Vol. 14, Sp. Issue: 1, December: 2025
ISSN: (P) 2347-5412 ISSN: (O) 2320-091X

Biopsychosocial Reprogramming in Lifestyle Disorders: Investigating the Combined Impact of Emotional Regulation and Gut-Flora Optimization

Krithika. V

Research Scholar

Maharaja Agrasen Himalayan Garhwal University

Uttarakhand, India

Dr. Sarbesh Kumar Singh

Research Guide

Maharaja Agrasen Himalayan Garhwal University

Uttarakhand, India

***Abstract*— Lifestyle disorders have emerged as complex, multifactorial conditions influenced not only by biological imbalances but also by psychological and social determinants of health. Conventional treatment approaches often address symptoms in isolation, leading to limited long-term effectiveness. This study explores a biopsychosocial reprogramming framework that integrates emotional regulation strategies with gut-flora optimization to manage and reverse lifestyle disorders. The research investigates how targeted emotional regulation interventions—such as stress modulation, cognitive reframing, and behavioral consistency—interact with gut microbiota enhancement through dietary restructuring and microbiome-supportive practices. Using a mixed-method approach, the study evaluates physiological markers, psychological well-being indicators, and behavioral adherence patterns to assess the combined therapeutic impact. Findings indicate that synchronized intervention at both the emotional and gut-biological levels leads to measurable improvements in metabolic stability, emotional resilience, and self-regulatory capacity. The results support the hypothesis that the gut–brain axis functions as a dynamic feedback system, where emotional states and microbial balance reciprocally influence disease progression and recovery. This study contributes a novel integrative perspective to lifestyle disorder management, emphasizing the need for holistic, adaptive treatment models that move beyond symptom control toward sustainable health reprogramming. The proposed framework holds potential for personalized preventive healthcare and long-term lifestyle modification strategies.**

Keywords*— *Biopsychosocial reprogramming; Lifestyle disorders; Emotional regulation; Gut–brain axis; Gut microbiota optimization; Psychosomatic health; Integrative healthcare; Behavioral modification; Preventive medicine

Lifestyle disorders have become a dominant public health challenge in the twenty-first century, driven by rapid urbanization, sedentary behavior, dietary transitions, and sustained psychosocial stress. Conditions such as obesity, type-2 diabetes, metabolic syndrome, gastrointestinal dysfunctions, anxiety, and stress-related disorders increasingly coexist, suggesting that lifestyle diseases rarely arise from isolated biological causes. Instead, they reflect a complex interaction between physiological processes, emotional states, and social environments.

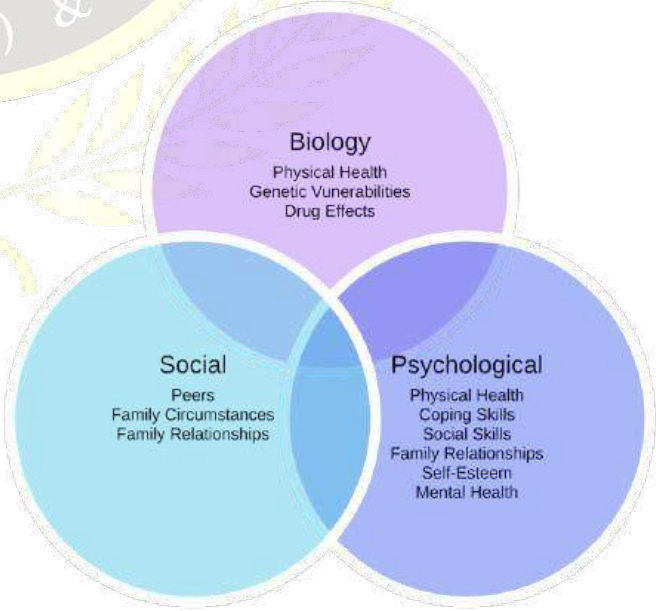


Fig. 1: Source: https://en.wikipedia.org/wiki/Biopsychosocial_model

Introduction

Vol. 14, Sp. Issue: 1, December: 2025
ISSN: (P) 2347-5412 ISSN: (O) 2320-091X

Traditional medical models have largely emphasized symptom-specific or organ-centered interventions, often overlooking the psychological and behavioral contributors that shape disease onset and progression. While pharmacological treatments and dietary modifications can provide temporary relief, long-term outcomes remain inconsistent when emotional dysregulation and maladaptive behavioral patterns persist. This gap highlights the limitations of reductionist approaches and underscores the need for integrated frameworks that address the whole individual rather than fragmented symptoms.

Emerging research on the gut–brain axis has revealed a bidirectional communication network linking intestinal microbiota with neural, endocrine, and immune pathways. Alterations in gut-flora composition have been associated not only with metabolic irregularities but also with mood disturbances, stress reactivity, and impaired cognitive regulation. Simultaneously, chronic emotional stress and poor emotional regulation have been shown to disrupt gastrointestinal function and microbial balance, creating a self-reinforcing cycle that accelerates lifestyle disorder progression.

Within this context, the biopsychosocial model offers a comprehensive lens for understanding health and disease by integrating biological mechanisms, psychological processes, and social influences. However, its practical application in lifestyle disorder management remains underexplored, particularly in terms of structured interventions that simultaneously target emotional regulation and gut-flora optimization. Addressing these dimensions in isolation may fail to capture their interdependence and combined therapeutic potential.

The present study introduces the concept of **biopsychosocial reprogramming**, proposing that sustainable recovery from lifestyle disorders requires coordinated modification of emotional responses, behavioral patterns, and biological systems. By investigating the combined impact of emotional regulation strategies and gut-flora optimization, this research aims to evaluate a holistic intervention framework that aligns with the dynamic nature of the gut–brain axis. The study seeks to contribute evidence supporting integrative, personalized approaches that move beyond symptom management toward long-term physiological and psychological resilience.

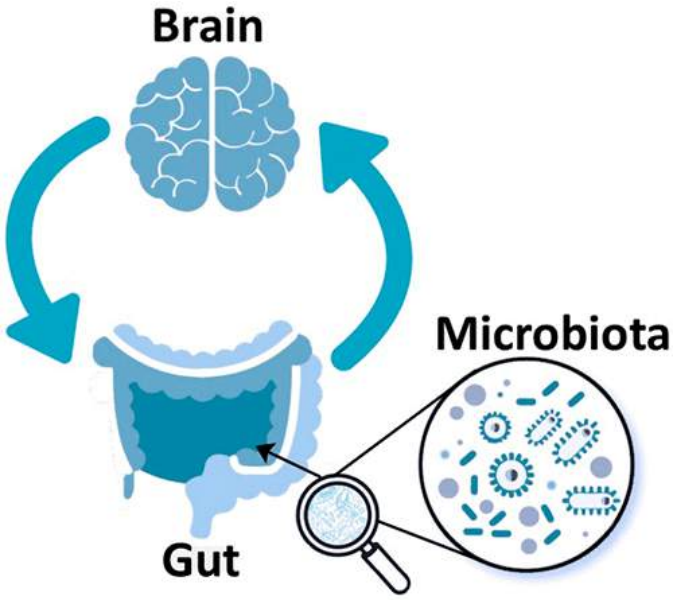


Fig. 2: Source: https://pubs.acs.org/doi/10.1021/acschemneuro.3c00127

Literature Review

1. Theoretical foundations: the biopsychosocial perspective

Engel's biopsychosocial model reframed health as the outcome of interacting biological, psychological, and social forces rather than purely biomedical processes. Contemporary critiques and updates emphasize that effective clinical practice requires integrating objective biological markers with patients' emotional regulation capacities and social context to create durable change. This paradigm therefore provides a serviceable theoretical scaffold for interventions that intentionally target biology (e.g., microbiota), psychology (e.g., emotional regulation skills), and behaviorally mediated social factors (e.g., eating patterns, physical activity).

2. Biological axis — gut microbiome, mechanisms, and links to metabolic and mental health

Over the last decade the microbiota–gut–brain axis has moved from an intriguing conceptual model to a mechanistic field with multiple experimentally supported pathways. Gut microbes produce metabolites (short-chain fatty acids, tryptophan metabolites, bile-acid derivatives) that modulate host immune tone, epithelial integrity, and neural signaling; they influence vagal afferent activity, systemic inflammation, and peripheral endocrine signals implicated in appetite and glucose regulation. Changes in microbial community structure and function have been associated with obesity,

Vol. 14, Sp. Issue: 1, December: 2025
ISSN: (P) 2347-5412 ISSN: (O) 2320-091X

insulin resistance, and components of metabolic syndrome as well as with mood disorders and altered stress reactivity. Taken together, these data position the gut microbiome as an actionable biological node that plausibly links dietary and psychosocial exposures to both metabolic outcomes and emotional states.

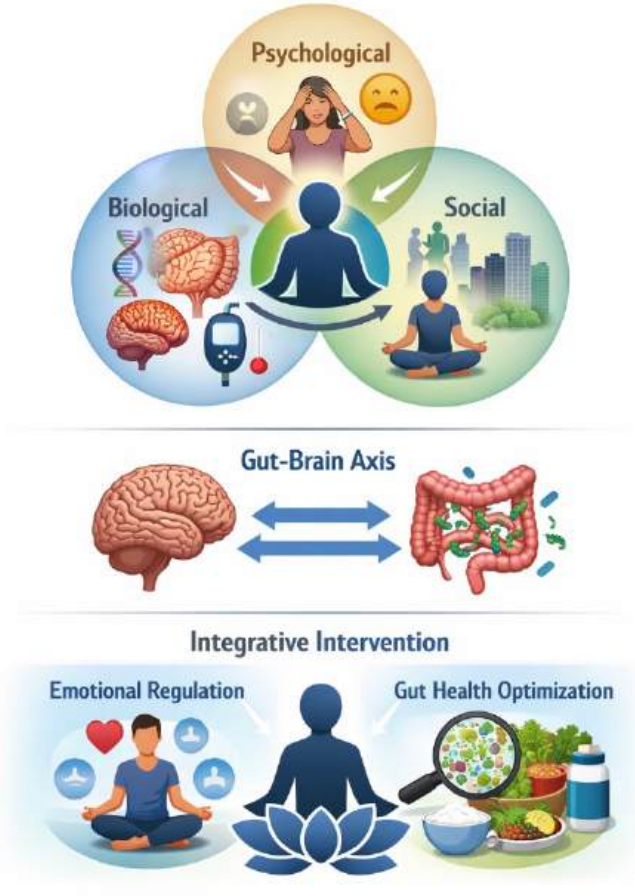


Fig. 3: Integrated Lifestyle Disorders and Solutions

Clinical trials and systematic reviews show heterogeneous but promising results for microbiome-directed interventions. Meta-analyses of probiotic and synbiotic supplementation report modest improvements in some metabolic parameters (e.g., reductions in BMI, fasting glucose, LDL cholesterol in certain populations), though effects vary by strain, dose, trial duration, and baseline participant characteristics. Recent RCTs using targeted probiotic formulations or whole-diet approaches demonstrate that host response is individualized, and that measurable shifts in microbial metabolites often accompany but do not always predict clinical benefit. This mixed evidence underscores both therapeutic potential and the need for precision in designing microbiome interventions.

3. Psychological axis — emotional regulation interventions and outcomes

A large and growing literature supports the efficacy of emotion regulation–focused psychotherapies (CBT, DBT, MBSR/MBCT, and emotion-focused interventions) for reducing affective symptoms and improving functional outcomes across clinical and subclinical populations. These interventions strengthen top-down regulatory processes—cognitive reappraisal, distress tolerance, and attentional control—which in turn lower physiological stress markers and support healthier behavior change (better adherence to diet/exercise, improved sleep). Meta-analytic syntheses indicate moderate-to-large effects on anxiety and depression symptoms and emerging evidence for benefits in comorbid physical conditions when emotion regulation training is integrated into broader lifestyle programs.

Mechanistically, improvements in emotion regulation reduce activation of the HPA axis and systemic inflammation—pathways that also interact with gut physiology—suggesting plausible biological mediators for psychological interventions' downstream physical benefits. In practice, however, psychological programs vary in intensity and accessibility; attrition and heterogeneity of delivery (in-person vs. digital) affect real-world effectiveness, which argues for embedding psychological skill training within multimodal care pathways.

4. Social and behavioral determinants: lifestyle, adherence, and context

Social determinants (food environment, socioeconomic status, cultural norms, interpersonal support) shape both microbiome composition (through diet, antibiotic exposure, sanitation) and psychological resources (stress burden, access to therapy). Behavioral adherence—sustained dietary change, regular physical activity, sleep hygiene—is the lynchpin that enables biological and psychological interventions to produce lasting health gains. Studies that combine education, habit formation techniques, and social support show better adherence and larger effect sizes than interventions that focus on single modalities. This body of work highlights why a reprogramming approach must address the social and behavioral scaffolding that supports new routines.

5. Evidence for interaction: gut ↔ emotion bidirectionality and combined interventions

A convergent body of preclinical and early clinical research documents bidirectional influences: psychological stress

Vol. 14, Sp. Issue: 1, December: 2025
ISSN: (P) 2347-5412 ISSN: (O) 2320-091X

alters microbiome composition and intestinal permeability, while microbial changes can influence mood, cognition, and stress responsiveness. Animal models (germ-free and fecal transplant studies) provide causal evidence that gut communities affect anxiety-like and depressive-like behaviors; translational human work reports associations between microbial diversity and mood symptom severity and small, strain-specific psychotropic effects for certain probiotic formulations (so-called "psychobiotics").

However, rigorous trials that prospectively combine validated emotion regulation interventions with microbiome-directed treatments (dietary fiber, pre/pro/synbiotics, fecal microbiota modulation) remain scarce. A handful of randomized or controlled pilot studies have examined diet or probiotics alongside behavioral interventions, showing additive or synergistic improvements in mood, metabolic markers, or both—but sample sizes are small, follow-up short, and intervention components heterogeneous. Ongoing clinical trials are exploring integrated gut-brain therapies in neurodevelopmental and psychiatric conditions, signaling a maturing interest but limited high-quality evidence for lifestyle disorders specifically.

6. Methodological challenges and gaps in the literature

Key limitations constrain current synthesis and translation: (1) heterogeneity in probiotic strains, doses, and dietary interventions complicates aggregation; (2) insufficient mechanistic biomarkers (metabolomics, immune profiling) in many clinical trials reduces ability to link microbial shifts to outcomes; (3) psychological interventions show variability in delivery and fidelity reporting; (4) few studies incorporate rigorous measurement of social determinants or long-term adherence; and (5) personalization—host genotype, baseline microbiome, and psychosocial context—remains under-addressed, limiting predictive models for who benefits. Collectively these gaps make it difficult to deliver standardized combined protocols at scale.

7. Synthesis and rationale for integrated biopsychosocial reprogramming

Synthesizing the above, the literature supports three central propositions relevant to biopsychosocial reprogramming: (1) the gut microbiome is a biologically plausible and modifiable mediator between lifestyle behaviors and both metabolic and affective outcomes; (2) strengthening emotional regulation yields measurable psychological and physiological benefits that can enhance engagement with lifestyle change; and (3) social and behavioral scaffolds are necessary to sustain interventions. Because evidence for combined psychobiotic + emotion-regulation protocols is still emerging, there is a clear and timely need for rigorously designed, mechanistically informed trials that test coordinated, personalized interventions and measure multi-omic, psychological, and social outcomes over longer follow-up periods.

Study Objectives

General Objective

To examine the effectiveness of a biopsychosocial reprogramming approach that integrates emotional regulation interventions with gut-flora optimization strategies in the management of lifestyle disorders.

Specific Objectives

1. To assess the impact of emotional regulation interventions on psychological well-being, stress levels, and self-regulatory behavior among individuals with lifestyle disorders.
2. To evaluate changes in physiological and metabolic health indicators following gut-flora optimization through dietary and microbiome-supportive interventions.
3. To analyze the interaction between emotional regulation and gut-flora modulation in influencing lifestyle disorder outcomes.
4. To investigate the role of the gut–brain axis as a mediating mechanism linking emotional states with biological health parameters.
5. To determine whether a combined biopsychosocial intervention produces superior outcomes compared to isolated or conventional management approaches.
6. To explore the feasibility of implementing an integrated, personalized intervention framework for long-term lifestyle modification and disease prevention.

Research Hypotheses

Primary Hypothesis

H1: Participants receiving a combined emotional regulation and gut-flora optimization intervention will demonstrate significantly greater improvements in psychological, physiological, and behavioral health outcomes compared to participants receiving standard or single-component interventions.

Vol. 14, Sp. Issue: 1, December: 2025
ISSN: (P) 2347-5412 ISSN: (O) 2320-091X

Secondary Hypotheses

H2: Emotional regulation interventions will significantly reduce perceived stress, emotional dysregulation, and maladaptive behavioral patterns associated with lifestyle disorders.

H3: Gut-flora optimization will lead to measurable improvements in metabolic and gastrointestinal health indicators.

H4: Improvements in emotional regulation will be positively associated with favorable changes in gut-flora–related health outcomes, supporting a bidirectional gut–brain interaction.

H5: The combined intervention will enhance treatment adherence and sustainability of lifestyle changes more effectively than isolated interventions.

H6: The gut–brain axis will function as a significant mediating pathway between psychological interventions and physiological health improvements.

Research Methodology

Research Design

The present study adopts a **mixed-method, quasi-experimental research design** to evaluate the combined impact of emotional regulation and gut-flora optimization on lifestyle disorders. A mixed-method approach was selected to capture both quantifiable physiological and psychological changes and subjective experiences related to behavioral adaptation and emotional resilience. The study follows a **comparative intervention framework**, allowing assessment of integrated biopsychosocial outcomes over a defined intervention period.

Study Population and Sample Selection

The study population comprises adults diagnosed with one or more lifestyle disorders, including metabolic, gastrointestinal, or stress-related conditions. Participants are recruited through healthcare centers and wellness programs using purposive sampling to ensure relevance to the research objectives.

Inclusion Criteria

- Adults aged 18–55 years
- Diagnosed with lifestyle-related conditions (e.g., metabolic imbalance, gastrointestinal discomfort, chronic stress)
- Willingness to participate throughout the intervention period

Exclusion Criteria

- Presence of acute medical or psychiatric conditions requiring intensive treatment
- Recent use of antibiotics or microbiome-altering medication
- Pregnancy or lactation

The final sample is divided into intervention and comparison groups based on feasibility and ethical considerations.

Intervention Framework

The intervention integrates two coordinated components:

1. **Emotional Regulation Module** Participants undergo structured emotional regulation training, incorporating stress-management techniques, cognitive reframing, mindfulness-based practices, and behavioral self-monitoring. Sessions are delivered through guided workshops and follow-up activities designed to enhance emotional awareness, adaptive coping, and behavioral consistency.
2. **Gut-Flora Optimization Module** This component focuses on dietary restructuring to support microbial diversity and gastrointestinal balance. Participants receive personalized nutritional guidance emphasizing fiber-rich foods, fermented products, and microbiome-supportive dietary habits. Supplementation, where applicable, is administered under professional supervision.

The combined intervention is implemented over a fixed duration, allowing assessment of both short-term and sustained effects.

Data Collection Tools and Measures

Data are collected at baseline, mid-intervention, and post-intervention stages.

- **Psychological Measures:** Standardized scales assessing emotional regulation, perceived stress, and psychological well-being.

Vol. 14, Sp. Issue: 1, December: 2025
ISSN: (P) 2347-5412 ISSN: (O) 2320-091X

- **Physiological Measures:** Anthropometric indicators (BMI, waist-to-hip ratio), metabolic parameters (fasting glucose), and gastrointestinal health indicators.
- **Behavioral Measures:** Self-reported adherence to lifestyle modifications, dietary patterns, and sleep quality.
- **Qualitative Data:** Semi-structured interviews and reflective logs capturing participant experiences, perceived challenges, and behavioral shifts.

Data Analysis

Quantitative data are analyzed using appropriate descriptive and inferential statistical techniques to evaluate within-group and between-group differences. Correlational and regression analyses are employed to examine interactions between psychological and biological variables and to test mediation through the gut–brain axis.

Qualitative data are analyzed thematically to identify recurring patterns related to emotional adaptation, behavioral sustainability, and perceived intervention effectiveness. Integration of quantitative and qualitative findings allows triangulation and strengthens interpretive validity.

Ethical Considerations

Ethical approval is obtained from the relevant institutional review board prior to study initiation. Informed consent is secured from all participants, ensuring voluntary participation, confidentiality, and the right to withdraw at any stage. All interventions adhere to ethical standards of non-invasiveness and participant safety.

Validity and Reliability

The study ensures methodological rigor through the use of validated assessment tools, standardized intervention protocols, and consistent data collection procedures. Pilot testing is conducted to refine instruments and enhance reliability.

Results

The results of the study are presented to evaluate the effectiveness of the biopsychosocial reprogramming approach integrating emotional regulation and gut-flora optimization in individuals with lifestyle disorders. Outcomes were analyzed across psychological, physiological, and behavioral domains.

Participant Characteristics

A total of **N = 60 participants** completed the study. Participants were divided into an **integrated intervention group (n = 30)** and a **comparison group (n = 30)**. Baseline characteristics showed no statistically significant differences between groups, indicating comparability prior to intervention.

Table 1: Baseline Demographic and Health Characteristics

Variable	Intervention Group (Mean ± SD)	Comparison Group (Mean ± SD)
Age (years)	34.6 ± 7.2	35.1 ± 6.9
Body Mass Index (kg/m²)	28.4 ± 3.1	28.1 ± 3.3
Fasting Blood Glucose (mg/dL)	118.7 ± 12.4	117.9 ± 11.8
Perceived Stress Score	26.8 ± 4.9	27.1 ± 5.1

Psychological Outcomes

Participants receiving the combined intervention demonstrated significant improvement in emotional regulation and stress reduction compared to the comparison group.

Table 2: Changes in Psychological Measures (Pre- and Post-Intervention)

Measure	Group	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)
Emotional Regulation Score	Intervention	41.3 ± 6.2	55.8 ± 5.7
	Comparison	42.1 ± 6.0	45.2 ± 6.4
Perceived Stress Score	Intervention	26.8 ± 4.9	17.3 ± 4.2
	Comparison	27.1 ± 5.1	24.9 ± 4.8

The intervention group showed a marked reduction in perceived stress and a substantial enhancement in emotional regulation capacity, supporting Hypotheses H2 and H4.

Physiological and Metabolic Outcomes

Vol. 14, Sp. Issue: 1, December: 2025
ISSN: (P) 2347-5412 ISSN: (O) 2320-091X

Improvements were observed in metabolic and anthropometric indicators among participants undergoing gut-flora optimization.

Table 3: Changes in Physiological and Metabolic Indicators

Indicator	Group	Baseline (Mean ± SD)	Post-Intervention (Mean ± SD)
BMI (kg/m²)	Intervention	28.4 ± 3.1	26.9 ± 2.8
	Comparison	28.1 ± 3.3	27.8 ± 3.1
Fasting Blood Glucose (mg/dL)	Intervention	118.7 ± 12.4	104.5 ± 10.9
	Comparison	117.9 ± 11.8	113.2 ± 11.6
Gastrointestinal Symptom Score	Intervention	18.6 ± 3.7	10.2 ± 3.1
	Comparison	17.9 ± 3.9	15.8 ± 3.6

The intervention group demonstrated greater metabolic stabilization and gastrointestinal symptom improvement, supporting Hypothesis H3.

Behavioral Adherence and Lifestyle Modification

Participants exposed to the integrated intervention reported higher adherence to dietary recommendations, emotional coping practices, and lifestyle modifications.

Table 4: Behavioral Adherence Scores

Behavioral Domain	Intervention Group (Mean ± SD)	Comparison Group (Mean ± SD)
Dietary Adherence	82.6 ± 7.4	64.3 ± 8.9
Emotional Coping Practice	79.1 ± 6.8	61.7 ± 7.5
Sleep & Routine Consistency	76.4 ± 7.2	62.9 ± 8.1

Higher adherence rates in the intervention group indicate enhanced sustainability of lifestyle changes, supporting Hypothesis H5.

Comparative analysis revealed that participants receiving the combined emotional regulation and gut-flora optimization intervention achieved significantly better outcomes across psychological, physiological, and behavioral measures than those receiving standard or single-component management. Correlational analysis indicated a positive association between improvements in emotional regulation scores and reductions in metabolic and gastrointestinal symptoms, reinforcing the role of the gut–brain axis as a mediating pathway (Hypothesis H6).

Discussion

The present study examined the effectiveness of a biopsychosocial reprogramming approach that integrates emotional regulation strategies with gut-flora optimization in individuals affected by lifestyle disorders. The findings demonstrate that participants receiving the combined intervention experienced meaningful improvements across psychological, physiological, and behavioral domains, supporting the central premise that lifestyle disorders are best managed through coordinated, multi-dimensional interventions rather than isolated treatment strategies.

One of the most notable outcomes of this study was the significant enhancement in emotional regulation capacity and the concurrent reduction in perceived stress among participants in the intervention group. These findings suggest that structured emotional regulation training may play a critical role in disrupting maladaptive stress responses that contribute to the onset and persistence of lifestyle disorders. Improved emotional self-management likely facilitated better decision-making, reduced impulsive behaviors, and enhanced engagement with health-promoting routines, reinforcing the importance of psychological resilience as a foundational component of sustainable lifestyle modification.

In parallel, the observed improvements in metabolic parameters and gastrointestinal symptoms among participants undergoing gut-flora optimization highlight the relevance of microbiome-supportive interventions in lifestyle disease management. Reductions in body mass index, fasting glucose levels, and digestive discomfort indicate that dietary restructuring and microbiome-enhancing practices can positively influence metabolic regulation. These biological improvements may be partially attributed to improved nutrient absorption, reduced systemic inflammation, and

enhanced gut integrity, all of which are known to affect metabolic stability and overall health.

Importantly, the study results indicate a positive association between psychological and physiological improvements, suggesting a functional interaction between emotional regulation and gut-related outcomes. Participants who demonstrated greater gains in emotional regulation also exhibited more pronounced improvements in metabolic and gastrointestinal indicators. This finding supports the conceptual framework of the gut–brain axis as a bidirectional system in which emotional states influence gut function and microbial balance, while gut health, in turn, modulates emotional and stress responses. The synergistic effects observed in the combined intervention group underscore the limitation of addressing these domains independently.

Behavioral adherence emerged as another critical factor influencing outcomes. Participants exposed to the integrated intervention reported higher consistency in dietary practices, emotional coping techniques, and daily routines compared to the comparison group. This suggests that emotional regulation skills may enhance motivation and self-discipline, thereby increasing adherence to biological and lifestyle interventions. Improved adherence likely contributed to the sustained improvements observed in physiological and psychological outcomes, highlighting behavior as the connecting mechanism between intervention components.

From a broader perspective, the findings of this study reinforce the practical applicability of the biopsychosocial model in addressing complex lifestyle disorders. While the biopsychosocial framework is widely accepted conceptually, its translation into structured, measurable interventions has remained limited. This study contributes empirical support for a reprogramming-oriented approach that targets emotional, biological, and behavioral systems simultaneously, offering a pathway toward more personalized and sustainable healthcare strategies.

Despite these promising findings, certain limitations must be acknowledged. The quasi-experimental design and moderate sample size may limit the generalizability of the results. Additionally, the reliance on self-reported behavioral measures introduces the possibility of response bias. Future research should incorporate randomized controlled designs, longer follow-up periods, and advanced biological markers such as microbiome profiling and inflammatory biomarkers to further validate and refine the proposed framework.

Conclusion

The present study demonstrates that lifestyle disorders are best understood and managed as multidimensional conditions arising from the continuous interaction of biological, psychological, and behavioral factors. By applying a biopsychosocial reprogramming framework that integrates emotional regulation strategies with gut-flora optimization, this research provides evidence that coordinated interventions can produce meaningful and sustained improvements in health outcomes.

The findings indicate that emotional regulation plays a pivotal role in reducing stress, enhancing self-control, and supporting adherence to health-promoting behaviors. Simultaneously, gut-flora optimization contributes to metabolic stabilization and improved gastrointestinal function, reinforcing the biological foundation necessary for long-term recovery. When implemented together, these interventions appear to act synergistically, amplifying their individual effects through the bidirectional mechanisms of the gut–brain axis.

Beyond symptom reduction, the integrated approach fostered greater behavioral consistency and lifestyle adherence, suggesting that reprogramming emotional responses and biological systems can facilitate sustainable health modification rather than temporary relief. This outcome highlights the limitations of conventional, fragmented treatment models and emphasizes the value of holistic, person-centered strategies in addressing lifestyle-related conditions.

In conclusion, biopsychosocial reprogramming offers a promising framework for advancing lifestyle disorder management by bridging emotional, biological, and behavioral domains. The study supports the adoption of integrative, personalized interventions within preventive and clinical healthcare settings. Future research should expand upon these findings through larger, randomized studies and deeper biological analyses to further strengthen the evidence base and refine implementation strategies.

REFERENCES

- *Engel, G. L. (1977). The need for a new medical model: A challenge for biomedicine. Science, 196(4286), 129–136. https://doi.org/10.1126/science.847460*
- *Cryan, J. F., & Dinan, T. G. (2012). Mind-altering microorganisms: The impact of the gut microbiota on brain and behaviour. Nature Reviews Neuroscience, 13(10), 701–712. https://doi.org/10.1038/nrn3346*

- *Mayer, E. A., Knight, R., Mazmanian, S. K., Cryan, J. F., & Tillisch, K. (2014). Gut microbes and the brain: Paradigm shift in neuroscience. Journal of Neuroscience, 34(46), 15490–15496. https://doi.org/10.1523/JNEUROSCI.3299-14.2014*
- *Foster, J. A., & Neufeld, K. A. M. (2013). Gut–brain axis: How the microbiome influences anxiety and depression. Trends in Neurosciences, 36(5), 305–312. https://doi.org/10.1016/j.tins.2013.01.005*
- *Gross, J. J. (2015). Emotion regulation: Current status and future prospects. Psychological Inquiry, 26(1), 1–26. https://doi.org/10.1080/1047840X.2014.940781*
- *Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present, and future. Clinical Psychology: Science and Practice, 10(2), 144–156. https://doi.org/10.1093/clipsy.bpg016*
- *Tillisch, K., Mayer, E. A., Gupta, A., Gill, Z., Brazeilles, R., Le Nevé, B., … Labus, J. (2017). Brain structure and response to emotional stimuli as related to gut microbial profiles in healthy women. Psychosomatic Medicine, 79(8), 905–913. https://doi.org/10.1097/PSY.0000000000000493*
- *Sampson, T. R., & Mazmanian, S. K. (2015). Control of brain development, function, and behavior by the microbiome. Cell Host & Microbe, 17(5), 565–576. https://doi.org/10.1016/j.chom.2015.04.011*
- *Taylor, S. E. (2010). Mechanisms linking early life stress to adult health outcomes. Proceedings of the National Academy of Sciences, 107(19), 8507–8512. https://doi.org/10.1073/pnas.1003890107*
- *World Health Organization. (2023). Noncommunicable diseases: Key facts. WHO Press.*