Micronutrients: Insulin Resistance, Type 2 Diabetes Mellitus, Metabolic Syndrome

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Keywords

Minerals, Vitamins, Microminerals, A Chemical Element, Essential Nutritional Need for Human Physiology, Insufficiency, Balanced Diet, Metabolic disorders, Supplements, Marginalized Communities.

World Health Organization (WHO) defines micronutrients as vitamins and minerals that are obligatory for our physiological needs in trivial quantities. Nonetheless, their pay-off on our health is precarious. Any insufficiency or overdose can trigger severe and even life-threatening disorders [1]. Vitamins that are required for our systems are vitamins A, $B_{1,2,3,5,6,\ 7,9,12}$, C, D, E, and K, and 20 minerals and microelements are arsenic (As^{3+}), cadmium (Cd^{2+}), calcium (Ca^{2+}), chromium (Cr^{1+}), copper (Cu^{2+}), fluoride (F^{-}), iodine (I^{-}), iron (Fe^{2+}or Fe^{3+}), lead (Pb^{2+}), magnesium (Mg^{2+}), manganese (Mn^{2+}), molybdenum (Mo^{1+}), phosphorus (P^{3-}), potassium (K^{+}), rubidium (Rb^{+}), selenium oxides (SeO_2 or SeO_3), sodium (Na^{+}), strontium (Sr^{2+}), vanadium ($V^{+2,\ +3,\ +4,\ +5}$), and zinc (Zn^{2+}) [2,3]. However, the exact number of trace elements is yet to be determined, and relentless research must be continued to revise the current list [3]. Nonetheless, the requirements for these elements in the human body are minimal. These elements are critical in maintaining normal physiology, especially typical growth, development, and metabolic processes [4]. It has been reported that multiple noncommunicable disorders (NCDs) can be promoted because of micronutrients excess or deficiency [5,6], e.g., eating disorders, overweight, obesity, insulin resistance (IR), type 2 diabetes mellitus (T2DM), metabolic syndrome (MetS), cardiovascular diseases (CVDs), essential hypertension, developmental deformities, food intolerances or sensitivities [2,7]. In sub-Saharan Africa and South Asia, micronutrient scarcities are public issues; nonetheless, vitamin and mineral insufficiencies are a global health offender [8-11]. It has been reported that low serum-level carotenoids and fat-soluble vitamins, such as A, D, and E, positively affect the development of MetS. These vitamins possess antioxidant and anti-inflammatory properties, and vitamins D and E play a central role in controlling lipid metabolism and glucose equilibrium detectors [12]. However, another study revealed that poorer

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serum concentrations of carotenoids and vitamin C and the more considerable presence of vitamins A and E, uric acid in serum, and reactive oxygen species were affiliated with an increased possibility of MetS, although the greater level of serum vitamin B_{12} found playing a defensive role [13]. Insufficient micronutrients, especially vitamin D, chromium, biotin, thiamine, and vitamin C, possess properties that undermine the glucose metabolic process and trigger IR [14,15]. Farag et al. 2018 reported that vitamin C or D with adequate physical activity increases for better clinical for MetS patients [16]. Multiple studies revealed that several NCDs pathogenesis and progression, e.g., obesity, dyslipidemia, T2DM, MetS, hypertension, renal disorders, hyperuricemia, carcinoma, anemia, and brain diseases are associated with micronutrient insufficiency, that is provoked by visceral obesity and IR [5, 17-22]. Dubey et al. (2020) reported that no less than 1 billion people around the globe suffer from microelement insufficiency [23]. Research studies revealed that micronutrient insufficiency, e.g., Cr^{1+}, Mg^{2+}, Mn^{2}, Zn^{2+}, and Fe^{3+} insufficiency, are responsible for low insulin sensitivity [23,24] and deficiency antioxidants such as vitamin A and trace elements, e.g., Cu^{2}, Zn^{2}, Fe^{3+}, and Mn^{2+} alteration of various physiological process which ultimately cause dysfunction and death pancreatic β-cell, an imbalance between free radicals and antioxidants, and defective insulin signaling mechanism, etc. thereby causes a plunge of biochemical and metabolic catastrophes [23,25-31]. This editorial principally concentrates on the effects of Zn^{2+} on IR, T2DM, and MetS. MetS is a bunch of disorders. At a minimum, three of the retinues five medical infirmities: a large waistline, elevated blood sugar, raised serum triglycerides, below typical serum high-density lipoprotein, and sustained upraised high blood pressure [32]. MetS is also known as IR syndrome and, as a consequence, increases the possibility of developing T2DM, coronary heart disease, and cerebrocardiovascular disease [33-35].

Research studies reported that Zn^{2+}, $Se0_{2}$ or SeO_{3}, Fe^{3+}, and Cu^{2+} are principal risk factors for the blossoming of T2DM [36-38]. Zn^{2+} has been known as an essential component of hundreds of enzymes. Insulin synthesis, storage, and release from pancreatic β-cells are strongly associated with serum Zn^{2+} concentration [39,40]. Atari-Hajipirloo et al. 2016 revealed that non-diabetic first-degree relatives (FDR) and T2DM cases had a lower level of Zn^{2+} than the average individual. However, these patients had higher serum levels of Cu^{3+} and Fe^{3+} [37]. A supererogatory amount of serum Cu^{2+} possesses the potential to promote oxidative stress and trigger the overproduction of reactive oxygen species (ROS) and diminished antioxidant effectivity, which fosters mitochondrial apoptosis and hepatocellular death through the tumor necrosis factor receptor 1 (TNF-R1) signaling trail [41,42]. Multiple studies reported that low serum levels of Zn^{2+} were observed among obese individuals [43,44] — a strong correlation was observed between obesity and T2DM [45,46]. Zn^{2+} triggers responsible vital bioparticles, which are accountable for the cell signaling system, thereby maintaining glucose homeostasis [47]. Several studies reported that Zn^{2+} insufficiency stimulates inflammation and oxidative stress initiation [36], promoting glucose intolerance, IR, T2DM, MetS, obesity, various carcinoma, neurodegenerative disorders, renal diseases, atherosclerosis, CVDs, and many other NCDs [48-50]. On the other hand, adequate maintenance of serum Zn^{2+} levels effectively controls insulin receptor physiological performance, thus providing satisfactory insulin accomplishment, and preserving a good lipid profile [36,51]. Norouzi et al. reported that the pharmacodynamics of Zn^{2+} mimic insulin [47].

Pompano and Boy 2021, in their systematic review, reported that low-dose, long-duration Zn^{2+} adjunction with daily dietary practice and possibly biofortification had advantages in minimizing the hazard issues for T2DM and CVD [52]. Biofortification is the procedure by which the food grain's nutrient concreteness is increased through usual plant breeding and/or better-quality agronomical exercises and/or up-to-date biotech without diminishing any typical advantages for selected customers or, most essentially, agriculturalists. [53] Another metanalysis reported that Zn^{2+} add-on with regular diet paybacks in controlling IR and blood sugar control among populations suffering from overweight and obesity by considerably minimizing fasting glucose (FG), 2-hour postprandial glucose (2 h- PG), glycated hemoglobin (HbA1c), and homeostasis model assessment-insulin resistance index (HOMA-IR) [54]. Ahmad et al. 2024, in their narrative, revealed that existing published documents sturdily hold up the serious positive role of Zn^{2+} in halting the pathogenesis of T2DM and improving glucose metabolism [55]. Multiple studies reported that supplementation is possibly a better method to fight IR and related metabolic disorders triggered through Zn^{2+} and other micronutrient insufficiency [55-60]; nevertheless, consumption and promotion of balanced

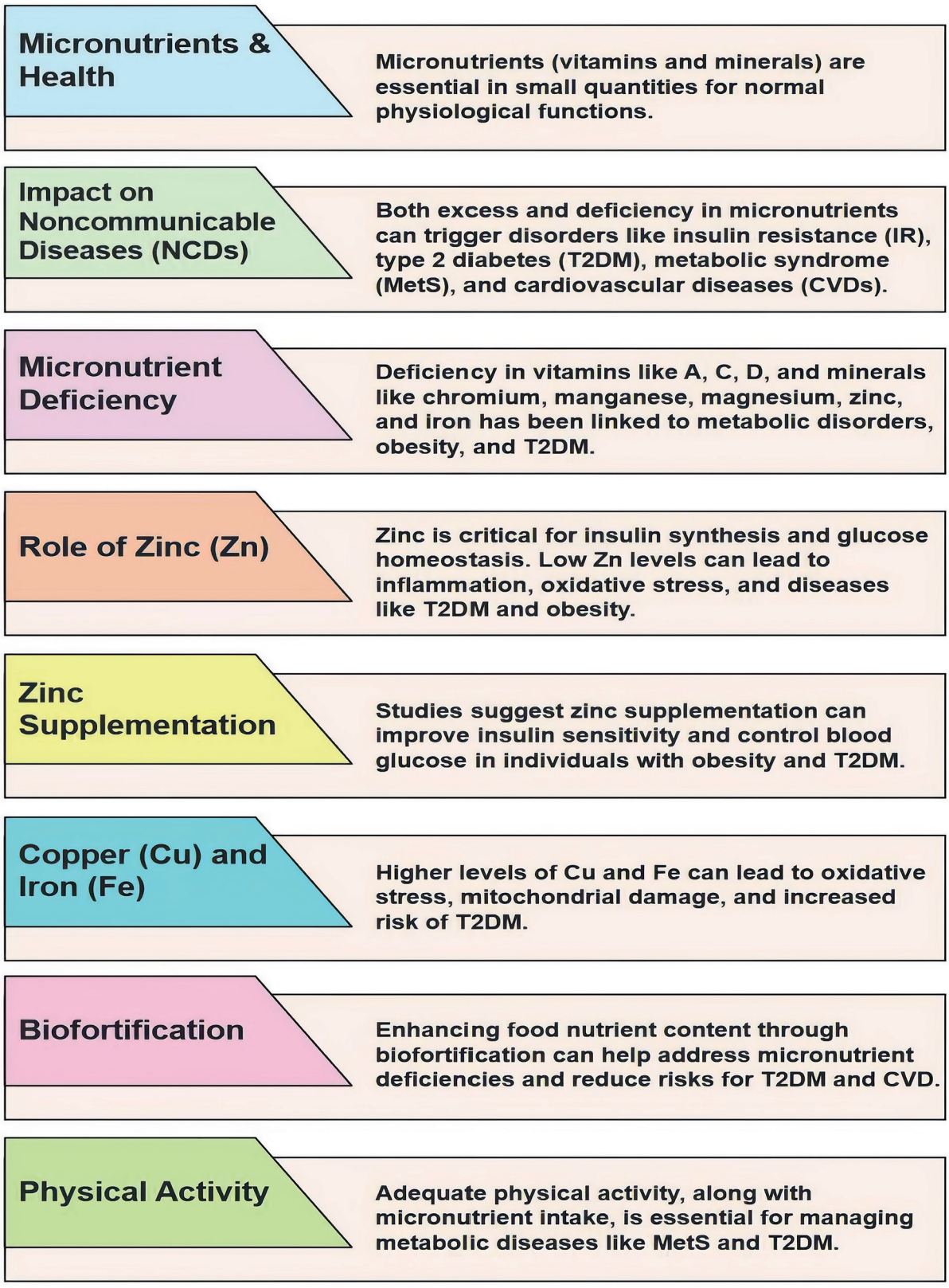

Figure 1: The Principal Findings of This Paper.

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dietary practice and increased physical remain the best choice than nutritional supplements and battle against metabolic diseases [61,62]. The principal findings of this is depicted in Figure 1.

CONSENT FOR PUBLICATION

The author reviewed and approved the final version and has agreed to be accountable for all aspects of the work, including any accuracy or integrity issues.

DISCLOSURE

The author declares that they do not have any financial involvement or affiliations with any organization, association, or entity directly or indirectly related to the subject matter or materials presented in this editorial. This includes honoraria, expert testimony, employment, ownership of stocks or options, patents, or grants received or pending royalties.

DATA AVAILABILITY

Information is taken from freely available sources for this editorial.

AUTHORSHIP CONTRIBUTION

All authors contributed significantly to the work, whether in the conception, design, utilization, collection, analysis, and interpretation of data or all these areas. They also participated in the paper's drafting, revision, or critical review, gave their final approval for the version that would be published, decided on the journal to which the article would be submitted, and made the responsible decision to be held accountable for all aspects of the work.

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