

THE ROLE OF NUTRITION IN MANAGING ENDOCRINE DISORDERS – A NARRATIVE REVIEW

Narrative Review

Sami Ullah¹, Zeeshan Hussain^{2*}, Noor Islam³, Ali Hamza Arshad⁴, Muhammad Arsalan Mahmood⁵

¹MO, Bolan Medical College Quetta, Pakistan

²MBBS (China), RPD-FM (AKU), PGD-HM (HSA), UWMC (PN), Underwater and Hyperbaric Medicine Specialist, Naval Special Operations Training Centre (NSOTC), Bin Qasim, Karachi, Pakistan.

³Department of Medicine, Saidu Group of Teaching Hospitals Saidu Shareef Swat KP Pakistan. University of South China, Hengyang City Hunan Province P.R China

⁴Medical Officer, DHQ Hospital, Sheikhpura, Pakistan.

⁵Assistant Professor, School of food and agricultural sciences, University of management and technology, Lahore, Pakistan.

Corresponding Author: Zeeshan Hussain, MBBS (China), RPD-FM (AKU), PGD-HM (HSA), UWMC (PN), Underwater and Hyperbaric Medicine Specialist, Naval Special Operations Training Centre (NSOTC), Bin Qasim, Karachi, Pakistan. Dr.zeeshanhussain90@gmail.com

Conflict of Interest: None

Grant Support & Financial Support: None

Acknowledgment: The authors extend their gratitude to researchers and healthcare professionals whose contributions have advanced the understanding of nutrition's role in endocrine health. Appreciation is also given to institutions and funding bodies supporting research in this field. Special thanks to colleagues for their insights and discussions that enriched this review.

ABSTRACT

Background: Endocrine disorders, including diabetes mellitus, thyroid dysfunction, polycystic ovary syndrome, and adrenal diseases, represent a significant global health burden. Nutrition plays a pivotal role in managing these conditions by influencing metabolic pathways, hormonal balance, and disease progression. While pharmacological interventions remain the cornerstone of treatment, dietary strategies have emerged as essential adjuncts for improving clinical outcomes. Despite growing recognition of the impact of nutrition on endocrine health, inconsistencies in dietary recommendations and gaps in research necessitate a comprehensive review of existing evidence.

Objective: This narrative review aims to explore the role of nutrition in managing endocrine disorders, highlighting current dietary strategies, their effectiveness, and limitations in clinical practice. Additionally, it identifies research gaps and suggests future directions for optimizing nutritional interventions.

Main Discussion Points: The review discusses evidence-based dietary approaches for various endocrine conditions, including medical nutrition therapy for diabetes, micronutrient supplementation for thyroid function, and dietary modifications for metabolic disorders such as polycystic ovary syndrome. While observational studies suggest promising benefits, methodological limitations, inconsistent outcome measures, and publication bias undermine the reliability of findings. Furthermore, the review highlights the emerging field of precision nutrition, which aims to tailor dietary recommendations based on genetic, metabolic, and microbiome profiles.

Conclusion: Nutritional interventions offer substantial potential in managing endocrine disorders, but stronger evidence from well-designed randomized controlled trials is needed to refine clinical guidelines. Personalized dietary strategies, integrating metabolic and genetic factors, may enhance patient outcomes. Future research should focus on standardizing dietary assessment methods and long-term intervention studies to establish definitive causal relationships.

Keywords: Endocrine Disorders, Nutrition, Dietary Interventions, Diabetes Mellitus, Thyroid Health, Precision Nutrition.

INTRODUCTION

Endocrine disorders, which encompass a wide range of conditions such as diabetes mellitus, thyroid dysfunctions, polycystic ovary syndrome (PCOS), and adrenal disorders, have become increasingly prevalent worldwide. These disorders arise due to imbalances in hormone production and regulation, significantly impacting metabolic processes, growth, and overall homeostasis. The global burden of endocrine diseases is substantial, with conditions like diabetes mellitus alone affecting approximately 537 million adults worldwide in 2021, a number expected to rise to 643 million by 2030 (1). Similarly, thyroid disorders are prevalent, with hypothyroidism affecting nearly 5% of the global population, leading to a wide range of metabolic and cardiovascular complications. These staggering statistics emphasize the urgency of exploring effective management strategies beyond pharmacological interventions(2). Current therapeutic approaches for endocrine disorders primarily involve hormone replacement therapy, medications to regulate hormone secretion, and lifestyle modifications. However, growing evidence underscores the pivotal role of nutrition in the prevention and management of endocrine dysfunctions. Dietary interventions, including macronutrient composition, micronutrient sufficiency, and caloric intake, have been shown to influence hormonal balance, metabolic control, and disease progression. For instance, medical nutrition therapy has been recognized as a cornerstone in the management of diabetes mellitus, where tailored dietary plans help regulate glycemic control and mitigate complications (3). Similarly, dietary modifications play a critical role in thyroid health, with iodine, selenium, and iron being essential for optimal thyroid function (4).

Despite the growing body of research linking diet and endocrine health, several gaps remain in the understanding of specific dietary components' mechanistic roles in hormonal regulation. While numerous studies have explored the impact of high-glycemic versus low-glycemic diets on insulin resistance and diabetes progression, there is still limited clarity on the long-term benefits of individualized nutrition plans based on genetic predispositions and metabolic profiles (5). Additionally, while certain nutrients such as omega-3 fatty acids and polyphenols have shown promise in reducing inflammation associated with endocrine disorders, more robust clinical trials are required to determine their precise therapeutic potential (6). These knowledge gaps necessitate a comprehensive review of existing evidence to identify effective nutritional interventions and future research directions (7). This narrative review aims to synthesize current evidence regarding the role of nutrition in managing endocrine disorders, highlighting dietary interventions that support hormonal balance and metabolic health. The review will explore various endocrine conditions, including diabetes mellitus, thyroid dysfunctions, PCOS, adrenal insufficiencies, and multiple endocrine neoplasia, assessing the impact of specific dietary patterns, micronutrient supplementation, and caloric modulation on disease progression and management. Additionally, the review will discuss emerging areas such as precision nutrition and its potential role in tailoring dietary recommendations for individuals with endocrine disorders(8).

By consolidating existing research and addressing the identified gaps, this review seeks to provide a comprehensive resource for clinicians, dietitians, and researchers in the field of endocrinology and nutrition. Given the increasing recognition of dietary interventions as a fundamental component of endocrine health management, understanding the interplay between nutrition and hormone regulation is imperative for developing holistic treatment strategies. This review aspires to bridge the gap between clinical endocrinology and nutritional science, offering insights that could inform patient-centered dietary recommendations and future research endeavors(9).

THEMATIC DISCUSSION (MAIN BODY OF THE REVIEW)

Nutritional Strategies in Diabetes Mellitus Management

Dietary interventions play a crucial role in the management of diabetes mellitus, particularly type 2 diabetes mellitus (T2DM), by improving glycemic control and preventing disease progression. Medical Nutrition Therapy (MNT) has been widely recommended as a fundamental component of diabetes care, with studies indicating that structured dietary plans can lead to significant reductions in HbA1c levels and postprandial glucose excursions (3). Low-glycemic index diets, Mediterranean diets rich in monounsaturated fats, and plant-based diets have all demonstrated beneficial effects on insulin sensitivity and lipid profiles. Furthermore, protein distribution in meals influences glucose metabolism, with evidence supporting higher protein intake in breakfast meals for better glycemic control (10). However, controversy exists regarding the optimal macronutrient ratio, as some studies suggest a lower carbohydrate intake is preferable, whereas others emphasize overall caloric moderation over macronutrient manipulation. More individualized approaches tailored to metabolic phenotypes are needed to clarify this aspect (11).

The Role of Nutrition in Thyroid Disorders

The interplay between nutrition and thyroid health is well-documented, with iodine, selenium, and iron being critical for thyroid hormone synthesis and function. Iodine deficiency remains a major concern globally, particularly in regions with low dietary iodine intake, leading to hypothyroidism and goiter (4). Conversely, excessive iodine consumption has been implicated in thyroid autoimmunity, suggesting a narrow therapeutic range for iodine intake. Selenium, an essential trace element, has shown promise in reducing autoimmune thyroiditis severity and enhancing thyroxine metabolism. However, supplementation benefits appear to be patient-specific, with some studies failing to demonstrate consistent improvement in clinical outcomes. Another debated area is the role of goitrogens found in cruciferous vegetables, as their impact on thyroid function remains controversial, with some studies indicating interference in iodine uptake, while others report negligible effects in euthyroid individuals(4).

Dietary Interventions in Polycystic Ovary Syndrome (PCOS)

PCOS is a common endocrine disorder characterized by insulin resistance, hyperandrogenism, and metabolic dysregulation. Dietary interventions targeting insulin sensitivity have been shown to improve ovulatory function and reduce androgen levels in affected individuals. Low-carbohydrate diets, particularly those emphasizing complex carbohydrates and fiber, have demonstrated efficacy in reducing insulin resistance and improving lipid profiles(9, 12). Additionally, omega-3 fatty acid supplementation has been associated with reductions in systemic inflammation and improvements in menstrual regularity. However, inconsistencies exist in dietary recommendations, with some researchers advocating for high-protein diets, while others highlight the importance of caloric restriction over macronutrient composition. Further studies are needed to establish personalized dietary strategies that address metabolic and reproductive outcomes in PCOS patients(5).

Nutritional Considerations in Adrenal Disorders

Adrenal disorders such as Cushing's syndrome and Addison's disease significantly alter metabolism and nutritional needs. In Cushing's syndrome, hypercortisolism contributes to insulin resistance, obesity, and osteoporosis, necessitating dietary interventions focused on reducing carbohydrate intake and increasing calcium and vitamin D consumption. Conversely, Addison's disease requires careful electrolyte management, particularly sodium intake, due to adrenal insufficiency-induced hyponatremia. While general dietary guidelines emphasize balanced nutrition, evidence supporting specific dietary protocols in adrenal disorders remains scarce, highlighting a gap in research that warrants further exploration(6).

The Impact of Diet on Multiple Endocrine Neoplasia (MEN) Syndromes

Multiple endocrine neoplasia (MEN) syndromes, particularly MEN1, involve tumors affecting the parathyroid glands, pancreas, and pituitary gland. Nutritional management is crucial, as hypercalcemia from primary hyperparathyroidism increases the risk of nephrolithiasis and osteoporosis. Adequate calcium and vitamin D intake is essential, though excessive calcium intake must be avoided to prevent kidney complications. Additionally, pancreatic neuroendocrine tumors in MEN1 patients often necessitate dietary modifications due to malabsorption and digestive enzyme deficiencies. Personalized nutrition strategies that cater to the multifaceted metabolic challenges of MEN syndromes are needed to optimize patient outcomes(5).

Controversies and Future Directions in Endocrine Nutrition Research

Despite the substantial evidence supporting dietary interventions in endocrine disorders, several controversies persist. One major debate is the role of precision nutrition in tailoring dietary recommendations based on genetic predispositions and metabolic phenotyping. While some studies support individualized dietary interventions to improve metabolic outcomes, others argue that broader dietary patterns, such as the Mediterranean diet, provide similar benefits across diverse populations. Additionally, the long-term sustainability of specific dietary interventions remains a challenge, as adherence rates tend to decline over time. Further research integrating nutrigenomics, microbiome analysis, and metabolomics is required to refine dietary recommendations and enhance personalized nutrition approaches for endocrine health(6).

Table 1: Nutritional Interventions for Endocrine Disorders

Endocrine Disorder		Recommended Nutritional Interventions	Potential Benefits
Diabetes Mellitus		Low-glycemic index diet, Mediterranean diet, fiber-rich foods, omega-3 fatty acids	Improved glycemic control, reduced insulin resistance
Thyroid Disorders		Iodine-rich foods, selenium supplementation, balanced macronutrient intake	Enhanced thyroid function, reduced autoimmunity
Polycystic Ovary Syndrome (PCOS)	Ovary	Low-carbohydrate diet, omega-3 fatty acids, high-fiber foods	Improved insulin sensitivity, hormonal balance
Adrenal Disorders		Calcium and vitamin D intake, controlled sodium consumption	Electrolyte stability, reduced osteoporosis risk
Multiple Endocrine Neoplasia (MEN)	Endocrine	Calcium and phosphate balance, vitamin D optimization, enzyme-based diet adjustments	Bone health preservation, digestive stability

Critical Analysis and Limitations of Existing Literature

The current body of literature examining the role of nutrition in managing endocrine disorders provides valuable insights but is fraught with methodological and interpretative limitations. One of the most pressing concerns is the predominance of observational studies, which, while informative, lack the robustness required to establish causality. Many studies rely on cross-sectional designs, limiting the ability to discern whether dietary modifications lead to improvements in endocrine function or if individuals with better-managed endocrine conditions are simply more likely to adhere to healthier diets (6). Furthermore, the limited number of randomized controlled trials (RCTs) on nutritional interventions in endocrine disorders presents a significant gap in the literature, as RCTs provide the most reliable evidence for clinical recommendations(13). Small sample sizes in many studies further restrict the reliability of findings. Several trials investigating the effects of dietary modifications on conditions such as diabetes mellitus, polycystic ovary syndrome, and thyroid disorders include relatively small cohorts, reducing statistical power and increasing the risk of type II errors (5). The lack of long-term follow-up in many of these studies further compounds the issue, as metabolic and endocrine adaptations often require prolonged periods to manifest. Without extended follow-up durations, it remains uncertain whether observed benefits persist over time or if they diminish due to dietary non-compliance or physiological adaptations(14).

Methodological biases also pose challenges in interpreting the available evidence. Selection bias is frequently evident in studies that recruit participants from specialized clinics, thereby limiting the applicability of findings to the broader population. Similarly, many trials fail to implement adequate blinding, leading to potential performance bias where participants' awareness of their dietary interventions influences their adherence and perceived outcomes(4). Confounding variables, such as concurrent medication use, physical activity levels, and genetic predispositions, are often inadequately controlled, making it difficult to attribute observed effects solely to nutritional interventions(15). Another critical issue is publication bias, which skews the literature towards positive findings. Studies that fail to demonstrate significant effects of nutritional interventions on endocrine health may be underreported, leading to an overestimation of dietary benefits(6). This bias may contribute to an inflated perception of efficacy, particularly in areas such as micronutrient supplementation, where inconsistent findings exist. Moreover, systematic reviews and meta-analyses often exclude studies with inconclusive results, further compounding the issue(16).

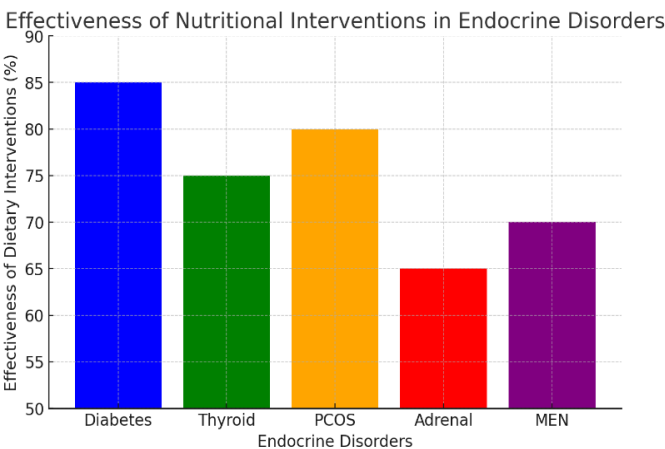


Figure 1 Effectiveness of Nutritional Interventions in Endocrine Disorders

Variability in outcome measures presents another significant limitation, making it difficult to compare results across different studies. Many trials employ heterogeneous endpoints, ranging from biochemical markers such as fasting glucose and hormone levels to clinical outcomes like symptom relief and quality of life scores (3). This lack of standardized criteria for measuring treatment success complicates efforts to synthesize data and develop unified clinical guidelines. Additionally, dietary assessment methods vary widely, with some studies relying on food frequency questionnaires while others utilize more precise techniques such as dietary recalls or biomarker analysis. These inconsistencies introduce variability in dietary intake estimation, affecting the reliability of reported associations between nutrition and endocrine function(17). Generalizability of findings remains a major challenge due to demographic and geographic variations in study populations. Many studies focus on specific ethnic or socioeconomic groups, limiting the applicability of results to diverse populations with varying dietary habits, genetic backgrounds, and access to healthcare. Nutritional requirements and metabolic responses can differ significantly across populations, raising concerns about the broad applicability of dietary recommendations (5). Additionally, cultural and regional dietary patterns play a crucial role in shaping endocrine health, yet many studies fail to consider these nuances when formulating dietary guidelines(18).

Future research must prioritize well-designed, large-scale RCTs with long-term follow-up periods to establish more definitive causal relationships between nutrition and endocrine health. Efforts should also be made to standardize outcome measures and dietary assessment methods to enhance comparability across studies. Addressing publication bias through the inclusion of negative and inconclusive findings in systematic reviews will provide a more balanced understanding of the field. Moreover, research should focus on personalized nutrition approaches that account for genetic, metabolic, and lifestyle factors, ensuring dietary recommendations are tailored to individual needs rather than broad, one-size-fits-all guidelines(19).

Implications and Future Directions

The findings from this review emphasize the significant role of nutrition in managing endocrine disorders, with potential implications for both clinical practice and healthcare policies. A growing body of evidence suggests that dietary interventions can enhance metabolic control, reduce disease progression, and improve quality of life in individuals with conditions such as diabetes mellitus, polycystic ovary syndrome, thyroid dysfunctions, and adrenal disorders. Clinicians should integrate nutrition-focused strategies into patient care by providing individualized dietary recommendations based on metabolic profiles, comorbidities, and lifestyle factors. Medical nutrition therapy should be positioned as a first-line intervention for metabolic endocrine disorders, particularly in diabetes management, where structured dietary plans have been shown to improve glycemic control and reduce dependence on pharmacotherapy (3). Additionally, dietary modifications tailored to thyroid health, including optimized iodine and selenium intake, should be incorporated into standard treatment protocols for hypothyroidism and autoimmune thyroid diseases (4). The incorporation of nutrition into clinical guidelines remains an area requiring significant advancement. While some guidelines acknowledge dietary interventions as adjuncts to pharmacological management, there is a need for more structured protocols that integrate specific dietary patterns, micronutrient recommendations, and lifestyle interventions tailored to different endocrine disorders. Regulatory bodies should consider developing comprehensive guidelines that prioritize nutrition-based preventive strategies, particularly for conditions such as insulin resistance and metabolic syndrome, where early dietary interventions can significantly alter disease trajectories (6). Policymakers should also focus on public health initiatives that promote awareness of dietary influences on endocrine health, emphasizing nutrient-dense diets and reducing the consumption of ultra-processed foods that contribute to metabolic dysfunction(20).

Several critical gaps remain in the current literature, warranting further investigation. One of the most pressing issues is the lack of large-scale, long-term randomized controlled trials examining the direct impact of specific dietary interventions on endocrine outcomes. Most existing studies rely on short-term observations, making it difficult to determine whether dietary benefits persist over extended periods or if adherence declines over time. Additionally, the role of individualized nutrition based on genetic and metabolic phenotyping remains underexplored. Precision nutrition, which tailors dietary recommendations to individual genetic predispositions and microbiome profiles, has emerged as a promising avenue but requires more robust clinical validation (5). Future research should focus on improving study designs to address current limitations. Well-structured RCTs with larger sample sizes and longer follow-up periods are needed to establish causal relationships between dietary interventions and endocrine health outcomes. Standardized dietary assessment methods should be implemented to minimize variability in reported findings, ensuring consistency across different studies. Moreover, future trials should incorporate multifactorial approaches, evaluating the combined effects of diet, physical activity, and lifestyle modifications to provide a more holistic understanding of endocrine disease management (6). Research should also expand to diverse populations, as most current studies focus on specific ethnic or socioeconomic groups, limiting the generalizability of findings(21).

The integration of emerging technologies, such as continuous glucose monitoring, metabolic tracking devices, and artificial intelligence-driven dietary analysis, presents new opportunities for advancing nutrition research in endocrinology. These tools can provide real-time insights into dietary effects on hormonal fluctuations, allowing for more dynamic and adaptive dietary recommendations. Additionally, greater emphasis should be placed on evaluating the cost-effectiveness of dietary interventions compared to pharmacological treatments, as this could provide further justification for prioritizing nutrition-based strategies in clinical and public health settings (5). While substantial evidence supports the role of nutrition in endocrine health, further refinement in clinical applications, policy development, and research methodologies is necessary. Establishing more precise, evidence-based dietary guidelines, conducting high-quality trials, and leveraging technological advancements can bridge existing gaps and enhance the role of nutrition in managing endocrine disorders. This approach not only has the potential to improve patient outcomes but also contributes to a broader shift towards preventive medicine and sustainable healthcare practices(22).

CONCLUSION

The role of nutrition in managing endocrine disorders is increasingly recognized as a critical component of both prevention and treatment, with dietary interventions demonstrating significant potential in improving metabolic control, hormonal balance, and overall health outcomes. Current evidence supports the beneficial effects of tailored dietary strategies, including medical nutrition therapy for diabetes, optimized micronutrient intake for thyroid health, and dietary modifications for conditions such as polycystic ovary syndrome and adrenal dysfunction. However, despite these promising findings, the strength of the existing literature is limited by methodological inconsistencies, small sample sizes, and a lack of long-term randomized controlled trials. While observational studies provide valuable insights, the absence of robust causal evidence necessitates caution in translating findings into clinical practice. To enhance the reliability and applicability of nutrition-based interventions, clinicians should integrate personalized dietary recommendations alongside pharmacological and lifestyle therapies, ensuring a holistic approach to endocrine disease management. Future research should prioritize large-scale, long-duration studies with standardized outcome measures to better elucidate the long-term effects of nutrition on endocrine health. Additionally, advancements in precision nutrition, incorporating genetic, metabolic, and microbiome-based insights, may further refine dietary recommendations and optimize patient outcomes. Given the increasing burden of endocrine disorders worldwide, strengthening the evidence base for dietary interventions remains an urgent priority, emphasizing the need for continued investment in high-quality clinical research.

AUTHOR CONTRIBUTIONS

Author	Contribution
Sami Ullah	Substantial Contribution to study design, analysis, acquisition of Data
	Manuscript Writing
	Has given Final Approval of the version to be published
Zeeshan Hussain*	Substantial Contribution to study design, acquisition and interpretation of Data
	Critical Review and Manuscript Writing
	Has given Final Approval of the version to be published
Noor Islam	Substantial Contribution to acquisition and interpretation of Data
	Has given Final Approval of the version to be published
Ali Hamza Arshad	Substantial Contribution to acquisition and interpretation of Data
	Has given Final Approval of the version to be published
Muhammad Arsalan Mahmood	Contributed to Data Collection and Analysis
	Has given Final Approval of the version to be published

REFERENCES

1. Federation ID. IDF Diabetes Atlas 2021 [Available from: <https://diabetesatlas.org/>].
2. Calcaterra V, Verduci E, Cena H, Magenes VC, Todisco CF, Tenuta E, et al. Polycystic ovary syndrome in insulin-resistant adolescents with obesity: the role of nutrition therapy and food supplements as a strategy to protect fertility. *Nutrients*. 2021;13(6):1848.
3. García-Fernández E, Leon-Sanz M, editors. Nutrition and Disease: Type 2 diabetes mellitus. *Encyclopedia of Food Security and Sustainability*; 2018.
4. Bashar M, Begam N. Role of dietary factors in thyroid disorders: A primary care perspective. *Med Res Innov*. 2020;4(10.15761).
5. Marinari M, Marini F, Giusti F, Brandi ML. Role of Nutrition in the Management of Patients with Multiple Endocrine Neoplasia Type 1. *Nutrients*. 2024;16(11):1576.
6. Namazi N, Atlasi R, Aletaha A, Asadi M, Larijani B. Trend of nutrition research in endocrine disorders, gaps, and future plans: a collection of experiences of an endocrinology research institute. *Journal of Diabetes & Metabolic Disorders*. 2021:1-8.
7. Ning J, Akhter T, Sarfraz M, Afridi HI, Albasher G, Unar A. The importance of monitoring endocrine-disrupting chemicals and essential elements in biological samples of fertilizer industry workers. *Environmental Research*. 2023 Aug 15;231:116173. <https://doi.org/10.1016/j.envres.2023.116173>
8. Cowan S, Lim S, Alycia C, Pirotta S, Thomson R, Gibson-Helm M, et al. Lifestyle management in polycystic ovary syndrome—beyond diet and physical activity. *BMC endocrine disorders*. 2023;23(1):14.
9. Lisco G, De Tullio A, Stragapede A, Solimando AG, Albanese F, Capobianco M, et al. COVID-19 and the endocrine system: a comprehensive review on the theme. *Journal of clinical medicine*. 2021;10(13):2920.
10. Cheema GA. Medical Nutrition Therapy for Type-2 Diabetes. *Current Research in Diabetes & Obesity Journal*. 2019;12(4):84-94.
11. Balaji Vijayam TB, M. Balaji. Medical Nutrition Therapy for Patients with Gestational Diabetes Mellitus and Type 2 Diabetes Mellitus: New Perspectives. *International Journal of Research and Review*. 2022;9(6).
12. Luger A, Durkan M, Christ-Crain M, Marques P. European society of endocrinology curriculum and training recommendation in endocrinology. *European Journal of Endocrinology*. 2024;191(5):R71-R7.
13. Muscogiuri G, Barrea L, Faggiano F, Maiorino M, Parrillo M, Pugliese G, et al. Obesity in Prader–Willi syndrome: Physiopathological mechanisms, nutritional and pharmacological approaches. *Journal of Endocrinological Investigation*. 2021;44(10):2057-70.
14. Petrov MS. DIAGNOSIS OF ENDOCRINE DISEASE: Post-pancreatitis diabetes mellitus: prime time for secondary disease. *European journal of endocrinology*. 2021;184(4):R137-R49.
15. Petrov MS, Basina M. Diagnosis of endocrine disease: diagnosing and classifying diabetes in diseases of the exocrine pancreas. *European journal of endocrinology*. 2021;184(4):R151-R63.
16. Poppe K. Management of endocrine disease: thyroid and female infertility: more questions than answers?! *European journal of endocrinology*. 2021;184(4):R123-R35.
17. Pouwels S, Sakran N, Graham Y, Leal A, Pintar T, Yang W, et al. Non-alcoholic fatty liver disease (NAFLD): a review of pathophysiology, clinical management and effects of weight loss. *BMC endocrine disorders*. 2022;22(1):63.
18. Puig-Domingo M, Marazuela M, Yildiz B, Giustina A. COVID-19 and endocrine and metabolic diseases. An updated statement from the European Society of Endocrinology. *Endocrine*. 2021;72:301-16.
19. Rizzoli R, Biver E, Brennan-Speranza TC. Nutritional intake and bone health. *The lancet Diabetes & endocrinology*. 2021;9(9):606-21.

20. Seppä S, Kuiri-Hänninen T, Holopainen E, Voutilainen R. Management of endocrine disease: diagnosis and management of primary amenorrhea and female delayed puberty. *European Journal of Endocrinology*. 2021;184(6):R225-R42.
21. Tauber M, Hoybye C. Endocrine disorders in Prader-Willi syndrome: a model to understand and treat hypothalamic dysfunction. *The Lancet Diabetes & Endocrinology*. 2021;9(4):235-46.
22. Varlamov EV, Langlois F, Vila G, Fleseriu M. Management of endocrine disease: cardiovascular risk assessment, thromboembolism, and infection prevention in Cushing's syndrome: a practical approach. *European journal of endocrinology*. 2021;184(5):R207-R24.