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The Power of Nutrition: A Key Player in Preventing and Managing Diabetes

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Abstract

Both the metabolic foundation of diabetes and the complications of the disease can result in significant losses of essential micronutrients. This review is a summary of the research that investigates the impact that type 2 diabetes has on the body's capacity to digest trace minerals, vitamins, and other nutrients. This review covers the micronutrient status, metabolic needs, and likely requirements for micronutrients in type 2 diabetics. Since vitamin D and type 2 diabetes have been the subject of extensive coverage elsewhere, we will not go into further detail about them here. Some of the less well-known micronutrients that were investigated include zinc, magnesium, chromium, copper, manganese, iron, selenium, and vanadium, as well as certain antioxidants and vitamins from the B group. Although there is still a great deal more research to be done in this field, it has been demonstrated that supplementing with micronutrients can have a positive impact on the control of glycemic levels. More research is needed to develop improved biomarkers of the status and requirements of micronutrients in type 2 diabetes. It can be challenging to determine how much micronutrient supplementation a person with type 2 diabetes should take in order to attain glucose homeostasis.

Keywords: diabetes, micronutrient, proteins, vitamins, zinc, magnesium, selenium

Introduction

Diabetes is a metabolic illness that is defined by hyperglycemia that is present for an extended period. This illness is brought on by many different factors, such as genetics, food, environmental factors, and physical activity, among others [1]. Type 1 diabetes and type 2 diabetes (often referred to simply as T2D) are the two forms of diabetes that are diagnosed the most frequently [2]. Environmental and behavioral factors, in addition to the heightened genetic susceptibility that is linked with particular racial and ethnic groups, play a key influence in the development of type 2 diabetes [3]. The patterns of people's diets and lifestyles have altered as a result of globalization. For example, people are now consuming a greater variety of foods that are rich in fat or carbs, and they are also living more sedentary lives that need less energy to sustain. Diets not only kick off a plethora of metabolic processes, but they also upset the homeostatic equilibrium of an organism's metabolism. Poor dietary habits, such as those connected with the Western diet, leads in diabetes. As a consequence of this, diabetes has become an increasingly common condition [4].

Blood glucose levels may be managed in patients with type 2 diabetes either by diet modification on its own or in conjunction with the use of hypoglycemic drugs [5]. Consuming a diet with fluctuating levels of amino acids, such as varying quantities of them, may result in changes in the plasma concentrations of branched-chain amino acids (BCAA). These changes in BCAA levels are associated with an increased risk of type 2 diabetes [6]. Increased consumption of a diet rich in fiber and protein resulted in a shift in the abundance of Akkermansia muciniphila, leading to reduced fasting glucose levels in individuals. However, a more thorough understanding of the significance of these effects on glucose regulation requires additional research into the connections between dietary patterns and glucose metabolism [7]. It is of the utmost importance to investigate and put into practice suitable dietary solutions that could minimize the incidence of diabetes as well as the challenges that are linked with it. These include consuming a broad range of meals and engaging in activities that encourage healthy eating [8].

Fat

It is possible for lipid metabolites to enter the body via a variety of entrance sites due to the body's complex structure. To begin, they may be taken in by our bodies via the food that we eat. According to Soler et al [9], the liver and adipose tissue may generate them intracellularly through a variety of distinct pathways. Because of the development of the science of lipidomics, it is now feasible for us to have a more in-depth understanding of the many lipid species that are present in circulation. It has been more apparent over the course of the last two decades that consuming a diet that is high in fat is associated with an increased risk of insulin resistance as well as type 2 diabetes. It is more probable that a person will become obese if they eat a diet that is high in fat. Obesity is connected with an increase in the quantity of fat that is stored in the cells of the body. According to findings from a study that was carried out in 2019 by Uusitupa and colleagues [10], the presence of extra fat in the body is associated with an increase in the production of proinflammatory cytokines, in addition to other hormones or chemicals that are associated with insulin resistance.

According to research that was conducted by Selathurai and colleagues in 2015 [11], free fatty acids prevent the activation of Akt and PKB, which, in turn, disrupts the pathway that insulin employs to convey signals. In addition to this, there is an increase in the creation of reactive oxygen species within the mitochondria, which has been proven to alter the way that glucose levels are controlled within the body [12]. This is a consequence of the fact that the formation of reactive oxygen species within the mitochondria is increased. There is a possibility that the improvement in glucose metabolism is due, at the very least in part, to the role that PPAR plays as a regulator of fatty acid oxidation. According to Wakeman [13], PPAR also stimulates the activity of its direct target, which is also known as TRB3. Insulin sensitivity is decreased as a consequence of this, and activation of the AKT pathway is stifled as a result. Not only is PPAR responsible for regulating the glucose levels in the body, but it also takes part in the process of adipogenesis as an effector by interacting with C/EBP [14]. This information was found in a study that was published in 2022.

In addition, it has been shown via in vitro testing that palmitate is not as effective in lowering insulin resistance as monounsaturated fatty acids (MUFAs) and oleate are. Trans fats have been the topic of a significant amount of debate due to the fact that they may have an impact on the upkeep and administration of glucose levels. Eating meals that are rich in cholesterol has been proven to be connected with an increased risk of acquiring type 2 diabetes, according to the results of a meta-analysis that was carried out in a recent study [15]. It has been shown that plant sterols and stanols may be able to reduce blood cholesterol levels, a result that may have good ramifications for glucose metabolism [16].

Protein

Proteins are important in almost every aspect of health except for how much you weigh and what you consume [17]. In some persons, eating more protein leads to a decrease in blood sugar levels due to an increase in insulin production. Short-term advantages of high-protein diets include weight reduction, better glucose metabolism, higher insulin sensitivity, and reduced inflammation, as described by [15]. Consuming a high protein diet seems to be associated with systemic insulin resistance over time. This occurs because of increased mTOR/S6K1 signaling, which causes gluconeogenesis to speed up and glucagon to be broken down quickly [18]. Healthy people who fed a high-protein diet for six months (1.87 0.26 g protein/kg body weight per day) had substantially higher fasting blood glucose levels, insulin's capacity to control hepatic glucose output was reduced, and gluconeogenesis was sped up [19]. Type 2 diabetics, on the other hand, benefit from low-protein diets (those in which protein accounts for just 5%-10% of total calories).

Fish protein has gained increased attention in recent years due to the lower incidence of type 2 diabetes in regions such as Alaska and Greenland, where fish consumption is notably high [20]. This is due to the widespread popularity of eating fish in Arctic regions such as Alaska and Greenland. Cod protein protected rats from developing insulin resistance in response to sucrose or saturated fat, as described by Lavigne et al. [21]. Improving skeletal muscle glucose uptake was shown to be crucial to achieving this goal. On the other hand, a quite different group of animals was given casein. Cod protein boosted GLUT4 translocation to the T tubules via activating the PI3K/AKT signaling pathway, as reported by a recent study [22]. The results were just published in the highly-regarded journal Cell. As a direct result, the amount of glucose transported in response to insulin increased. Cod protein consumption has also been linked to a decreased risk of developing type 2 diabetes in human studies. In 2018 research, Leary [23] found that the ratio of insulin to glucose generated by cod protein was lower than that of milk protein. The research of the aforementioned academics led to this conclusion. In comparison to those who ate beef protein, those who ate cod protein had higher plasma insulin concentrations after eating [22].

According to [24], the amino acid response is the normal strategy for coping with a deficiency of amino acids. Deacetylation of matching tRNAs occurs when quantities of essential amino acids decline. According to a study by Akhlaghi et al. [25], charge-free tRNAs may bind to and activate GCN2 kinase. This is what the team of investigators found [25]. Increasing one's consumption of BCAAs has been found to have a favorable impact on type 2 diabetes in a number of studies. However, research suggests that elevated insulin sensitivity and glucose tolerance may result from a deficiency in BCAAs [26].

Role of micronutrient in preventing diabetics

Mineral compounds, which are a kind of micronutrient, are important for healthy development; nevertheless, because of the critical roles that they play in the preservation of metabolic homeostasis, they can only be present in very trace amounts. There is an increasing body of research that suggests there may be a link between a shortage in mineral components and type 2 diabetes (also known as T2D) [27].

Chromium

The results of two clinical investigations that were conducted in China and involved diabetic participants found that the usage of chromium supplements resulted in a significant improvement in the participants' capacity to maintain appropriate control over their blood glucose levels. Both of these studies were carried out with the participation of diabetic patients. These studies did not examine either the initial chromium levels or the alterations in chromium levels resulting from the supplementation. It was decided that none of these variables was significant enough to warrant measurement. The practice of taking chromium supplements (of any type) in order to assist in the management of diabetes or in obtaining a healthy weight has not been supported by the research that has been carried out in recent years [28].

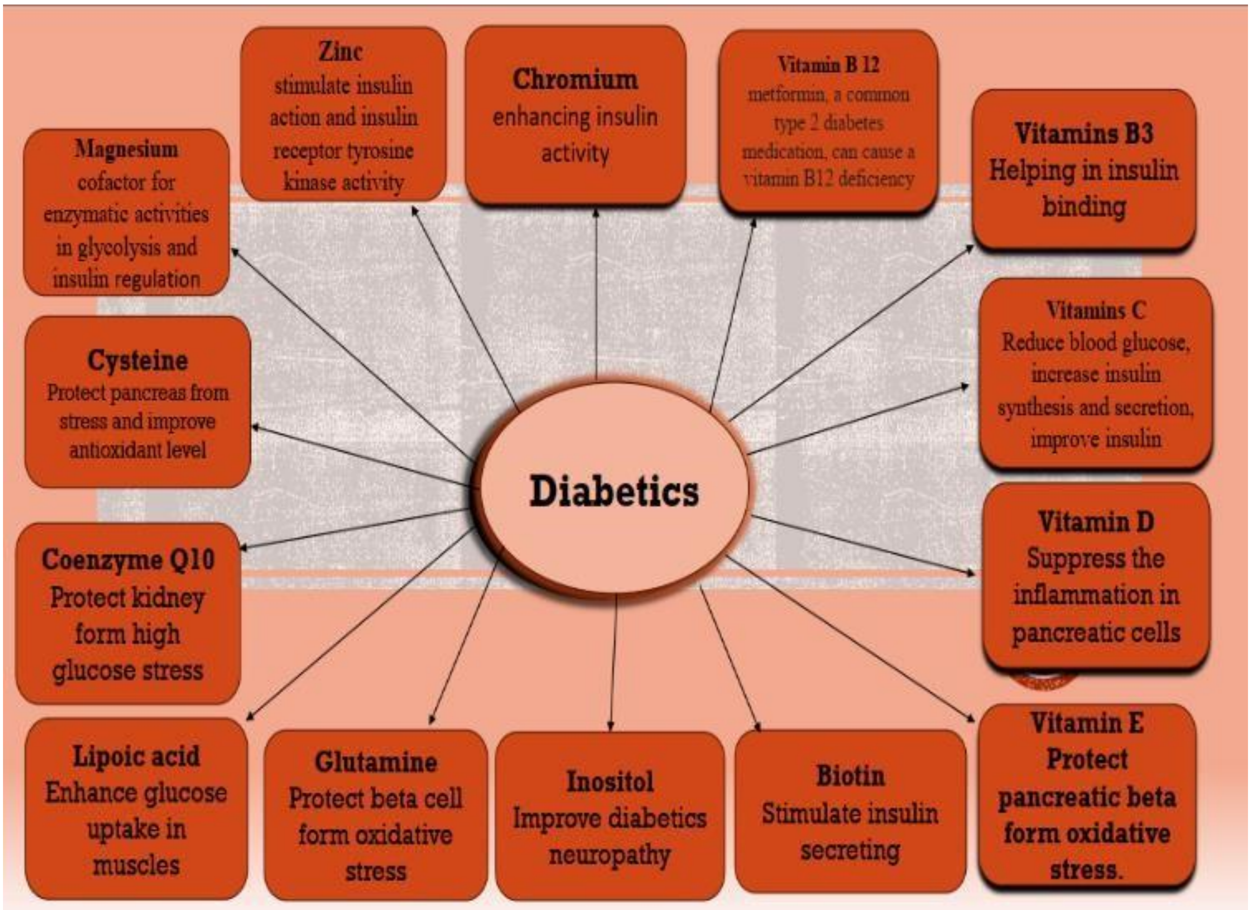

Figure 1: Represent the various micronutrient helps in preventing diabetes

Zinc

Uncontrolled hyperglycemia leads to elevated urinary zinc excretion, resulting in a frequent occurrence of zinc deficiency in individuals with diabetes. To compensate for these losses, the body increases zinc absorption in the intestines. However, if this second compensatory mechanism fails to function properly, it is likely insufficient to address the zinc deficiency issue. This is primarily because zinc is an indispensable element for the body [29]. If there is a concern about insufficient zinc intake in an individual's diet, it may be advised to consider taking a 220-milligram zinc sulfate supplement three times a day. This recommendation is especially relevant for individuals at high risk, including those who have had prolonged glycosuria or use diuretic medications. However, it's important to note that zinc supplements should not be used continuously for more than three months, as prolonged use can potentially impact the body's ability to absorb copper and influence lipid profiles negatively. Therefore, it is not recommended to exceed this three-month duration for zinc supplementation [30].

Calcium

While it has long been established that calcium and vitamin D are crucial for bone health, recent research has unveiled additional roles for them. These studies suggest that they may play a part in immune system regulation and the production and function of insulin in the pancreas. This newfound understanding adds to the previously recognized importance of calcium and vitamin D for maintaining healthy bones, highlighting a dimension that was previously overlooked [31, 32]. The Recommended Daily Intake (RDI) of calcium and vitamin D varies not only based on a woman's age but also her specific stage in the menopausal transition. Interestingly, individuals with diabetes don't appear to require a greater amount of calcium and vitamin D compared to a group of non-diabetic individuals of the same age [33].

Vanadium

Extensive evidence suggests that vanadium plays a role in glucose metabolism. However, clinical studies involving vanadium salts as a diabetes therapy have yielded less-than-encouraging results. To explore potential diabetes treatments, researchers are now investigating novel organo-vanadium compounds that not only demonstrate enhanced effectiveness but also pose fewer risks [34].

Selenium

Selenoproteins, a category of proteins incorporating selenium, have demonstrated an influence on both thyroid hormone function and the management of oxidative stress. Furthermore, recent studies conducted on adult populations in the United States have indicated a positive association between the prevalence of diabetes and increased blood selenium levels [35].

Vitamins

Vitamin A, Carotenoids, and Retinoids

There is no need for vitamin A supplementation in excess of the Recommended Dietary Intake (DRI) [36]. Indeed, studies indicate that the consumption of excessive quantities of vitamin A could potentially have adverse effects on one's health [37].

B Vitamins

Plasma homocysteine levels in individuals with type 2 diabetes appear to be unrelated to disease-related factors such as disease duration, current treatment, or the presence of complications. Additionally, the cognitive decline associated with aging may be mitigated through the use of folic acid supplements. In the United States, the widespread fortification of wheat and other grain products with folate was driven by the recognition of folate's crucial role in lowering the risk of birth defects [38].

An association exists between elevated levels of this amino acid in the bloodstream and a heightened risk of cardiovascular disease (CVD), sparking greater interest in the use of folate supplements to lower homocysteine levels. While it has been established that supplementation with folate, vitamin B6, and vitamin B12 can reduce homocysteine levels, intervention studies have yet to demonstrate a reduction in the incidence of cardiovascular events as a result [38].

Niacin, referred to as nicotinic acid and its amide, serves as the active component in B3. Studies have suggested that nicotinamide may contribute to preserving β-cell mass in individuals recently diagnosed with type 1 diabetes. However, due to the relatively small size of the studied group, conclusive findings regarding the therapeutic efficacy of nicotinamide in this population remain elusive [39].

Vitamin C (Ascorbic Acid)

Ascorbic acid serves as a potent antioxidant, playing a crucial role in combating oxidative stress in the body. However, when blood glucose levels remain consistently high, there may be a reduction in the absorption of dehydroascorbate by various tissues. Despite the known benefits of vitamin C as an antioxidant, randomized controlled trials have failed to provide substantial evidence supporting the idea that vitamin C supplementation effectively reduces the risk of developing cancer or cardiovascular disease [40].

Vitamin E (Tocopherols)

Vitamin E is known for its antioxidant capabilities, and animal studies have demonstrated that excessive vitamin E intake can have a stabilizing effect on platelet membranes and reduce the oxidation of LDL cholesterol. Several observational studies have suggested that adding vitamin E supplements to one's diet might be associated with a reduced risk of developing cardiovascular disease. However, when it comes to interventional studies, particularly those involving a substantial number of individuals with diabetes, the hypothesis that vitamin E reduces the risk of cardiovascular disease did not find support in the results [41].

Conclusion

The research discussed in this review underscores the substantial body of evidence highlighting the impact of micronutrients on regulating blood sugar levels in individuals with type 2 diabetes. Although there is clear evidence indicating increased excretion of micronutrients among those with type 2 diabetes, it remains challenging to determine how these deficiencies might influence the development of the condition. Even when patients receive established hypoglycemic treatments, it is crucial to explore alternative approaches to enhance insulin sensitivity. The available evidence strongly supports the combined use of zinc, magnesium, antioxidants (including vitamins E, C, and ALA), and B-group vitamins as part of diabetes management and therapy. These micronutrients appear to complement each other, leading to positive results in controlling blood sugar levels in type

2 diabetes. Further research is needed to better understand the effects of other micronutrients such as vanadium, selenium, manganese, and biotin on glycemic control in individuals with type 2 diabetes.

References

1. Dyson P, Twenefour D, Breen C, Duncan A, Elvin E, Goff L, et al. Diabetes UK evidence-based nutrition guidelines for the prevention and management of diabetes. Diabetic medicine. 2018;35(5):541-7.
2. Najeeb S, Zafar MS, Khurshid Z, Zohaib S, Almas K. The role of nutrition in periodontal health: an update. Nutrients. 2016;8(9):530.
3. Forouhi NG, Wareham NJ. Epidemiology of diabetes. Medicine. 2019;47(1):22-7.
4. Sun Y, You W, Almeida F, Estabrooks P, Davy B. The effectiveness and cost of lifestyle interventions including nutrition education for diabetes prevention: a systematic review and meta-analysis. Journal of the Academy of Nutrition and Dietetics. 2017;117(3):404-21. e36.
5. Alkhatib A, Tsang C, Tiss A, Bahorun T, Arefanian H, Barake R, et al. Functional foods and lifestyle approaches for diabetes prevention and management. Nutrients. 2017;9(12):1310.
6. Tao Z, Shi A, Zhao J. Epidemiological perspectives of diabetes. Cell biochemistry and biophysics. 2015;73:181-5.
7. Abdelhafiz AH, Sinclair AJ. Diabetes, nutrition, and exercise. Clinics in geriatric medicine. 2015;31(3):439-51.
8. Schoenaker DA, Mishra GD, Callaway LK, Soedamah-Muthu SS. The role of energy, nutrients, foods, and dietary patterns in the development of gestational diabetes mellitus: a systematic review of observational studies. Diabetes Care. 2016;39(1):16-23.
9. Soler-Vázquez MC, Mera P, Zagmutt S, Serra D, Herrero L. New approaches targeting brown adipose tissue transplantation as a therapy in obesity. Biochemical pharmacology. 2018;155:346-55.
10. Uusitupa H-M, Rasinkangas P, Lehtinen MJ, Mäkelä SM, Airaksinen K, Anglenius H, et al. Bifidobacterium animalis subsp. lactis 420 for Metabolic Health: Review of the Research. Nutrients. 2020;12(4):892.
11. Selathurai A, Kowalski GM, Burch ML, Sepulveda P, Risis S, Lee-Young RS, et al. The CDPethanolamine pathway regulates skeletal muscle diacylglycerol content and mitochondrial biogenesis without altering insulin sensitivity. Cell metabolism. 2015;21(5):718-30.
12. Calder PC. Very long-chain n-3 fatty acids and human health: fact, fiction and the future. Proceedings of the Nutrition Society. 2018;77(1):52-72.
13. Wakeman M, Archer DT. Metformin and micronutrient status in type 2 diabetes: does polypharmacy involving acid-suppressing medications affect vitamin B12 levels? Diabetes, Metabolic Syndrome and Obesity. 2020:2093-108.
14. Wu J, Meng Q-H. Current understanding of the metabolism of micronutrients in chronic alcoholic liver disease. World Journal of Gastroenterology. 2020;26(31):4567.
15. Sun Y, Yang T, Wang C. Capparis spinosa L. as a potential source of nutrition and its health benefits in foods: A comprehensive review of its phytochemistry, bioactivities, safety, and application. Food Chemistry. 2022:135258.
16. van der Hee B, Wells JM. Microbial regulation of host physiology by short-chain fatty acids. Trends in Microbiology. 2021;29(8):700-12.
17. Hahn O, Drews LF, Nguyen A, Tatsuta T, Gkioni L, Hendrich O, et al. A nutritional memory effect counteracts the benefits of dietary restriction in old mice. Nature metabolism. 2019;1(11):1059-73.
18. Chan JC, Cho NH, Tajima N, Shaw J. Diabetes in the Western Pacific Region—past, present and future. Diabetes research and clinical practice. 2014;103(2):24455.
19. Bonnefont-Rousselot D. The role of antioxidant micronutrients in the prevention of diabetic complications. Treatments in endocrinology. 2004;3:4152.
20. Mooradian AD, Morley J. Micronutrient status in diabetes mellitus. The American journal of clinical nutrition. 1987;45(5):877-95.
21. Lavigne M, Little C, Major J. Increasing the sink: source balance enhances photosynthetic rate of 1-year-old balsam fir foliage by increasing allocation of mineral nutrients. Tree physiology. 2001;21(7):417-26.
22. Via M. The malnutrition of obesity: micronutrient deficiencies that promote diabetes. International Scholarly Research Notices. 2012;2012.
23. Leary MP, Roy SJ, Lim J, Park W, Ferrari R, Eaves J, et al. Nonfat milk attenuates acute hyperglycemia in individuals with android obesity: A randomized control trial. Food Science & Nutrition. 2018;6(8):2104-12.
24. Opara EC. Oxidative stress, micronutrients, diabetes mellitus and its complications. The journal of the Royal Society for the Promotion of Health. 2002;122(1):28-34.
25. Akhlaghi F, Bagheri SM, Rajabi O. A comparative study of relationship between micronutrients and gestational diabetes. International scholarly research notices. 2012;2012.

26. Dubey P, Thakur V, Chattopadhyay M. Role of minerals and trace elements in diabetes and insulin resistance. Nutrients. 2020;12(6):1864.

27. Gunderson EP, Lewis CE, Lin Y, Sorel M, Gross M, Sidney S, et al. Lactation duration and progression to diabetes in women across the childbearing years: the 30year CARDIA study. JAMA internal medicine. 2018;178(3):328-37.

28. Bagherniya M, Butler AE, Barreto GE, Sahebkar A. The effect of fasting or calorie restriction on autophagy induction: A review of the literature. Ageing research reviews. 2018;47:183-97.

29. Kitada M, Ogura Y, Monno I, Koya D. Sirtuins and type 2 diabetes: role in inflammation, oxidative stress, and mitochondrial function. Frontiers in endocrinology. 2019;10:187.

30. Anton SD, Moehl K, Donahoo WT, Marosi K, Lee SA, Mainous III AG, et al. Flipping the metabolic switch: understanding and applying the health benefits of fasting. Obesity. 2018;26(2):254-68.

31. Association AD. Standards of medical care in diabetes—2018 abridged for primary care providers. Clinical diabetes: a publication of the American Diabetes Association. 2018;36(1):14.

32. Ades PA, Keteyian SJ, Wright JS, Hamm LF, Lui K, Newlin K, et al., editors. Increasing cardiac rehabilitation participation from 20% to 70%: a road map from the Million Hearts Cardiac Rehabilitation Collaborative. Mayo clinic proceedings; 2017: Elsevier.

33. Zubrzycki A, Cierpka-Kmiec K, Kmiec Z, Wronska A. The role of low-calorie diets and intermittent fasting in the treatment of obesity and type-2 diabetes. Journal of Physiology & Pharmacology. 2018;69(5).

34. Niu X, Xiao R, Wang N, Wang Z, Zhang Y, Xia Q, et al. The molecular mechanisms and rational design of anti-diabetic vanadium compounds. Current topics in medicinal chemistry. 2016;16(8):811-22.

35. Khurana A, Tekula S, Saifi MA, Venkatesh P, Godugu C. Therapeutic applications of selenium nanoparticles. Biomedicine & Pharmacotherapy. 2019;111:802-12.

36. Marcelino G, Machate DJ, Freitas KdC, Hiane PA, Maldonade IR, Pott A, et al. β-Carotene: preventive role for type 2 diabetes mellitus and obesity: a review. Molecules. 2020;25(24):5803.

37. Su L, He J, Liu Z, Wu S, Chen P, Li K, et al. Dietary total vitamin A, β-carotene, and retinol intake and the risk of diabetes in chinese adults with plantbased diets. The Journal of Clinical Endocrinology & Metabolism. 2022;107(10):e4106-e14.

38. Jenkins DJ, Spence JD, Giovannucci EL, Kim Yi, Josse R, Vieth R, et al. Supplemental vitamins and minerals for CVD prevention and treatment. Journal of the American College of Cardiology. 2018;71(22):257084.

39. Smith AD, Refsum H. Homocysteine, B vitamins, and cognitive impairment. Annual review of nutrition. 2016;36:211-39.

40. Santosh H, David CM. Role of ascorbic acid in diabetes mellitus: a comprehensive review. Journal of Medicine, Radiology, Pathology and Surgery. 2017;4(1):1-3.

41. Pavithra D, Praveen D, Chowdary PR, Aanandhi MV. A review on role of Vitamin E supplementation in type 2 diabetes mellitus. Drug Invent Today. 2018;10(2):236-40.