Global research trends in bone mineral density in children with diabetes: a bibliometric and visualization study

Yuan Jianhua[1],#,*, Feng Xiaoyan[2],#, Jiang Jiemei[2], Wu Pingping[1], Shen Long[2]

[1]Department of Pediatrics, Peace Hospital Affiliated to Changzhi Medical College, Changzhi, 046000, China
[2]Office of Graduate Studies, Changzhi Medical College, Changzhi, 046000, China
#Co-first author.
*Corresponding author

Abstract: Research on bone density in children with diabetes has attracted increasing attention, and this study aims to investigate the global status and trends in this field.From the Web of Science's Science Citation Index, research papers related to bone density in children with diabetes from 1984-2022 were retrieved. Source data were studied and indexed using bibliometric methods. The visualization study used VOS viewer software for literature coupling, co-authorship, co-citation and co-occurrence analysis to analyze the publication trend of bone density in children with diabetes.A total of 1074 articles were included. Globally, the number of related research interests and publications is increasing every year. The United States contributes the most to global research, receives the most citations, and has the highest h-index. The Journal of Clinical Endocrinology and Metabolism has the highest number of publications.The university of pennsylvania,Childrens hospital of philadelphia,Pennsylvania medicine,Harvard university and university of Sydney are the largest contributors. Research can be divided into four categories: mechanistic research, animal research, clinical trials, and tissue engineering. Mechanism research is expected to be the next hot topic in this field.From the current global research trend, the number of papers on bone density in children with diabetes will continue to increase. The United States is the largest contributor in this area. Much of the effort is devoted to the mechanisms of changes in bone density in children with diabetes, which could be the next hot spot in research.

Keywords: Diabetes mellitus in children; Bone mineral density; Global trends; Bibliometrics; Visualization research

1. Introduction

Childhood diabetes is an endocrine metabolic disease caused by insufficient insulin secretion, mainly carbohydrate, protein and fat metabolism disorders, which can cause hyperglycemia and urine glucose(1) Because glucose is important for osteoblast differentiation and energy expenditure, as blood glucose changes, osteoblast functional activity also changes, and bone density also changes (2). (3) Bone mineral density is an important marker of bone mass, reflecting the degree of osteoporosis and predicting fracture risk. (4) In recent years, the study of the mechanism of bone density change in children with diabetes has become a hot spot, among which genetically, the changes in insulin synthesis, secretion, metabolism and mechanism of action caused by differences in gene expression in diabetic children have become the focus of researchers (5). (6) Therefore, before further research and discussion on the bone density mechanism of pediatric diabetics, we need to summarize the current status of bone density mechanism research in pediatric diabetic patients and predict promising keywords and trends. Among them, the number of publications, as the core part of scientific research, is an important indicator to measure the contribution of scientific research. Bibliometric analysis provides information based on bibliographic databases and bibliometric characteristics for qualitative and quantitative evaluation of trends in research activities over time, providing a way to capture developments in a field and compare contributions from scholars, journals, institutions and countries (7) Bibliometric analysis has also been used to develop policy and clinical practice guidelines, and this feasible approach has been successfully used in studies to assess spine, sepsis, diabetes and injury. To our knowledge, in the field of changes in bone density in children with diabetes, research on genetic mechanisms is relatively hot and in small numbers. (8) Therefore, the purpose of this study is to evaluate the current status and trend of research on the mechanism of bone

density change in pediatric diabetic patients, including genetics.

2. Materials and methods

2.1. Data Sources

Bibliometric analysis was performed based on the Science Citation Index-Expanded (SCI-E) of the Web of Science (WoS) which is considered the optimal database for bibliometrics .

2.2. Search strategy

All publications were searched in WoS from 01.01.1984 to 31.12.2022 in the database. In this study, the search criteria were: Subject = Diabetes AND in Children Topic = Year of Publication of Bone Density AND = (1984-2022) AND Language = (English) AND Literature Type = (Article or Review). We've also improved searching for certain countries or regions by indexing them in WoS.

2.3. Data collection

Download the complete record of each publication, including title, year of publication, author name, nationality, affiliation, publication journal name, keywords, and abstract from the WoS database, and import it into Microsoft Excel 2017 as a TXT file. Two authors (FXY and YJH) independently screened and extracted data entries and collections. Any disagreement is reached through discussion. Finally, the two authors manually cleaned and analyzed the data in Microsoft Excel 2017.

2.4. Bibliometric Analysis

The internal function of WoS is used to describe the basic characteristics of the above qualified publications. The H-index is a measure of scientific impact .The H-index indicates that a scholar or country has published h papers, and each paper has been cited by other publications at least h times . Therefore, the H-index reflects both the number of publications and the number of citations per publication[9] .Using R software (version 3 . 1 .3), the logistic regression model was used to plot the publication time curve :$f(x) = c/(1+a \times exp[-b \times (X-1984)])$ .Where, the independent variable x is the year and $f(x)$ is the cumulative number of publications .The formula $T = lna/b + 1984$ is used to calculate the inflection point, which is defined as the time when the publication growth rate changes from positive to negative [10] .

2.5. Visual analysis

Visual analysis using VOSviewer (LeidenUniversity, Leiden, the Netherlands) for publications for visual analysis [11]. In this study, VOSviewer was used to conduct bibliographic coupling, coauthorization, co-citation and co-occurrence analysis.

3. Results

### 3.1. Trend

3.1.1. Global Publishing Trends

A total of 1,074 articles were published worldwide from 1984 to 2022, which met the search criteria. At the time of the annual publications, most studies were published in 2019 (75 articles, 6.983%). From 1984 to 2022, the total number of global publications per year showed an overall upward trend (Figure 1a).

3.1.2. National Contributions

A total of 66 countries and territories have contributed to this area. Among these countries, the United States published the most relevant articles (516, 48.045%), followed by Australia (84, 7.821%), Germany (75, 6.983%), Italy (68, 6.331%) and Sweden (62, 5.773%) (Figures 1b, 1c).

3.1.3. Global publishing trend prediction

Use logistic regression models to create a time curve of the number of publications that can predict future trends12. Figure 1d shows a model fitting curve that predicts the growth trend in the number of global publications over the next few years (Figure 1d).

(1a)   *(1b)*

(1c)   *(1d)*
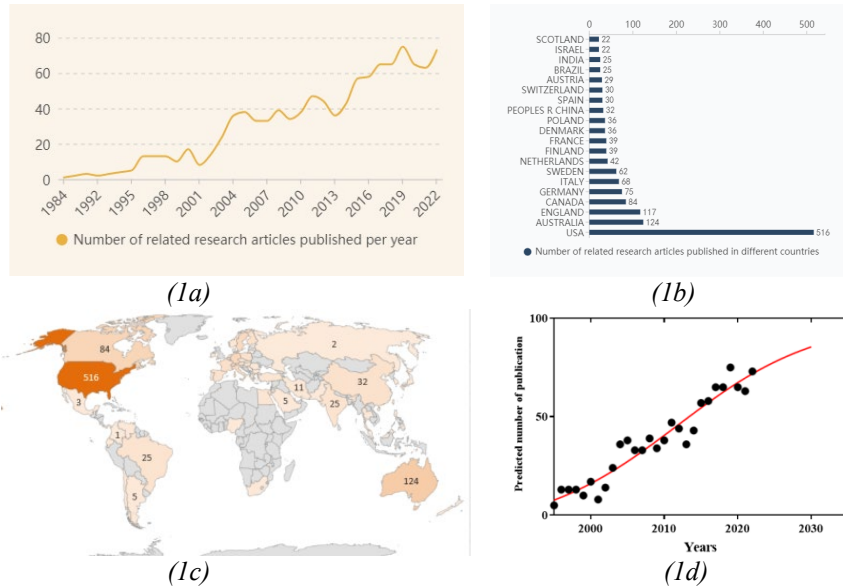
(a) Number of publications worldwide related to bone mineral density studies in children with diabetes in different years. (b) Number of publications on bone mineral density in children with diabetes in different countries.(c) World map showing the distribution of bone density studies in children with diabetes.(d) A model fitting curve predicting the growth trend in the number of global publications related to the field of bone mineral density in children with diabetes in the coming years.

Figure 1: Global trends and countries in bone mineral density studies in children with diabetes.

3.2. Quality of publications in different countries

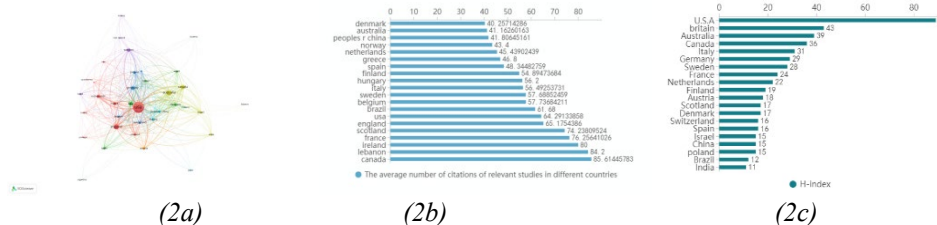### 3.2.1. Total citation frequency

Papers from the United States had the highest overall citations (32,660). The UK ranked second in total citations (7,430), followed by Canada (7,106), Australia (5,063) and Germany (3,785) (Figure 2a).

3.2.2. Average citations

The highest was for Canadian publications (85.6). Lebanon ranked second in average citations (84.2), followed by Ireland (80), France (76.2) and Scotland (74.2), with Figure 2b listing the top 20 journals with the highest average citations.

3.2.3. H-Index

The United States had the highest H-index (84), followed by China (53), Canada (39), the United Kingdom (39), Japan (37) and Germany (34) (Figure 2C).

(2a)   *(2b)*   *(2c)*

(a) Total citations of research papers on bone mineral density in children with diabetes in different countries (b) Average citations per paper in different countries (c) H-index of publications in different countries.

Figure 2: Citation frequency and h index of different countries.

3.3. Analysis of global publications

3.3.1. Journal Analysis

There are 80 articles on Journal of clinical endocrinology metabolism (IF=3.269, 2021), 67 articles on Bone(IF=2.721, 2021), 64 articles on Journal of Bone and mineral research (IF=4.297, 2021), 33 articles on osteoporosis international (IF=2.562, 2021), and 32 articles on current opinion in endocrinology diabetes and obesity (IF=5.526, 2021) on bone mineral density in children with diabetes. Figure 3a lists the top 20 journals that have published the most studies.

3.3.2. Research Directions

Figure 3b shows the distribution of research directions in the literature related to the study of pediatric diabetic bone density. The most popular research areas are endocrinology and metabolism13,14, pediatrics, nutrition15, 16, general internal medicine, and experimental research medicine.

3.3.3. Institutional output

The top 20 institutions with the highest output are shown in Figure 3c. The university of pennsylvania (104), Childrens hospital of philadelphia (98) and Pennsylvania medicine (98) ranked second,Harvard university (89) ranked third, and university of Sydney (64) ranked fourth.

3.3.4. Sources of funds

The top 20 funding agencies supporting this research area are shown in Figure 3d, with a total of 1242 studies funded by funding. Among them, 343 grants from the National Institutes of Health and the U.S. Department of Health and Human Services (ranked first), and 204 grants from the National Institute of Diabetic Digestive and Kidney Disease (ranked second).

3.3.5. Authors

The top 20 authors published a total of 375 papers, accounting for 18.418% of all papers in the field. In the field of degenerative discs and degenerative disc diseases, the three authors with the most published papers were Liu H (39), followed by Zhang Y (26) and Wang H (23) (Figure 3e).

(3a)   *(3b)*   *(3c)*

(3d)   *(3e)*
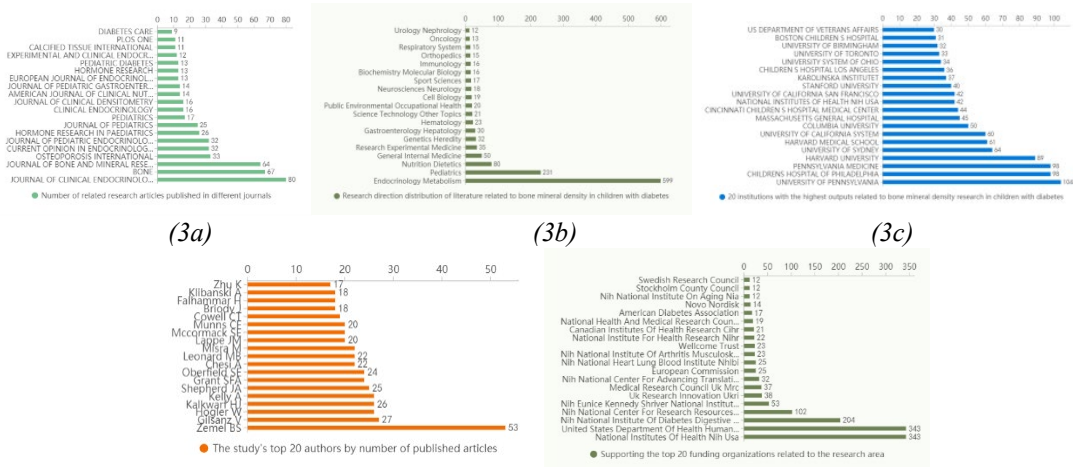
(a) Leading research journals worldwide.(b) The global aggregate of research directions.(c) Global high-impact institutions.(d) Major global funding funds.(e) Authors of global significance.

Figure 3: High-contribution journals, research fields, high-impact institutions, authors and funding of bone mineral density research in childhood diabetes worldwide.

3.4. Bibliographic coupling analysis

Bibliographic coupling is a measure that uses citation analysis to establish similar relationships between documents. Use VOS viewer to analyze journal names in total publications.

3.4.1. Magazines

As shown in Figure 4a, a total of 37 identified journals (defined as the minimum number of publications used by a magazine with more than 5 copies) appear in the total link strength. The top 5

journals by total link strength were: Journal of Clinical Endocrinology & Metabolism (total link strength = 10,249), BONE (total link strength = 8,477), Journal of Bone and Mineral Research (total link strength = 6,672), and Osteoporosis International (total link strength = 3379) and Journal of Pediatric endocrinology & metabolism (total link strength = 3388).

3.4.2. Institutions

Papers identified in 55 institutions (defined as the minimum number of publications used by an organization of more than 10) were analyzed using VOS viewer. The top five institutions for total link strength were: University of Pennsylvania (total link strength = 46,946x), Children's Hospital of Philadelphia (total link strength = 40,747x), Columbia University (total link strength = 29,830x), Cincinnati Children's Hospital (total link strength = 25,878x), and Children's Hospital of Los Angeles (total link strength = 23,986x) (Figure 4b).

3.4.3. Countries

Identified country papers (defined as the minimum number of publications using more than 5 copies in a country) were analysed using VOS viewer. The top five countries for total link strength are: the United States (total link strength = 95,298x), the United Kingdom (total link strength = 52,917x), Canada (total link strength = 37,005x), Australia (total link strength = 36,704x), and Germany (total link strength = 35,682x) (Figure 4c).

(4a)   *(4b)*   *(4c)*
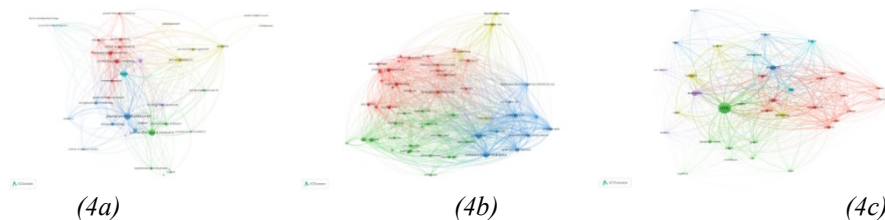
(a) Mapping of 37 journals identified as relevant to bone mineral density studies in children with diabetes. (b) Maps of 55 institutions associated with bone mineral density studies in children with diabetes.(c) Mapping studies related to bone mineral density in children with diabetes in 36 countries. The line between the two points in the graph indicates that a similar relationship has been established between the two journals/institutions/countries. The thicker the line, the stronger the connection between the two journals/institutions/countries.

Figure 4: Literature coupling analysis of global studies on bone mineral density in children with diabetes.

3.5. Co-citation analysis

3.5.1. Publications

74 documents (defined as the minimum number of citations for a document with more than 20 citations) were analyzed using VOS viewer. The top five studies with the highest total link strength were as follows: The Journal of Pediatrics, January 2004; 144(1): 56-62 (total link strength = 413x)17; Hormone Research in Paediatrics 2002; 58(6): 266-272 (total link strength = 382 times) 18; The Journal of Pediatrics, November 2004; 145(5): 662-669 (total link strength = 345 times) 19; Journal of Pediatric Endocrinology and Metabolism, January 2001; 14(5) 525 (total link strength = 329x) 20 and Journal of Hormone Research in Paediatrics 1998; 50(4): 193-196 (total link strength = 328x) 21 (Figure 5a).

3.5.2. Journals

Using VOS viewer to analyze the co-cited journal names (which are defined as a source with a minimum citation of more than 25 times), 294 identified journals appear in the total link strength. The top 5 journals in total link strength were: J Clin Endocr Metab (total link strength = 270212 times), J Bone Miner RES (total link strength = 126792 times), J Pediatr-Us (total link strength = 72204 times), Osteoporosis INT (total link strength = 71564), AM J CLIN NUTR (TOTAL LINK STRENGTH = 70966).

(5a)   *(5b)*

(a) Link strength graph of cited frequency of 74 articles in bone mineral density related research fields in children with diabetes. (b) Link strength maps of 294 journals cited in the field of bone mineral density research in childhood diabetes.

Figure 5: Co-author analysis of a global study on bone mineral density in children with diabetes.

3.6. Co-occurrence analysis

VOS viewer color-codes keywords (defined as words used more than 5 times in the titles and abstracts of all publications, out of 425 qualifying keywords) based on the average time they appear in all indexed publications. Purple indicates that the keyword appeared earlier, and yellow indicates that the keyword appeared later. Prior to 2014, in the early stages of research, most of the research focused on "clinical studies." According to the latest trends, "mechanism research" will receive widespread attention in the future (Figure 6).

(6a)   *(6b)*

Figure 6: (a) 425 keywords were grouped into domains related to disc degeneration and degenerative disc disease.(b) Position of 425 key words over time in areas related to disc degeneration and degenerative disc disease.

4. Discussion

4.1. Trends in disc degeneration and degenerative disc disease:

Trends in the study of bone density changes in pediatric diabetics: bibliometrics and visual analysis can present the current status and predictions in the search field. Therefore, this study aims to evaluate changes in bone density changes in children with diabetes, including contributing countries, institutions, funding agencies, and research priorities22,23. Recent studies of changes in bone density in children with diabetes have been rapid and exciting. As this study shows, the number of publications per year has increased significantly. In addition, research interest in this area has increased dramatically over the past few years, with a total of 67 countries publishing relevant research in this area. Based on the available data, we forecast the number of future publications. Therefore, more in-depth research on changes in bone density in children with diabetes will be published in the coming years 24,25. The current optimistic results will, in turn, encourage researchers to further high-quality research work.

4.2. Quality and status of global publications:

A country's total citations and h-index represent its scholarly impact and publication quality26. While the total number of publications in the U.S. is lower than in China, the U.S. contributes the most to global research in terms of total citation frequency and h-index. So, the United States can still be considered a leader in this field. China ranks first in the total number of publications, 2nd in the total number of citations and h-index, the number and quality of Chinese publications are increasing and improving year by year compared with previous years, and research in this field is also in a leading position. With the gradual increase of China's scientific research funding (National Natural Science Foundation of China: ranked first), the quality of research will further improve significantly27.

Springer Nature, Elsevier, Lippincott Williams & Wilkins, Wiley, and Sage have published more research on degenerative discs and degenerative disc disease. However, Springer Nature, Elsevier, Lippincott Williams & Wilkins published 2-3 times more papers than the fourth-ranked journals, so further research in this area is most likely to appear first among these publishers at the top of the list.

In these top five countries, their research institutions are leading the way in the field of bone density change research in children with diabetes, which is consistent with their leadership in global publications. And, almost all of the top 20 universities are located in the top five countries. This shows that the foundation of a country's academic level lies in the creation of more first-class universities and research institutions28. We also list more authors of published studies in this area, suggesting that we can closely follow further research by these authors to obtain the latest advances in the study of changes in bone density in children with diabetes.

This study uses bibliographic coupling analysis to establish similarities between publications in journals, institutions, and countries29. Bibliographic coupling occurs when two works cite the same third work in their bibliography. These data show that Spine is the most relevant journal in the field, and the United States is leading the way in this field. The purpose of co-citation analysis is to investigate the impact of a study by counting the number of times it has been cited simultaneously. The current results show that the study of the mechanism of bone density change in pediatric diabetics is a keyword with high frequency of citation in the field.

4.3. Research mainly focused on nucleus pulposus cells and inflammatory response:

Based on co-occurrence analysis, we found research directions and hot topics in this field. Keywords in the titles and abstracts of all included studies were analysed to create co-occurrence network diagrams. Four research directions can be observed from the co-occurrence map, including mechanism research, animal research, clinical trials, and tissue engineering. While this result is consistent with common sense in the field, this study can provide more clarity on future research directions. In the center of the co-occurrence map, keywords such as genetics and mechanism have higher weights and are more prominent. Therefore, further high-quality studies are needed to evaluate the role of genetics in the study of the mechanism of bone density change in children with diabetes30.

In summary, this study presents a global development trend in the study of the mechanism of bone density change in children with diabetes. The United States and China are the largest contributors to this research and are leading global research in this field. The Springer Nature Publishing Group has published the most articles related to it. We can predict that more research will be published on changes in bone density in children with diabetes in the coming years. In particular, the study of the genetic mechanism of bone density change in childhood diabetic patients will receive more attention and become a hot spot in the future.

References

[1] Hou L, Li X, Liu L, et al. A Multicenter Survey of Type I Diabetes Mellitus in Chinese Children. Front Endocrinol. 2021;12:583114. doi:10.3389/fendo.2021.583114

[2] Donat A, Knapstein PR, Jiang S, et al. Glucose Metabolism in Osteoblasts in Healthy and Pathophysiological Conditions. IJMS. 2021;22(8):4120. doi:10.3390/ijms22084120

[3] Cipriani C, Colangelo L, Santori R, et al. The Interplay Between Bone and Glucose Metabolism. Front Endocrinol. 2020;11:122. doi:10.3389/fendo.2020.00122

[4] Di Iorgi N, Maruca K, Patti G, Mora S. Update on bone density measurements and their interpretation in children and adolescents. Best Pract Res Clin Endocrinol Metab. 2018;32(4):477-498. doi:10.1016/j.beem.2018.06.002

[5] Ikle JM, Gloyn AL. 100 YEARS OF INSULIN: A brief history of diabetes genetics: insights for pancreatic beta-cell development and function. Journal of Endocrinology. 2021;250(3):R23-R35. doi:10.1530/JOE-21-0067

[6] Rosen ED, Kaestner KH, Natarajan R, et al. Epigenetics and Epigenomics: Implications for Diabetes and Obesity. Diabetes. 2018;67(10):1923-1931. doi:10.2337/db18-0537

[7] Ninkov A, Frank JR, Maggio LA. Bibliometrics: Methods for studying academic publishing. Perspect Med Educ. 2021;11(3):173-176. doi:10.1007/S40037-021-00695-4

[8] Sanyoura M, Philipson LH, Naylor R. Monogenic Diabetes in Children and Adolescents: Recognition and Treatment Options. Curr Diab Rep. 2018;18(8):58. doi: 10.1007 /s11892-018-1024-2

[9] Ali MJ. Forewarned Is Forearmed: The h-Index as a Scientometric. Semin Ophthalmol.

2021;36(1-2):1. doi:10.1080/08820538.2021.1894889

[10] Schober P, Vetter TR. Logistic Regression in Medical Research. Anesth Analg. 2021;132(2):365-366. doi:10.1213/ANE.000000000005247

[11] Casey F, Negi S, Zhu J, et al. OmicsView: Omics data analysis through interactive visual analytics. Comput Struct Biotechnol J. 2022;20:1277-1285. doi:10.1016/j.csbj.2022.02.022

[12] Engoren M, Pancaro C, Yeldo NS, Kerzabi LS, Douville N. Comparison of static and rolling logistic regression models on predicting invasive mechanical ventilation or death from COVID-19-A retrospective, multicentre study. Clin Respir J. 2023; 17(1):40-49. doi: 10.1111/ crj.13560

[13] Predieri B, Bruzzi P, Bigi E, et al. Endocrine Disrupting Chemicals and Type 1 Diabetes. Int J Mol Sci. 2020;21(8):2937. doi:10.3390/ijms21082937

[14] Bernasconi S. Management of the main endocrine and diabetic disorders in children. Minerva Pediatr. 2020;72(4). doi:10.23736/S0026-4946.20.05990-3

[15] Albert Pérez E, Mateu Olivares V, Martínez-Espinosa R, Molina Vila M, Reig García-Galbis M. New Insights about How to Make an Intervention in Children and Adolescents with Metabolic Syndrome: Diet, Exercise vs. Changes in Body Composition. A Systematic Review of RCT. Nutrients. 2018; 10(7):878. doi:10.3390/nu10070878

[16] MacPherson M, Cranston K, Locke S, Vis-Dunbar M, Jung ME. Diet and exercise interventions for individuals at risk for type 2 diabetes: a scoping review protocol. BMJ Open. 2020;10(11):e039532. doi:10.1136/bmjopen-2020-039532

[17] Heap J, Murray MA, Miller SC, Jalili T, Moyer-Mileur LJ. Alterations in bone characteristics associated with glycemic control in adolescents with type 1 diabetes mellitus. The Journal of Pediatrics. 2004;144(1):56-62. doi:10.1016/j.jpeds.2003.10.066

[18] Valerio G, Del Puente A, Esposito-del Puente A, Buono P, Mozzillo E, Franzese A. The Lumbar Bone Mineral Density Is Affected by Long-Term Poor Metabolic Control in Adolescents with Type 1 Diabetes mellitus. Horm Res Paediatr. 2002;58(6):266-272. doi:10.1159/000066441

[19] Moyer-Mileur LJ, Dixon SB, Quick JL, Askew EW, Murray MA. Bone mineral acquisition in adolescents with type 1 diabetes. The Journal of Pediatrics. 2004;145(5):662-669. doi:10. 1016/j.jpeds.2004.06.070

[20] Gunczler P, Lanes R, Paoli M, Martinis R, Villaroel O, Weisinger JR. Decreased Bone Mineral Density and Bone Formation Markers Shortly After Diagnosis of Clinical Type 1 Diabetes Mellitus. Journal of Pediatric Endocrinology and Metabolism. 2001;14(5). doi:10.1515/JPEM.2001.14.5.525

[21] De Schepper J, Smitz J, Rosseneu S, Bollen P, Louis O. Lumbar Spine Bone Mineral Density in Diabetic Children with Recent Onset. Horm Res Paediatr. 1998;50(4):193-196. doi:10.1159/000023273

[22] Wu H, Patterson CC, Zhang X, et al. Worldwide estimates of incidence of type 2 diabetes in children and adolescents in 2021. Diabetes Res Clin Pract. 2022;185:109785. doi: 10.1016/ j.diabres. 2022.109785

[23] Patterson CC, Karuranga S, Salpea P, et al. Worldwide estimates of incidence, prevalence and mortality of type 1 diabetes in children and adolescents: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. Diabetes Res Clin Pract. 2019;157:107842. doi:10. 1016/j.diabres.2019.107842

[24] Bilinski WJ, Paradowski PT, Sypniewska G. Bone health and hyperglycemia in pediatric populations. Crit Rev Clin Lab Sci. 2020;57(7):444-457. doi:10.1080/10408363.2020.1739619

[25] Kindler JM, Gallo S, Khoury PR, Urbina EM, Zemel BS. Diet Quality and Bone Density in Youth with Healthy Weight, Obesity, and Type 2 Diabetes. Nutrients. 2021;13(9):3288. doi:10. 3390/nu 13093288

[26] Calò LN. Impact metrics and science evaluation. Rev Peru Med Exp Salud Publica. 2022; 39(2):236-240. doi:10.17843/rpmesp.2022.392.11171

[27] Yip W, Fu H, Chen AT, et al. 10 years of health-care reform in China: progress and gaps in Universal Health Coverage. Lancet. 2019;394(10204):1192-1204. doi: 10.1016/ S0140-6736 (19)321 36-1

[28] Chen P, Wang D, Shen H, et al. Physical activity and health in Chinese children and adolescents: expert consensus statement (2020). Br J Sports Med. 2020;54(22):1321-1331. doi:10.1136/ bjsports-2020-102261

[29] Guo H, Shen Z, Zeng J, Hong N. Hybrid Methods of Bibliographic Coupling and Text Similarity Measurement for Biomedical Paper Recommendation. Stud Health Technol Inform. 2022;290:287-291. doi:10.3233/SHTI220080

[30] Ciancia S, van Rijn RR, Högler W, et al. Osteoporosis in children and adolescents: when to suspect and how to diagnose it. Eur J Pediatr. 2022;181(7):2549-2561. doi: 10.1007/ s00431-022-04455-2