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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.
GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.
ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

**Articles that Fail to Meet the Aforementioned
Requirements are not Assigned to be Reviewed.**

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman** (**Кириллица**), ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ,რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

Содержание:

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THE HIDDEN LINK: HOW VITAMIN D AND ZINC INFLUENCE GROWTH AND MENTAL HEALTH IN CHILDREN

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Abstract.

Background and Aims: Vitamin D and zinc are critical micronutrients for growth and neurocognitive development. This Case-controlled, single-center, clinical study evaluates their associations with anthropometric and mental health parameters in Georgian children. The aim of the study was to assess the correlation between vitamin D and zinc levels and children's growth and mental health indicators.

Methods: The study focused on children's growth and mental health. Anthropometric and biochemical data were collected, and growth rates as well as mental/emotional indicators were assessed. Statistical analysis included group comparisons and Pearson correlation. A total of 226 healthy children aged 3 to 10 years (mean age: 7.4 ± 2.2 years) participated in the study, of whom 117 (51.8%) were girls. The participants were randomly selected and divided into four groups: Group I – children with both vitamin D and zinc deficiency, Group II – children with vitamin D deficiency and normal zinc levels, Group III – children with normal vitamin D levels and zinc deficiency, Group IV – children with both vitamin D and zinc levels within the normal range. Among the participants, 82.7% had a socially satisfactory status. The study was conducted over an extended period without considering seasonality, as vitamin D deficiency is common in our population, especially among children. Children with chronic illnesses, a history of premature birth, or nutritional disorders were excluded from the study.

Results: Children with vitamin D and zinc deficiency exhibited significantly lower height, increased BMI, and lower IQ. Strong correlations were observed between vitamin D levels and growth (height, BMI), vitamin D had positive correlation with height ($r = 0.148$, $p < .05$), positive correlation with Zinc ($r = 0.696$, $p < 0.001$) and zinc levels were significantly associated with IQ, mood, physical indicators, and metabolic markers. Children with zinc deficiency were more likely to show emotional, skin, and immune issues. A total of the 226 patients only 30.5%, had normal vitamin D and zinc levels, only 23.5% had only vitamin D deficiency, 1.3% had only zinc deficiency, 44.7% had both deficiencies.

Conclusion: Although there are studies on the relationship between zinc deficiency growth and mental health, as well as between vitamin D growth and mental health, there is no information on the connection between vitamin D and zinc deficiency and their combined effect on child growth and mental development. The analysis of our conducted study clearly demonstrated that there is a correlational relationship between zinc deficiency, vitamin D deficiency, and child growth and development. The findings highlight the importance of maintaining adequate levels of vitamin D and zinc for optimal physical and mental development in children. Therefore, it is important to pay attention to a child's healthy nutrition and a balanced daily diet in order to provide them with the necessary micro- and macroelements for proper development.

Key words. Vitamin D, zinc, child development, mental health, growth, pediatrics.

Introduction.

Micronutrients are vitamins and minerals that are required by the body in very small amounts. Their impact on bodily health is critical, and a deficiency in any of them can lead to serious or even irreversible life-threatening conditions. Micronutrient deficiency affects approximately two billion people worldwide, and the primary cause of this condition is unhealthy nutrition. Although dietitians emphasize the importance of healthy eating, the World Health Organization (WHO) has published alarming data regarding micronutrient deficiencies [1]. About 1.7 million deaths (2.8% of global mortality) are caused by micronutrient deficiency, ranking it among the top ten causes of death globally [2]. According to WHO, the most commonly deficient nutrients are iron (Fe), zinc (Zn), vitamin A, vitamin D, selenium (Se), and iodine (I).

Childhood is a particularly vulnerable period in terms of nutrition, and nutritional vulnerability increases during adolescence due to higher dietary demands. However, the quality of food consumed by this age group often deteriorates significantly. Micronutrients, needed in much smaller amounts, are especially important during pediatric years. Rapid urbanization, high-calorie diets, sedentary lifestyles [3], and unbalanced diets—especially in children—disrupt nutritional status, resulting in stunted growth and delayed mental development.

Micronutrients like vitamin D and zinc play essential roles in child development, affecting both physical growth and mental health. Deficiencies in these nutrients are increasingly prevalent and have been linked to stunted growth, obesity, and neurocognitive impairment. This study seeks to analyze the relationship between these deficiencies and development indicators among children in Georgia.

Especially in children under the age of 5, proper growth, delayed mental development, correct formation of the musculoskeletal system [4], rickets, osteomalacia, osteoporosis, early activation of the hypothalamic-pituitary-gonadal axis, diabetes, asthma, upper respiratory tract infections, autoimmune disorders, and food allergies — this is just a partial list of conditions whose risk increases in the presence of vitamin D deficiency [5]. Maintaining a normal level of vitamin D in the body is vital for a child — not only for the proper development of the bone and joint system but also for overall growth and psychomotor development [4].

Zinc is an essential element for the survival of all living organisms. In the human body, the total content of zinc is estimated at about 30 mmol (2 grams) [6]. Plasma zinc accounts for only about 0.1% of the body's total zinc, yet this small percentage plays a critical role in maintaining homeostasis. Zinc has been identified in almost all human organs, and it plays a crucial role in the function of each one [7,8]. Zinc is present in the skin, kidneys, liver, and blood cells. Zinc regulates both systemic and intracellular homeostasis, underscoring its vital role in maintaining human health. Zinc is involved in over 750 transcription factors that support gene transcription [9], and it serves as a catalyst for more than 2,000 enzymes. Approximately 8% of the human genome requires zinc for structural integrity. Zinc plays a role in smell and taste perception, supports wound healing, prevents acne, improves skin structure, and strengthens and adds shine to nails and hair. In the brain, zinc is involved in structural development and proper functioning, particularly in neuronal myelination and signal transmission, and has a profound effect on fetal growth and embryonic development [10].

Vitamin D and zinc are essential micronutrients that individually contribute to various physiological processes, particularly those involving growth, and neurological function, they are essential for cognitive, behavioral and motor development [11]. However, emerging evidence suggests a significant biochemical and functional interplay between the two, highlighting the importance of evaluating them not in isolation but as part of an interdependent nutritional framework. Zinc plays a critical role in vitamin D metabolism. Specifically, it serves as a cofactor for the enzyme 1α-hydroxylase, which catalyzes the conversion of 25-hydroxyvitamin D [25(OH)D] into its biologically active form, 1,25-dihydroxyvitamin D [1,25$(OH)_2$D]. Without sufficient zinc, the enzymatic activation of vitamin D may be impaired, even when circulating levels of 25(OH)D appear adequate [12]. This mechanism suggests that zinc deficiency could indirectly contribute to a functional vitamin D deficiency, potentially diminishing the effectiveness of vitamin D supplementation in populations with marginal zinc status [13]. Vitamin D deficiency/insufficiency is observed in the majority of the Georgian population, both in children and adolescents, regardless of seasonality. It is clear that vitamin D deficiency can interfere with the absorption and utilization of essential inorganic elements such as iron, zinc, calcium, magnesium, phosphorus [14]. Several studies have suggested that vitamin D may enhance the bioavailability of certain trace elements by influencing intestinal transport and cellular uptake mechanisms. Specifically, vitamin D is known to facilitate the absorption of zinc, contributing to the maintenance of intracellular zinc concentrations necessary for optimal biological function. This mechanism is especially relevant for rapidly developing tissues and neural cells, where zinc demand is high.

This mutual dependence is especially significant in pediatric populations, where growth and mental development require precise micronutrient regulation. Children suffering from deficiencies in both nutrients are at an increased risk for growth failure, and developmental delays. Addressing one deficiency without correcting the other may reduce the efficacy of interventions, making combined nutritional strategies essential for improving health outcomes.

Study description: This study investigates the interrelationship between vitamin D and zinc levels, their individual and combined deficiencies, and the impact on growth parameters, cognitive functioning, and mental health indicators in children. The study stems from growing global evidence emphasizing the role of micronutrients in children's physical and mental development, and from a lack of research addressing their combined effect—especially in the Georgian pediatric population. Participants included 226 children (mean age = 7.43 years), almost evenly split between 109 males (48.2%) and 117 females (51.8%). Children with chronic diseases, acute infections at the time of assessment, or those on vitamin/mineral supplementation were excluded.

The findings of this study demonstrate a strong and statistically significant positive correlation between vitamin D and zinc levels among children aged 3 to 10 years in Georgia. Children with deficiencies in both nutrients showed significantly lower height, reduced physical performance, and lower IQ scores. These results highlight the interconnected role of micronutrients in supporting physical growth and mental development. The high prevalence of both vitamin D and zinc deficiency underlines an urgent need for public health attention.

The study design was reviewed and approved by the Ethics Committee. The study was conducted in accordance with the concepts of good clinical practice. Each patient that participated in the study signed an informed consent form.

Statistical analysis: We studied demographic, anthropometric, laboratory data and clinical characteristics. Anthropometric data were studied: by studying the physical characteristics of the children, measuring, weighing and calculating BMI. IQ was determined according to Raven's Progressive Matrics Test. Statistical analysis for quantitative indicators, the mean (Mean) and standard deviation (SD) were calculated. For qualitative indicators - absolute and percentage values. The difference between the groups was determined: for quantitative indicators - using the Student's t criterion; for qualitative indicators - using the Fisher's exact criteria, the relationship between quantitative factors was determined by correlation analysis - Pearson's test; for qualitative indicators - Spearman's test. The sensitivity and specificity of the test were determined by ROC analysis. Results are considered reliable when $p<0.05$. Data were processed using the SPSS-23 software package.

Results.

The data indicates a meaningful relationship between micronutrient status and child growth/development. Children with deficiencies in vitamin D and zinc were more likely to exhibit suboptimal growth and decreased cognitive performance. Our findings corroborate global data linking vitamin D deficiency with impaired linear growth and higher BMI [15,16], and zinc deficiency with poorer cognitive and emotional outcomes [17,18]. The observed correlations, although modest, underscore the need for integrated micronutrient screening in pediatric care. Mechanistically, vitamin D may modulate adipogenesis and bone growth via the VDR pathway, while zinc influences neurogenesis and synaptic plasticity [19,20]. These findings align with existing global research emphasizing the role of nutrition in developmental outcomes.

This study included 226 children aged 3 to 10 years, assessing their physical, biochemical, and cognitive health in relation to vitamin D and zinc levels. The analysis revealed a high prevalence of micronutrient deficiencies: only 66 children (30.5%) of participants had normal levels of both vitamin D and zinc, while 52 patients (23.5%) had only vitamin D deficiency, and a significant 101 children (44.7%) suffered from both vitamin D and zinc deficiency. Only 7 patients (1.3%) had isolated zinc deficiency.

Zinc levels were significantly lower (71.0 vs. 101.3 mg/dL, p < 0.0001) in vitamin D deficiency. Correlation analysis showed a positive association between vitamin D and zinc levels (r = 0.696, p < 0.001).

Children with vitamin D deficiency exhibited significantly lower average height (123.9 cm vs. 131.6 cm, r = 0.148 p = 0.026), weight (r = 0.073 p = 0.275), BMI (21.3 vs. 19.1 r = 0.255 p = 0.000) compared to children with normal vitamin D levels. Zinc was positively correlated with height (r = 0.198 p = 0.003), weight (r = 0.010 p = 0.883), BMI (r = -0.199 p = 0.003). Here's the chart visualizing the correlation of vitamin D and zinc levels with height, weight, and BMI (Table 1).

Both nutrients are positively correlated with height. They show negative correlation with weight and BMI, meaning deficiencies are linked to higher BMI, there is little correlation with weight alone. The analysis confirms that vitamin D and zinc are important for child growth and development, particularly in promoting height, weight and maintaining a healthy BMI. These results underscore the importance of monitoring and maintaining adequate levels of these micronutrients in early childhood to support optimal growth and prevent malnutrition or obesity.

Table 1. *Correlation between Nutrient levels and Growth indicators (N=226).*

Nutrient	**Variable**	**r**	**p**
Vitamin D (ng/mL)	Height	0.148	0.026
	Weight	-0.073	0.275
	BMI	-0.255	0.000
Zinc (ng/mL)	Height	0.198	0.003
	Weight	-0.010	0.883
	BMI	-0.199	0.003

Table 2. *Comparison of Zinc and vitamin D concentrations according to IQ level.*

	Low IQ (N=24)	**Low IQ (N=24)**	**High IQ (N=202)**	**High IQ (N=202)**		
IQ	Mean	SD	Mean	SD	t	p
Vitamin D	16.39	6.74	26.46	11.6	-4.16	0.0
Zinc	64.96	18.56	82.54	21.32	-4.31	0.0002

Cognitive outcomes were also significantly associated with nutritional status. Children with higher IQ scores had significantly higher levels of vitamin D (26.1 vs. 19.6 ng/mL, p = 0.0097) and zinc (82.3 vs. 66.6 mg/dL, p = 0.0007) than those with lower IQs. Here's the chart comparing vitamin D and zinc levels between children with low and high IQ: Children with high IQ had higher average levels of both vitamin D and zinc. This supports the observed connection between better micronutrient status and cognitive performance (Table 2).

Table 3. *Area Under the Curve.*

Asymptotic 95% Confidence interval					
Test result (Variable)	**Area**	**Std.Error**	**p**	**Lower Bound**	**Upper Bound**
Vitamin D	0.76	0.041	<0.000	0.68	0.84
Zinc	0.747	0.044	<0.000	0.66	0.834

Among the participants in the study, vitamin D and zinc levels were analyzed in relation to IQ levels, categorized as low IQ (n = 24) and high IQ (n = 202). The results demonstrated significantly higher levels of both vitamin D and zinc in children with high IQ compared to those with low IQ. Specifically, vitamin D levels were 26.07 ng/mL in the high IQ group and 19.62 ng/mL in the low IQ group (p = 0.00), while zinc levels were 82.34 mg/dL and 66.58 mg/dL respectively (p = 0.0002). These findings indicate a positive association between both nutrient levels and mental development. Children with higher IQs tended to have higher vitamin D and zinc levels. The low IQ group's poorer levels (particularly with average zinc below normal and vitamin D in the deficient range) highlight that micronutrient deficiencies are more prevalent among the lower IQ children. This could imply that inadequate nutrition – specifically deficiencies in vitamin D and zinc – may adversely affect cognitive development or reflect environmental factors that influence both nutrition and IQ. Importantly, vitamin D and zinc are critical for brain development and function. Both of them play a role in neurodevelopment and cognitive ability.

These data allowed us to consider vitamin D and zinc concentrations as predictive factors for low IQ in children. The diagram shows a ROC Curve showing the diagnostic properties (sensitivity and specificity) of vitamin D and zinc for mental development (IQ).

The cut-off value for vitamin D is 24.8, with very low sensitivity (0.540) and high specificity (0.917). The cut-off value for zinc is 79.4, with low sensitivity (0.624) and high specificity (0.794).

Furthermore, vitamin D and zinc deficiencies were associated with an increased incidence of various physical and psychological symptoms. In cases of vitamin D and zinc deficiency, the incidence of correlation: hair loss, excessive sweating, and skin rashes was significantly higher. These included fatigue, emotional instability, poor mood and increased appetite, frequent illnesses, dry skin, brittle nails, and reduced physical activity. Children with deficiencies also had significantly lower IQ scores, more frequent developmental delays, and lower general well-being.

In the next stage of the study, we compared the clinical characteristics of patients in all four groups Table 4. Statistical evaluation of clinical characteristics with patients who had everything normal, patients with vitamin D deficiency, zinc deficiency, and simultaneous vitamin D and zinc deficiency.

In the case of normal vitamin D and zinc, we did not encounter hair loss, skin rash, brittle nails, caries, stunted growth,

Table 4. Comparison of clinical characteristics with study patients in all four groups.

Factors	Norm (n=65)		Vit. D (n=53)		Zinc (n=7)		Vit.D +Zinc (n=101)		F	P.
	n	%	n	%	n	%	N	%		
Hirsutism	17	26.15	21	39.62	0	0.00	33	32.67	1.94	0.1241
Hair loss	0	0.00	6	11.32	2	28.57	35	34.65	12.99	<0.0001
Hyperhidrosis	15	23.08	28	52.83	2	28.57	57	56.44	7.19	0.0001
Dry skin	20	30.77	16	30.19	0	0.00	52	51.49	5.14	0.0019
Skin rash	0	0.00	8	15.09	1	14.29	34	33.66	11.31	<0.0001
Stretch marks	1	1.54	8	15.09	3	42.86	31	30.69	9.18	<0.0001
Brittle nails	0	0.00	6	11.32	0	0.00	24	23.76	7.52	0.0001
Dental caries	0	0.00	9	16.98	0	0.00	42	41.58	17.31	<0.0001
High IQ	65	100.00	48	90.57	6	85.71	83	82.18	4.67	0.0035
Growth delay	0	0.00	10	18.87	0	0.00	24	23.76	6.93	0.0002
High Physical activity	57	87.69	37	69.81	3	42.86	50	49.50	10.22	<0.0001
Positive mood	65	100.00	41	77.36	2	28.57	67	66.34	13.85	<0.0001
Dizziness	0	0.00	4	7.55	3	42.86	12	11.88	6.55	0.0003
Emotional instability	1	1.54	14	26.42	7	100.00	37	36.63	18.89	<0.0001
Feeling of weakness	2	3.08	11	20.75	3	42.86	35	34.65	8.92	<0.0001
Increased appetite	4	6.15	16	30.19	2	28.57	41	40.59	8.60	<0.0001
Balanced nutrition	59	90.77	19	35.85	0	0.00	8	7.92	83.68	<0.0001
Synthetic fluids	14	21.54	34	64.15	6	85.71	78	77.23	23.21	<0.0001

Norm – Zinc and vitamin D level is normal
Vit. D – Vitamin D level is reduced
Zinc – Zinc level is reduced
Vit. D + Zinc – Zinc and vitamin D is reduced

Table 5. Distribution of micronutrients according to IQ; n=24 Patients with reduced IQ; n=130 Patients with normal IQ.

Group Statistics	n=24		n=130			
	Mean	SD	Mean	SD	t	P
Fe (37-170 μg/dl)	77.49	45.29	74.85	36.45	0.27	0.7893
Ca (1.12-1.3 mmol/l)	1.23	0.19	1.19	0.23	0.94	0.3527
Mg (1.7-2.5 mg/dl)	1.94	0.41	2.01	0.30	0.91	0.3645
Na (130-156 mmol/l)	139.71	6.72	138.54	5.61	0.80	0.4286
K (3,5-5,1 mmol/l)	4.40	0.52	4.26	0.57	1.20	0.2386
P (4,00-7 mg/dl)	5.34	1.05	5.36	1.14	-0.08	0.9340
Cl (98-110 mmol/l)	101.79	4.09	103.52	4.80	-1.85	0.0721

Table 6. Distribution of micronutrients in terms of growth retardation; n=120 Patients without growth retardation; n=34 Patients growth retardation.

Group statistic	n=120		n=34		t	p
	Mean	SD	Mean	SD		
Fe (37-170 μg/dl)	77.30	39.14	68.06	32.16	1.41	0.1646
Ca (1.12-1.3 mmol/l)	1.21	0.22	1.12	0.21	2.11	0.0391
Mg (1.7-2.5 mg/dl)	2.01	0.33	1.95	0.27	1.10	0.2751
Na (130-156 mmol/l)	138.69	5.44	138.82	6.97	-0.10	0.9193
K (3,5-5,1 mmol/l)	4.32	0.55	4.17	0.58	1.35	0.1830
P (4,00-7 mg/dl)	5.30	1.14	5.56	1.05	-1.21	0.2312
Cl (98-110 mmol/l)	103.33	4.73	102.97	4.77	0.39	0.6966

dizziness. Significantly less were excessive sweating, stretch marks, emotional lability, feeling of weakness, increased appetite. Significantly higher were high IQ, balanced nutrition, high physical activity, positive mood, stunted growth. In the case of vitamin D+zinc deficiency, the frequency of hair loss, excessive sweating, dry skin, skin rash was significantly higher.

As part of our study, patients were tested not only for zinc, but also for seven other micronutrients (Fe, Mg, Na, K, Ca, Cl, P). As can be seen from the table, the distribution by IQ did not reveal any significant differences between any of the microelements we studied; moreover, the concentration of microelements in both groups is within the normal range.

The distribution of growth retardation did not reveal any significant differences between any of the microelements we studied; moreover, the concentrations of microelements in both groups were within the normal range.

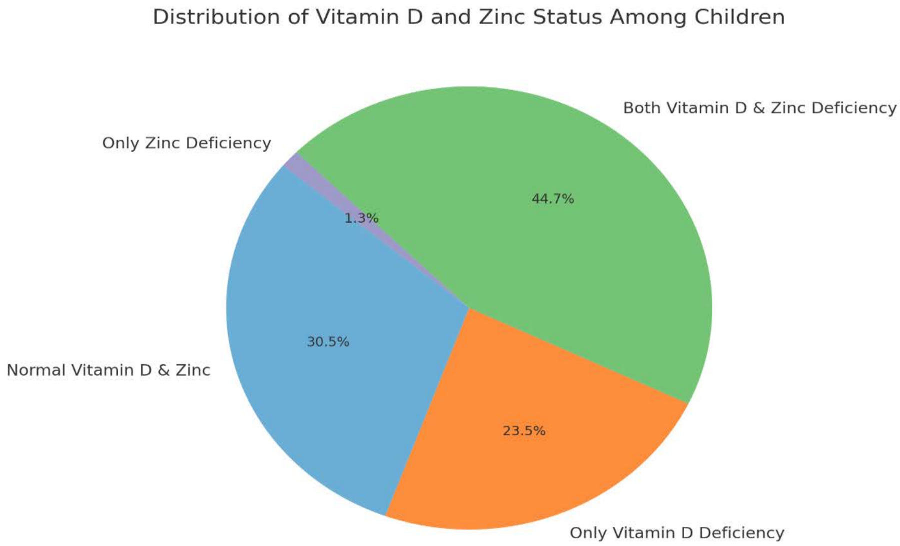

Figure 1. *Distribution of Vitamin D and Zinc Status Among Children.*

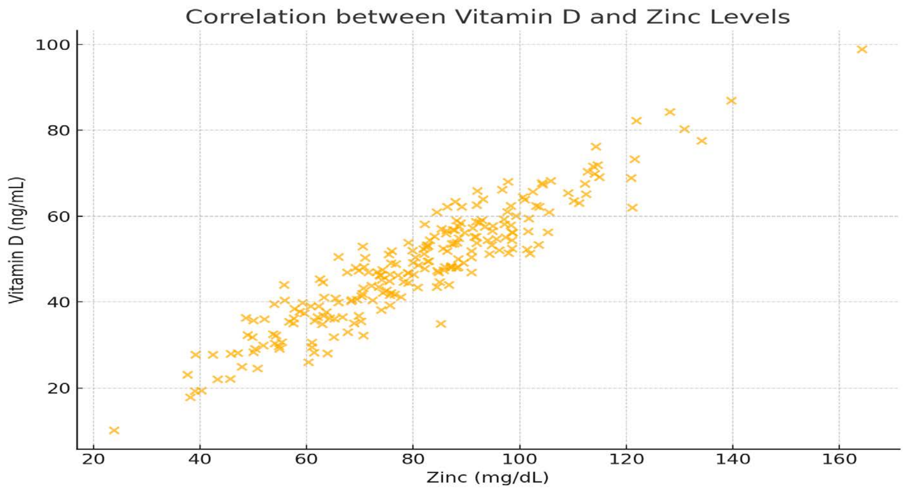

Figure 2. *Correlation between Vitamin D and Zinc levels, P<0.001.*

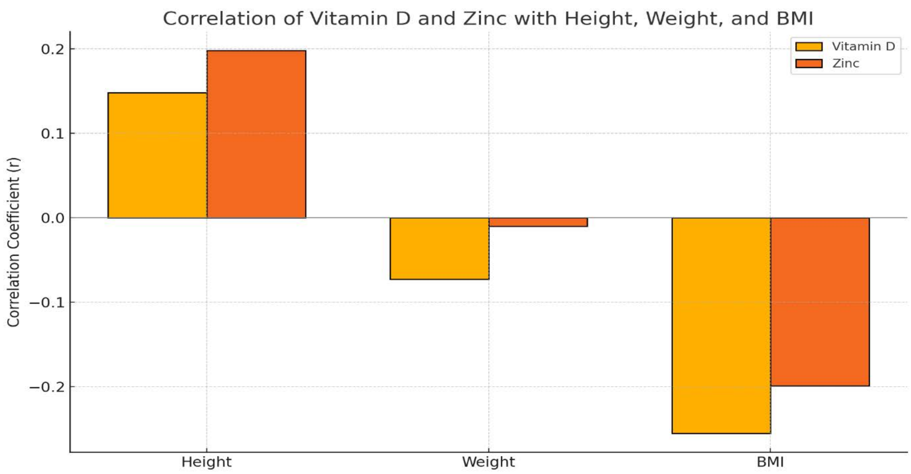

Figure 3. *Correlation of Vitamin D and Zinc with Height, Weight, and BMI.*

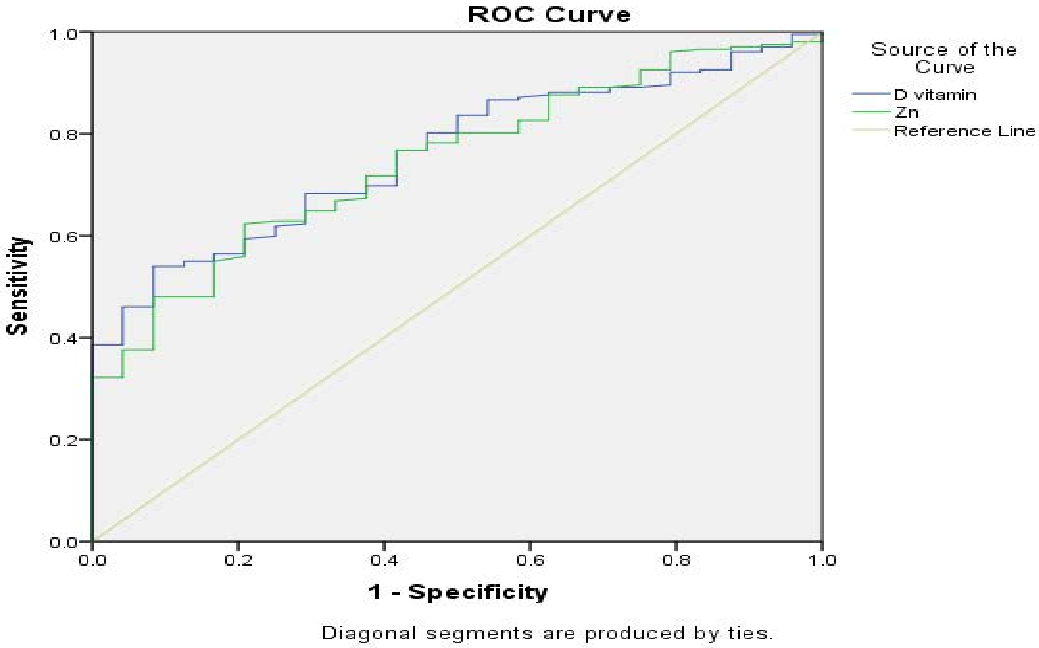

Figure 4. *Shows the area under the curve, which is averaged for both vitamin D and zinc.*

Overall, the findings of this study provide strong evidence that vitamin D and zinc deficiencies are common among Georgian children and are closely associated with poor growth outcomes, and impaired mental development. The observed correlations suggest a synergistic effect between vitamin D and zinc, emphasizing the need for early detection, nutritional education, and targeted supplementation programs to ensure healthy child development.

Discussion.

The present study explored the correlation and combined effect of vitamin D and zinc deficiencies on physical growth and mental development among children aged 3 to 10 years. The findings provide compelling evidence of significant relationships between these micronutrients and key health indicators, underlining their critical role in pediatric health. Vitamin D and zinc deficiency prevalence analysis revealed that 44.7% of the children had a combined deficiency of both vitamin D and zinc, with only 30.5% falling within normal reference ranges. This high prevalence of co-deficiency indicates a significant public health concern. Zinc deficiency was rarely found in isolation (1.3%), suggesting a potential link in the metabolic or dietary absorption patterns of these nutrients. The study found a strong positive correlation between Vitamin D and zinc ($r = 0.696$, $p < 0.001$) between vitamin D and zinc levels. This relationship may be attributed to shared dietary sources and synergistic roles in immune regulation, enzyme activation, and cellular signaling pathways. It also indicates that a deficiency in one of these nutrients may serve as a biomarker or predictive indicator for the other. Had a significant impact on Growth parameters, Children with deficiencies in vitamin D and/or zinc had significantly lower height, reduced physical development than target height. For instance: Height in children with vitamin D and zinc deficiency was significantly lower (mean = 123.91 cm) than those with sufficient levels (mean = 131.60 cm, $p = 0.0012$). The percentile score was also much lower in the deficient group (35.58 vs. 60.74, $p < 0.0001$). BMI was paradoxically higher in vitamin D and/or zinc deficient children, suggesting an association between deficiency and increased risk of overweight or obesity ($p = 0.0044$). These findings align with previous studies highlighting that both vitamin D and zinc are essential for bone growth, hormonal regulation, and metabolic health. Interesting effect on mental and cognitive outcomes.

Cognitive functioning, as measured by IQ, was also significantly associated with micronutrient status. Children with higher IQ scores had: Higher mean vitamin D levels (26.07 ng/mL vs. 19.62 ng/mL, $p = 0.0097$). Higher mean zinc levels (82.34 µg/dL vs. 66.58 µg/dL, $p = 0.0007$). Furthermore, children with lower IQ scores exhibited greater deficiencies, supporting the hypothesis that these micronutrients play a vital role in neurodevelopment, cognitive processing, and executive function. The study also examined behavioral variables like emotional lability, mood, physical activity, and mental fatigue. These indicators were significantly worse in children with dual deficiencies. Emotional lability was 100% prevalent in children who had both deficiencies, compared to just 1.5% in the normal group ($p < 0.0001$). Such associations point to the psychological impact of chronic micronutrient deficiency, possibly mediated by oxidative stress, neuroinflammation, or neurotransmitter imbalance caused by insufficient zinc and vitamin D levels. A significantly higher rate of deficiency was found in children from families with lower socioeconomic status, a factor closely linked to limited access to nutrient-rich foods, outdoor activity (and thus sun exposure), and overall health literacy [21].

Conclusion.

Approximately 2 billion people worldwide suffer from micronutrient deficiencies, mainly due to poor nutrition. Micronutrient deficiencies, which are often caused by an unbalanced diet, are associated with cognitive and motor development, behavioral problems, and skeletal growth disorders. A balanced diet is especially important during childhood and adolescence, when nutrient needs are high. Vitamin D deficiency is widespread in Georgia, zinc deficiency has not been studied before, and even less is zinc tested in the laboratory. However, the results are important, especially its impact on children's mental and physical development. The study was conducted on 226 patients and the results of the study established the relationship between vitamin D and zinc deficiency ($p<0.001$) and their combined impact on children's growth and mental health, which emphasizes the need for improved nutrition and awareness at both medical and social levels.

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