinal microbiome, diet, and physical activity, emphasizing the complex interactions between these factors (Grace-Farfaglia et al., 2022). This complexity is further underscored by the fact that the relationship between physical activity and gut microbiome composition has not been fully characterized in large, population-based cohorts (Holzhausen et al., 2022). While the relationships between gut microbiome and physical activity are well established in animal models, further research is needed to fully understand these connections in human populations (Shahar et al., 2020).

In conclusion, the relationship between lifestyle factors such as diet, physical activity, and sleep habits, and the composition of the human microbiome is a complex and bidirectional one. While the influence of diet on the gut microbiome has been extensively studied, the impact of physical activity and sleep habits is still not fully understood. Further research is needed to unravel the intricate interactions between these lifestyle factors and the human microbiome, which may contribute to efforts to prevent and treat microbiome-related diseases.

Lifestyle factors are paramount in shaping the composition of the human microbiome, encompassing various elements such as diet, physical activity, age, chronic health disorders, smoking habits, and social interactions. Research has elucidated the profound impact of these factors on different microbial communities within the body. For instance, the gut microbiota exhibit high susceptibility to dietary patterns and physical activity, reflecting the dynamic nature of their composition. Similarly, the oral microbiome responds to a multitude of influences, including age, chronic health conditions, smoking, and social connectivity. Dysbiosis, or imbalance in the gut microbiome, has been linked to metabolic and inflammatory diseases like type 2 diabetes and diabetic retinopathy. Furthermore, modifications observed in response to oxidative stress, antioxidant therapies, diet, and exercise underscore the intricate interplay between lifestyle factors and microbiome health. Understanding these relationships is imperative, given their potential to influence disease biomarkers and overall health status.

Particularly, diet emerges as a central determinant in shaping the human gut microbiota and subsequently influencing health outcomes. Studies have consistently demonstrated the impact of dietary diversity and fiber intake on microbial diversity and stability. A diet rich in natural sources and high in fiber promotes microbial diversity and stability, consequently enhancing immunological responses, mental well-being, and metabolic equilibrium. In contrast, the Western diet, characterized by high processed food intake and low fiber content, correlates with decreased microbial diversity and associated health issues. Beyond diet, lifestyle factors such as chronic stress, irregular sleep patterns, and sedentary behaviors also exert influence on the gut microbiota. Therefore, personalized nutrition strategies that prioritize gut health and overall well-being are pivotal for promoting microbial equilibrium and mitigating disease risk.

Overall, the intricate relationship between lifestyle factors and the human microbiome underscores the importance of adopting holistic approaches to health management. By understanding the multifaceted influences on microbial communities, interventions can be

tailored to optimize microbiome health and enhance overall well-being.

3.2. Interaction Between Lifestyle Factors

The relationship between lifestyle factors, such as dietary patterns, physical activity, and sleep habits, and their influence on the human microbiome composition is a complex and interconnected area of research. Adiwinata et al. (2021) highlighted the interplay between a fiber-rich diet, sleep habits, and physical activity, emphasizing the need for a holistic approach to understand these interactions. The gut microbiome's relationship with the host diet has been extensively studied, emphasizing its involvement in human nutrition, metabolism, physiology, and immune neurohormonal systems (Cohen & Borenstein, 2022). Furthermore, the influence of dietary patterns on the microbiome has been recognized as a comprehensive determinant of health, indicating the limited literature in this area (Jin et al., 2019). Additionally, the impact of gut permeability on the breast microbiome due to dietary patterns has been studied, demonstrating concurrent shifts in microbial species (Bawaneh et al., 2022).

Moreover, the implications of diet and the gut microbiome in neuroinflammatory and neurodegenerative diseases have been explored, emphasizing the significant changes in human lifestyle and dietary behaviors over the last century (Hirschberg et al., 2019). The attributes of physical activity and its relationship with the gut microbiome in adults have been systematically reviewed, indicating the use of dietary intervention as a control in the studies (Shahar et al., 2020). Additionally, a posteriori dietary patterns have been found to better explain variations in the gut microbiome than individual markers, emphasizing the importance of considering overall diet (Cotillard et al., 2022). Furthermore, the relationship between physical activity and the gut microbiome has been assessed in a large, population-based sample of Wisconsin adults, revealing interactions in the association between diversity and physical activity (Holzhausen et al., 2022).

In summary, the literature from 2019-2024 provides comprehensive insights into the intricate relationship between lifestyle factors and the human microbiome. These studies underscore the need for a holistic approach to understand the complex interplay between dietary patterns, physical activity, and sleep habits, ultimately contributing to the development of more effective intervention strategies to improve human microbiome health.

3.3. Moderating and Mediating Factors

The relationship between lifestyle and human microbiome composition is a complex interplay influenced by various moderating and mediating factors such as gender, age, health status, inflammation, and insulin resistance (Hagerty et al., 2020). Research has shown that the effects of diet on the gut microbiome can vary between male and female individuals, as well as between different age groups (Hagerty et al., 2020). Additionally, mediating factors, such as the level of inflammation or insulin resistance, may influence the composition of the microbiome (Hagerty et al., 2020). For instance, sufficient physical activity can reduce inflammation and improve insulin sensitivity, thereby influencing the microbiome composition (Hagerty et al., 2020). Furthermore, the gut microbiota has been identified as a contributing factor to the pathophysiology of obesity, indicating its potential therapeutic implications (Hagerty et al., 2020). Lifestyle habits can also impact the composition of the gut microbial community (Hagerty et al., 2020). These findings highlight the complexity of the relationship between lifestyle and the human microbiome, emphasizing the need to consider moderating and mediating factors to develop targeted prevention and intervention strategies (Hagerty et al., 2020).

Recent studies have further emphasized the bidirectional relationship between physical activity and the gut microbiome, indicating that physical activity is a critical component of human health and may alter the health of the gut microbiome (Holzhausen et al., 2022; Knoll et al., 2023). Moreover, the gut microbiota has been associated with metabolic

diseases such as obesity and insulin resistance, with the potential for targeted interventions through modulation of the microbiome (Orsso et al., 2021; Sohail et al., 2019; Dash & Bataineh, 2021). The use of shotgun metagenomics has been proposed to advance the understanding of associations between microbiome composition, functions, and human metabolic diseases (Orsso et al., 2021). Additionally, the impact of gut microbiota on obesity has been highlighted, suggesting its potential as a therapeutic target (Liu et al., 2021; Zhou et al., 2021). Furthermore, the gut microbiome has been implicated in the pathobiology of metabolic disorders, inflammation, and insulin resistance, indicating its significance in the context of lifestyle-related health outcomes (Sohail et al., 2019; Petrick et al., 2020).

In conclusion, the relationship between lifestyle and the human microbiome is multifaceted, influenced by factors such as gender, age, health status, inflammation, and insulin resistance. The bidirectional relationship between physical activity and the gut microbiome, as well as the potential therapeutic implications of modulating the microbiome in metabolic diseases, underscores the importance of considering the microbiome in the development of targeted prevention and intervention strategies.

4. Conclusion

The conclusion of the discussion regarding lifestyle factors and the composition of the human microbiome, interactions between lifestyle factors, as well as moderating and mediating factors, highlights the importance of a holistic understanding of the complex relationship between lifestyle and the human microbiome. Findings from the literature show that lifestyle factors such as diet, physical activity, and sleep habits have a significant impact on the composition and diversity of the human microbiome, both in the digestive system, skin, and oral cavity. These factors interact and influence each other, forming a complex network of relationships that influence the health and balance of the human microbiome.

The implications of these findings are very important in the context of preventing and treating various microbiome-related diseases, such as obesity, diabetes, and inflammatory bowel disease. By understanding the relationship between lifestyle and the human microbiome, we can develop more effective and targeted intervention strategies, both in terms of behavior change and the development of therapies focused on modulating the microbiome. However, there are several limitations in this study that need to be noted, such as the heterogeneity of research methodology and lack of data in certain areas.

For future research, it is recommended to further explore the mechanisms underlying the interaction between lifestyle and the human microbiome, and involve more comprehensive and longitudinal analysis. In addition, it is also necessary to expand the scope of research to cover a wider and more diverse population, and consider more complex moderating and mediating factors. Thus, it is hoped that future research will provide a more in-depth and relevant understanding of the role of lifestyle in influencing the health of the human microbiome, as well as direct the development of more effective prevention and intervention strategies in the future.

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