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Obesity, Metabolic Syndrome, and Nutrition

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Introduction

Obesity represents a significant global public health challenge, currently affecting over 300 million children worldwide. This condition carries profound implications for both physical and psychological health, and is likely to persist into adulthood, thereby increasing the risk of long-term morbidity and premature mortality. The etiology of obesity is multifactorial, encompassing a complex interaction between genetic predispositions and modifiable environmental influences, particularly sedentary lifestyles and excessive caloric intake.

Emerging evidence highlights the critical role of the early life environment in shaping long-term physiological and metabolic trajectories.

Early and crucial developmental periods represent critical window during which nutritional exposures can exert lasting effects on future disease susceptibility.

Adverse intrauterine conditions may initiate metabolic programming processes that predispose individuals to lifelong health challenges. Maternal obesity during pregnancy has been consistently linked to increased risks of obesity and metabolic disorders in the offspring. Several studies reviewed in this chapter focus on in utero exposures and their associations with childhood obesity and metabolic outcomes.

Maternal dietary patterns, including adherence to a Mediterranean diet or consumption of a high-protein, low-glycemic index diet, may influence fetal metabolic development, highlighting the importance of prenatal nutrition in the intergenerational transmission of obesity risk. In addition, nutritional practices during infancy and early childhood play a pivotal role in shaping long-term health. Exclusive breastfeeding for the first 6 months of life is recommended to support optimal growth and development, and has been proposed as a potential protective factor against obesity.

Some of the included studies investigated associations between breastfeeding and adiposity outcomes, including early adiposity rebound (AR), a known predictor of later adiposity and metabolic disease, which appears to be less prevalent in breastfed infants. One study reported that breast milk lipid profiles were associated with AR status, suggesting a regulatory effect on the metabolic risk later in life. Other findings indicated that breastfeeding may attenuate the impact of genetic susceptibility to obesity and modify associations between gestational diabetes exposure and subsequent adiposity when paired with healthy postnatal feeding behaviors, such as limiting sugary beverage consumption.

Additional studies examined the influence of dietary composition in later childhood on adiposity outcomes. A nutritionally balanced diet in childhood is essential for appropriate growth and the prevention of diseases in late childhood or adulthood. One large surveillance study offered new insights into how trace elements in drinking water may relate to BMI in pediatric populations. Meanwhile, research from low- and middle-income countries highlighted the growing impact of ultra-processed food consumption on the health and wellbeing of young children. Another longitudinal study emphasized the importance of sustained adherence to the Mediterranean diet as a predictor of BMI trajectories over time.

Several studies assessed the relationship between specific dietary components, such as calcium intake, nut consumption, and adherence to the Indo-Mediterranean diet (characterized by high intake of whole grains, spices, mustard oil, fruits, vegetables, and fish), and cardiometabolic risk factors in pediatric populations.

In light of the substantial health burden associated with childhood obesity, there is an urgent need for effective public health strategies that prioritize nutritional interventions and support policy efforts to cultivate healthy dietary behaviors from infancy onward.

In this year's edition of the Yearbook chapter focused on nutrition, obesity, and metabolic comorbidities across early life stages, we highlight 14 notable articles published between July 2024 and June 2025. These selections represent key advances in the understanding of how early-life nutrition influences the development of obesity and metabolic health from infancy through childhood and into young adulthood.

Key articles reviewed for this chapter

Maternal Diet during Pregnancy and Risk of Childhood Obesity

Effects of Mediterranean diet during pregnancy on the onset of overweight or obesity in the offspring: a randomized trial
Coppola S, Paparo L, Bedogni G, Nocerino R, Costabile D, Cuomo M, Chiariotti L, Carucci L, Agangi A, Napolitano M, Messina F, Passariello A, Berni Canani R
Int J Obes (Lond) 2025;49:101–108

Effect of a high-protein and low-glycaemic index diet during pregnancy in women with overweight or obesity on offspring metabolic health – a randomized controlled trial
Mogensen CS, Magkos F, Zingenberg H, Geiker NRW
Pediatr Obes 2025;20:e13191

Nutrition during Infancy and Risk of Childhood Obesity

Interaction between breastfeeding duration and an obesity genetic risk score to predict body fat composition in European adolescents: the HELENA study
Baxevanis GK, Iglesia I, Seral-Cortes M, Sabroso-Lasa S, Flores-Barrantes P, Gottrand F, Meirhaeghe A, Kafatos A, Widhalm K, Hockamp N, Molnár D, Marcos A, Nova E, González-Gross M, Gesteiro E, Gutiérrez Á, Manios Y, Anastasiou CA, Rodríguez G, Moreno LA on behalf of the HELENA Study Group
Pediatr Obes 2025;20:e13205

Fetal exposure to gestational diabetes severity and postnatal infant feeding in the first year of life associated with preadolescent obesity: a prospective cohort
Sun B, Lo JC, Greenspan LC, King AS, Davis JN, Faith MS, Wakimoto P, Josefson JL, Basi T, Quesenberry CP Jr, Hudson EA, Lowe W, Metzger B, Gunderson EP
Obesity (Silver Spring) 2025;33:996–1010

Efficacy of a 24-month behavioral intervention focused on sugary beverage reduction for Latino mother-infant dyads: evidence from a randomized controlled trial
Machle CJ, Berger PK, Salvy SJ, Rios C, Durazo-Arvizu R, Goran MI
Am J Clin Nutr 2025;121:355–366

Exploring the association between human breast milk lipids and early adiposity rebound in children: a case-control study
Sawane K, Takahashi I, Ishikuro M, Takumi H, Orui M, Noda A, Shinoda G, Ohseto H, Onuma T, Ueno F, Murakami K, Higuchi N, Furuyashiki T, Nakamura T, Koshiba S, Ohneda K, Kumada K, Ogishima S, Hozawa A, Sugawara J, Kuriyama S, Obara T
Nutrition 2025;135:112739

Nutrition during Childhood and Risk of Childhood Obesity

Adherence to the Mediterranean diet and changes in body mass index
Homs C, Berruezo P, Según G, Torres S, Ribera M, Sauri A, Tejada J, Ródenas J, Juton C, Milà R, Fíto M, Gómez SF, Schröder H
Pediatr Res 2025;97:1911–1917

The modifying effects of lifestyle behaviors on the association between drinking water micronutrients and BMI status among children and adolescents aged 7~17: a population-based regional surveillance in 2022
Chen M, Zhang X, Jiang J, Yang T, Chen L, Liu J, Song X, Zhang Y, Wang R, Qin Y, Dong Z, Yuan W, Guo T, Song Z, Ma J, Dong Y, Song Y, Qin Y
Nutrients 2024;16:3931

Cashew nut consumption reduces waist circumference and oxidative stress in adolescents with obesity: a randomized clinical trial
de Oliveira LFN, Maia CSC, Nogueira MDA, Dias TDS, Firmino MAD, Loureiro APM, Marzola EL, Nunes PIG, Santos FA, Freire WBS, Fortunato RS, Loureiro ACC
Nutr Res 2025;134:60–72

Nutrition transition's latest stage: are ultra-processed food increases in low- and middle-income countries dooming our preschoolers' diets and future health?
Popkin BM, Laar A
Pediatr Obes 2025;20:e70002

Nutrition and Risk of Obesity-Related Comorbidities

Association between calcium intake from different food sources during childhood and cardiometabolic risk on adolescence: the Generation XXI birth cohort
Silva S, Severo M, Lopes C
Pediatr Obes 2024;19:e13158

Dietary lipid profile in Spanish children with overweight or obesity: a longitudinal study on the impact of children's eating behavior and sedentary habits
García S, Ródenas-Munar M, Argelich E, Mateos D, Ugarriza L, Tur JA, Bouzas C
Nutrients 2025;17:494

Skipping breakfast and nutrient density: influence on obesity, blood pressure, glucose, and cholesterol in elementary school students
Mun H, Oh SW
Obes Res Clin Pract 2025;19:94–100

Effect of Indo-Mediterranean diet versus calorie-restricted diet in children with non-alcoholic fatty liver disease: a pilot randomized control trial
Deshmukh A, Sood V, Lal BB, Khanna R, Alam S, Sarin SK
Pediatr Obes 2024;19:e13163

Maternal Diet during Pregnancy and Risk of Childhood Obesity

Effects of Mediterranean diet during pregnancy on the onset of overweight or obesity in the offspring: a randomized trial

Coppola S[1,2], Paparo L[1,2], Bedogni G[3,4], Nocerino R[1,2], Costabile D[2], Cuomo M[2,5], Chiariotti L[2,5], Carucci L[1,2], Agangi A[6], Napolitano M[6], Messina F[6], Passariello A[7], Berni Canani R[1,2]

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Comments: The Mediterranean diet (MD) is widely regarded as one of the healthiest dietary patterns, characterized by high intakes of fiber, antioxidants, polyphenols, essential vitamins, and a balanced ratio of essential fatty acids. It has been associated with numerous health benefits, including the prevention of excessive weight gain in adults and children [1, 2]. Increasing attention has been directed toward the role of maternal nutrition during pregnancy as a strategic target for preventing obesity and overweight in offspring, potentially through mechanisms related to fetal programming and epigenetic modulation of gene expression.

While prior observational studies, both prospective and retrospective, have reported inconsistent findings regarding the impact of MD during pregnancy on offspring adiposity, the present well-designed, parallel-arm randomized controlled trial (RCT) offers robust evidence. Specifically, adherence to an MD pattern during pregnancy was associated with a significantly lower risk of overweight or obesity in offspring at 2 years of age, compared to the control group. Notably, this protective effect occurred independently of maternal gestational weight gain, which did not differ between groups.

An important mechanistic insight from the study is the observed increase in DNA methylation at the promoter region of the *leptin* gene in cord blood mononuclear cells among the MD group. Given leptin's central role in appetite regulation, metabolism, and fat distribution, and its established association with neonatal adiposity [3], this epigenetic modification may suggest reduced gene expression and a potential pathway through which MD influences early growth trajectories. The findings are consistent with the hypothesis that epigenetic mechanisms mediate the long-term effects of maternal nutrition on offspring health [4]. A diet rich in plant-based foods, as characterized by the MD, has been shown to enhance maternal gut microbiome diversity, supporting the proliferation of microbial taxa and metabolites capable of influencing epigenetic regulation. This study contributes to a growing body of evidence indicating that maternal dietary patterns can exert lasting effects on offspring metabolic outcomes, potentially through epigenetic programming and early modulation of the infant gut microbiome and energy homeostasis pathways.

Among the strengths of this trial are its randomized controlled design and the adjustment for potential maternal confounders such as prepregnancy BMI, smoking status, and socioeconomic indicators, thereby enhancing the validity of causal inferences. However, several limitations must be acknowledged. The relatively small sample size ($n = 97$) may limit the generalizability of findings and statistical power for subgroup analyses. Dietary adherence was assessed through self-reported food frequency questionnaires, which are susceptible to recall and reporting biases. Additionally, the study did not account for postnatal environmental influences, such as infant feeding practices and physical activity, which could have impacted the observed outcomes. The epigenetic analyses were conducted on a limited number of samples ($n = 22$), and the study population was restricted to women of Caucasian ethnicity, thereby limiting external validity to more diverse populations.

Despite these limitations, the study provides compelling evidence in support of dietary counseling during pregnancy as a potential early-life intervention to prevent childhood obesity, a condition that remains difficult to reverse once established. Integrating structured MD guidance into routine prenatal care may offer a low-cost, low-risk public health strategy with long-term benefits.

Future research should aim to evaluate the persistence of these effects into later childhood and adolescence. Moreover, implementation studies are warranted to determine effective methods for delivering and maintaining dietary interventions across diverse populations and healthcare settings.

Effect of a high-protein and low-glycaemic index diet during pregnancy in women with overweight or obesity on offspring metabolic health – a randomized controlled trial

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Comments:

Prepregnancy overweight and excessive gestational weight gain (GWG) are well-established risk factors for maternal complications and increased susceptibility to obesity in the offspring [5].

Previous data showed that increased exposure to protein during fetal development may influence the future offspring protein requirements and appetite regulation with contribution to calorie overconsumption and weight gain [6]. Additionally, high-protein intake during infancy (from birth to 2 years) is associated with later obesity outcomes [7] suggesting a long-term risk for overweight and obesity in offspring with prolonged exposure to high-protein levels during early life.

The APPROACH (An Optimized Programming of Healthy Children) randomized controlled trial (RCT) previously demonstrated that, in pregnant women with overweight or obesity, adherence to a high-protein and low-glycemic-index (HPLGI) diet during the second and third trimesters resulted in reduced GWG and fewer maternal complications compared to a moderate-protein moderate-glycemic-index (MPMGI) diet. However, no significant differences were observed in offspring birth weight between the groups [8].

This RCT provides important insights into the influence of maternal dietary composition on early childhood metabolic health, specifically among offspring of women with overweight or obesity. While no significant differences were identified in BMI Z-scores, fat mass, fat-free mass, or body fat percentage between groups during the first 5 years of life, there was a tendency toward less favorable body composition and cardiometabolic profiles in the HPLGI group. Notably, offspring born to mothers in the HPLGI group exhibited higher glucose levels and a trend toward lower insulin levels at birth. At 3 years of age, these children had lower HDL cholesterol and elevated triglyceride levels. By 5 years, total cholesterol and LDL cholesterol concentrations were higher in the HPLGI group compared to the MPMGI group.

Key strengths of the study include its randomized controlled design, which minimizes selection bias and enhances causal inference. Additionally, the focus on women with overweight or obesity, populations at increased risk for adverse perinatal and intergenerational metabolic outcomes, adds clinical relevance and applicability to the findings. However, the study also presents several limitations. Dietary intake data during follow-up were limited, with no detailed information on offspring energy or macronutrient intake beyond breastfeeding and timing of solid food introduction. Self-reported maternal dietary intake introduces potential recall and social desirability bias. Attrition of approximately 30% during follow-up may have influenced outcome estimates. Furthermore, the lack of long-term follow-up beyond age 5 restricts conclusions regarding the persistence of observed metabolic trends. The generalizability of the findings is limited, as the study population consisted exclusively of women with overweight or obesity and may not reflect outcomes in women of normal weight or those from different cultural or socioeconomic backgrounds.

This study adds to the growing body of literature investigating the role of prenatal nutrition in shaping offspring metabolic trajectories. The findings raise important considerations regarding the potential unintended consequences of HPLGI dietary interventions during pregnancy on offspring metabolic health. Maternal protein intake may therefore help explain the effect of the HPLGI diet on offspring metabolic markers, which would imply that the recommendation for limited protein consumption from infancy to 2 years of age may need to be extended to cover the fetal life as well (i.e., pregnancy). These results underscore the need for caution in formulating maternal dietary guidelines and highlight the importance of further research, including long-term follow-up studies in diverse populations and mechanistic investigations, to validate these findings and inform public health policy.

Nutrition during Infancy and Risk of Childhood Obesity

Interaction between breastfeeding duration and an obesity genetic risk score to predict body fat composition in European adolescents: the HELENA study

Baxevanis GK[1,2], Iglesia I[2,3,4], Seral-Cortes M[2,3,5], Sabroso-Lasa S[6,7,8], Flores-Barrantes P[2,3], Gottrand F[9], Meirhaeghe A[10], Kafatos A[11], Widhalm K[12], Hockamp N[13], Molnár D[14], Marcos A[15], Nova E[15], González-Gross M[15,16], Gesteiro E[16], Gutiérrez Á[17], Manios Y[1,18], Anastasiou CA[1], Rodríguez G[2,3,4,19], Moreno LA[2,3,5] on behalf of the HELENA Study Group

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Comments: Breastfeeding has been associated with a reduced risk of overweight and obesity in children and adolescents [9]. The present study, based on data from the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) cohort, offers important insights into the interaction between early-life nutrition and genetic predisposition to obesity. Specifically, it investigates whether the duration of breastfeeding moderates the relationship between a polygenic obesity risk score and adolescent body fat composition.

In this cohort of European adolescents, a significant interaction effect was observed between breastfeeding duration and the polygenic obesity risk score on various body composition parameters, independent of socioeconomic status, diet quality, and physical activity. Specifically, longer breastfeeding duration appeared to attenuate the influence of genetic predisposition on obesity development.

These findings contribute meaningfully to the expanding field of gene, environment interaction research, which seeks to elucidate the sources of individual variation in susceptibility to obesity. Notably, in this study, the adolescents at high genetic risk who were breastfed for at least 1 month had lower mean adiposity indices compared to those who were never breastfed, indicating that breastfeeding may counteract genetic susceptibility to obesity.

Among the study's strengths is the inclusion of a large (n = 751), geographically diverse sample of European adolescents, enhancing the external validity and generalizability of the findings across various Western European populations. However, several limitations should be noted. The reliance on retrospectively reported breastfeeding data introduces potential recall bias. Moreover, the cross-sectional design limits the ability to draw causal inferences regarding the influence of breastfeeding on the developmental trajectory of genetic obesity risk. Despite statistical adjustments, residual confounding by unmeasured variables, such as maternal prepregnancy BMI, gestational weight gain, timing of complementary feeding, and the home food environment, cannot be ruled out.

Nonetheless, the study contributes valuable evidence to the hypothesis that modifiable early-life exposures, such as breastfeeding, may attenuate genetic risk for obesity. While the findings align with current public health recommendations promoting breastfeeding, further longitudinal studies are needed to replicate these results and elucidate the biological mechanisms underlying these interactions. The integration of genetic risk assessment with individualized early-life interventions may represent a promising approach in the development of personalized strategies for obesity prevention.

Fetal exposure to gestational diabetes severity and postnatal infant feeding in the first year of life associated with preadolescent obesity: a prospective cohort

Sun B[1], Lo JC[1,2,3], Greenspan LC[1,4], King AS[1], Davis JN[5], Faith MS[6], Wakimoto P[1], Josefson JL[7], Basi T[1], Quesenberry CP Jr[1], Hudson EA[5], Lowe W[7,8], Metzger B[7,8], Gunderson EP[1,3]

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Comments:

Children exposed to gestational diabetes mellitus (GDM) in utero face an elevated risk of developing obesity and metabolic disorders later in life [10]. Modifiable postnatal dietary factors, such as breastfeeding, formula feeding, and sugary beverage intake, may serve as important intervention targets to mitigate the effects of intrauterine GDM exposure [11]. This prospective cohort study provides meaningful insights into the interplay between GDM severity, early infant feeding practices, and the development of obesity during preadolescence. By jointly examining prenatal and postnatal influences, the study addresses a critical gap in life-course epidemiology – specifically, how intrauterine metabolic programming interacts with early-life behavioral exposures to shape long-term child health outcomes.

The findings of this study showed that inadequate (<6 months) or adequate breastfeeding combined with sugar-sweetened beverages (SSB)/fruit juice (FJ) intake from birth to age 1 year was associated with a 1.5- to 1.9-fold higher risk of developing obesity compared with adequate breastfeeding (≥6 months) with no SSB/FJ intake in preadolescent youth exposed to GDM in utero. These findings were independent of exposure to GDM severity (i.e., gestational age at diagnosis, treatment type, and maternal glycemic control under treatment) and covariates, including prepregnancy BMI, gestational weight gain, and sociodemographic factors.

Key strengths of this study include its prospective longitudinal design, which follows a well-characterized birth cohort from the prenatal period through preadolescence. This approach enhances the temporal validity of exposure-outcome relationships and minimizes recall bias. The study benefits from detailed characterization of maternal glycemic status, allowing for nuanced examination of GDM severity in relation to obesity risk. Additionally, the inclusion of comprehensive infant feeding data, such as breastfeeding duration and timing of solid food introduction, enables assessment of both potential modifying effects and independent contributions to obesity risk. Adjustment for a broad range of sociodemographic, maternal, and infant covariates further strengthens causal inference. Nevertheless, some limitations should be acknowledged. Residual confounding may persist due to unmeasured factors such as maternal dietary quality, physical activity, or paternal BMI, which could influence both GDM severity and child weight trajectories. Moreover, reliance on self-reported infant feeding practices introduces the possibility of recall bias.

In conclusion, this study makes an important contribution to the understanding of early-life determinants of childhood obesity by linking the severity of intrauterine hyperglycemia with postnatal feeding behaviors. The findings underscore the potential value of a dual-intervention approach that combines maternal glycemic control during pregnancy with promotion of optimal infant feeding practices to reduce the risk of childhood obesity. While methodologically robust and highly relevant, further research is warranted to elucidate underlying mechanisms and evaluate targeted interventions across diverse populations.

Efficacy of a 24-month behavioral intervention focused on sugary beverage reduction for Latino mother-infant dyads: evidence from a randomized controlled trial

Machle CJ[1,2], Berger PK[3], Salvy SJ[4], Rios C[1], Durazo-Arvizu R[5,6], Goran MI[1,6]

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Comments: Obesity and its associated comorbidities disproportionately impact minoritized racial and ethnic populations, as well as individuals from low-income households [12]. Interventions targeting young children often face challenges in achieving sustained parental engagement, and existing programs have demonstrated variable effectiveness. There is a pressing need for innovative strategies that not only improve maternal adherence but also foster healthy weight-related behaviors in both mothers and their children. The postpartum period represents a critical window of opportunity for the adoption of long-term healthy lifestyle behaviors, particularly when appropriate support systems are in place [13].

This randomized controlled trial (RCT) evaluates the long-term effectiveness of a culturally tailored, 24-month behavioral intervention aimed at reducing sugar-sweetened beverage (SSB) consumption among Latino mother-infant dyads. The study addresses a significant public health concern, especially in Latino communities, where early-life SSB intake is common and strongly linked to elevated risks of obesity and metabolic dysregulation in children.

Among the key strengths of the study is its culturally adapted intervention model, which integrates cultural relevance and community-based engagement, factors known to enhance participant adherence and long-term program sustainability. By targeting the mother-child dyad, rather than focusing solely on the child, the intervention acknowledges and leverages the influential role of mothers in shaping early dietary habits. The extended 24-month intervention period, combined with repeated follow-up assessments, enabled a comprehensive evaluation of behavioral changes during infancy and toddlerhood, periods that are particularly critical for obesity prevention. Furthermore, the study employed both 24-h dietary recalls and anthropometric measurements, offering a multidimensional assessment of behavioral and physiological outcomes. However,

several limitations warrant consideration. The intervention's focus on Latino families limits the generalizability of findings to other racial, ethnic, or socioeconomically diverse populations. Dietary intake assessments relied partly on maternal self-report, introducing potential for recall and social desirability biases. The absence of objective metabolic or biochemical markers (e.g., insulin sensitivity, lipid profiles) limits the capacity to draw conclusions regarding the intervention's impact on metabolic health. The study does not have a reliable measure of participant adherence to the intervention protocol beyond the measured consumption of free sugars from beverages at each time point. Additionally, the high-intensity nature of the intervention, characterized by frequent contact and home visits, may pose challenges for real-world implementation in resource-limited settings.

Despite these limitations, the study offers valuable insights into the potential of early, family-centered interventions to reduce SSB consumption in Latino populations. The findings demonstrate that a 2-year intervention targeting SSB and juice intake can lead to initial reductions in maternal consumption, particularly when supplemented by frequent contact and the provision of bottled water. However, reductions in SSB consumption were not sustained during the second year as the intensity of the intervention declined, and no significant changes were observed in weight or body composition outcomes. Future research is warranted to assess the broader applicability, biological impact, cost-effectiveness, and long-term sustainability of such interventions. Moreover, efforts to scale culturally responsive interventions must consider adaptation to diverse populations and real-world implementation constraints. This trial contributes meaningfully to the growing body of literature on early-life obesity prevention and highlights the critical role of culturally-tailored, family-focused strategies in addressing health disparities.

Exploring the association between human breast milk lipids and early adiposity rebound in children: a case-control study

Sawane K[1], Takahashi I[2], Ishikuro M[2,3], Takumi H[1], Orui M[2,3], Noda A[2,3,4], Shinoda G[2,3], Ohseto H[2], Onuma T[5], Ueno F[3], Murakami K[3], Higuchi N[1], Furuyashiki T[1], Nakamura T[6,7], Koshiba S[5,8], Ohneda K[8,9], Kumada K[8,9], Ogishima S[6,8], Hozawa A[3,10,11], Sugawara J[12], Kuriyama S[2,3,13], Obara T[2,3,4]

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Comments: Body mass index (BMI) is globally accepted as a main measure for defining obesity. Typically, BMI rises rapidly during the first year of life, then decreases to its lowest point around age 6, before rising again throughout childhood. This second increase is known as the adiposity rebound (AR). The timing of AR has been shown to predict the risk of obesity in adulthood [14]. Research, including several studies and meta-analyses, indicates that an early AR, occurring before age five, is linked not only to obesity but also to higher levels of triglycerides and cholesterol during adolescence and adulthood [14]. Therefore, AR serves as a valuable marker not only for childhood adiposity but also for future risks of obesity and metabolic diseases.

Breastfeeding has been identified as a protective factor against childhood adiposity and early AR, as reported in various cohort studies and meta-analyses. Breast milk contains many nutrients essential for child growth, with lipids playing a crucial role. However, the specific types of lipids involved in AR are not yet well understood. Comprehensive lipid analysis may help identify specific lipids connected to AR, which could aid in early detection and serve as targets for interventions to reduce disease risk later in life.

In a study by Sawane K. and colleagues, the authors performed a case-control study involving 184 mother-child pairs from the Tohoku Medical Megabank Project Birth and Three-Generation Cohort Study. In all mothers, breast milk samples were collected 1 month after birth, and a detailed lipid profiling, identifying 667 lipid molecules across 12 classes, was performed. The study found associations between certain lipid concentrations in breast milk and the child's AR status. Specifically, fatty acid-hydroxy fatty acid was positively linked to early AR in exclusively breastfed pairs, while cholesterol ester was negatively associated with early AR across all pairs and those exclusively breastfed.

A relevant strength of the study is the highly selected population included in the analysis. Particularly, authors did not include obese mothers, thus reducing confounding effects of maternal adiposity. However, some major limitations need to be evaluated, particularly the small sample size as well the use of breast milk samples precollected as a part of the biobank project. In addition, no information regarding the nutritional intake or dietary behaviors of both the mother and infant was available. Finally, breast milk was collected at 1 month only, thus the lack of longitudinally collected samples do not allow to properly characterize changes in lipid composition over the course of lactation and particularly their effect on AR.

These results offer new insights into how breastfeeding may influence childhood adiposity and the risk of metabolic disorders in adulthood. Further longitudinal research is needed to explore the long-term metabolic effects of these breast milk components during the growth of children and adolescents with overweight or obesity.

Adherence to the Mediterranean diet and changes in body mass index

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Comments: The Mediterranean diet (MedDiet) is widely recognized as one of the most balanced and health-promoting dietary patterns globally, characterized by a high intake of plant-based proteins, low-glycemic-index carbohydrates, monounsaturated fatty acids, dietary fiber, and antioxidants [15]. A better understanding of the effects of MedDiet-based interventions on anthropometric outcomes could support their integration into obesity prevention strategies targeting the pediatric population. A previous meta-analysis, which included all randomized controlled trials (RCTs) up to March 2023, demonstrated that MedDiet-based interventions led to modest but statistically significant reductions in BMI, as well as a notable decrease in obesity prevalence among children and adolescents when compared to control groups [16]. The current study examined the association between MedDiet adherence and longitudinal changes in BMI in a cohort of children aged 8–12 years. The findings indicated that higher adherence to the MedDiet at baseline was associated with a reduction in BMI Z-score at follow-up. However, this association lost statistical significance after adjusting for baseline BMI Z-score. Moreover, the magnitude of change in BMI Z-score (≤0.20 units) was not considered clinically meaningful. No significant association was observed between baseline MedDiet adherence and the incidence of excessive weight at follow-up.

Strengths of this study include its longitudinal design, which allows for stronger inferences regarding potential causal relationships between dietary patterns and BMI trajectories. The use of standardized MedDiet adherence scores enhances the consistency and reliability of dietary assessments. Additionally, the analyses accounted for several important confounding variables, including age, physical activity, and screen time, thereby improving the internal validity of the findings. However, several limitations should be acknowledged. The reliance on self-reported dietary intake data may introduce recall and social desirability bias. Furthermore, the use of BMI as an outcome measure limits the ability to distinguish between fat mass and

lean mass, which may mask relevant changes in body composition. The study sample, drawn exclusively from a Spanish population, may also limit the generalizability of the findings to more diverse or international pediatric populations.

Despite these limitations, the study contributes valuable evidence to the existing literature on the role of the MedDiet in pediatric health. The findings suggest that higher adherence to the MedDiet may be associated with more favorable BMI trajectories in children. Specifically, the consumption of vegetables, nuts, and dairy products was negatively associated with a high increase in BMI.

Future research employing objective dietary biomarkers and more precise measures of body composition is warranted to better elucidate the impact of the MedDiet on pediatric obesity prevention and management.

The modifying effects of lifestyle behaviors on the association between drinking water micronutrients and BMI status among children and adolescents aged 7~17: a population-based regional surveillance in 2022

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Comments: Dietary strategies aimed at preventing weight gain or promoting weight loss often recommend increasing water intake (for example, "drink at least eight glasses of water daily") alongside reducing calorie consumption and boosting physical activity. However, there is limited evidence about the relationship between regular monitoring of drinking water characteristics and BMI in children and adolescents, especially concerning micronutrients in drinking water.

Chen and colleagues conducted a large-scale regional and population-based study, analyzing data from over 170,000 children and adolescents aged 7–17 years and more than 5,000 drinking water samples. Their findings revealed associations between certain drinking water parameters, such as nitrate nitrogen, pH, total hardness, and chemical oxygen demand, and BMI or BMI Z-scores. Additionally, the study suggested that maintaining a healthy lifestyle can help reduce the negative impact of fluoride, chloride, and sulfate on BMI Z-scores.

Strengths of this study include the availability of a large population that allowed to employ a systematic and comprehensive assessment approach, coupled with highly accurate monitoring of common diseases and drinking water indicators, thus strongly supporting the validity of the results. In addition, reported data were further supported by a sensitivity analysis to verify the robustness of the results and better understand whether drinking water indicators may influence BMI in various demographic subgroups.

However, some important limitations mainly regarding the selection of the study population that was limited to students within a large regional surveillance system, which does not include children and adolescents outside the school system, might limit the extension of the results. In addition, in the study, no information regarding the amount or sources of their water consumption was available. More importantly, no records were available regarding the use of soft drinks utilized by the students, which might affect the fluoride and chloride intake.

Despite these limitations, this extensive surveillance provides valuable insights into the complex relationship between drinking water micronutrients and BMI in youth. The influence of different drinking water components on BMI varies, highlighting the importance of continued research, particularly among girls and urban populations. Water plays a crucial role in the body's structure, forming cells, tissues, and organs, and functions acting in nutrient hydrolysis, cell regulation, nutrient transport, and temperature balance. Overall, the study underscores the need to further investigate the effects of drinking quality water on growth, especially in urban settings, and emphasizes how healthy lifestyle behaviors can mitigate potential harmful effects. These findings could inform future improvements in drinking water standards and support targeted lifestyle interventions to promote better health among children and adolescents.

Cashew nut consumption reduces waist circumference and oxidative stress in adolescents with obesity: a randomized clinical trial

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Comments: Several multidimensional strategies have been proposed to prevent and manage overweight and obesity. Dietary guidelines primarily focus on reducing overall energy intake while improving diet quality. This improvement is often achieved by replacing unhealthy snacks consumed between main meals with nutrient-dense foods such as nuts – including walnuts, hazelnuts, almonds, pistachios, cashews, Brazil nuts, pecans, and pine nuts [17]. Nuts are rich sources of unsaturated fatty acids, plant-based proteins, dietary fibers, vitamins, minerals, and bioactive compounds such as plant sterols and antioxidants. Growing epidemiological evidence supports daily nut consumption as an effective strategy for the primary prevention of obesity [17].

Beyond prevention, emerging research also suggests that nuts may play a role in obesity treatment. Since diet is the main source of these nutrients, further studies are needed to evaluate their potential benefits in preventing and managing childhood obesity. However, to date, few studies have focused on the metabolic effects of nut consumption in children. In one such study, de Oliveira et al. conducted a 12-week randomized clinical trial involving 142 adolescents divided into four groups. Participants were randomly assigned to receive either 30 grams of roasted cashew nuts combined with nutrition education (cashew nut group, CNG) or nutrition education alone (control group, CG). The study's key findings indicated that nut consumption led to a reduction in waist circumference and significantly improved oxidative stress markers. These results support the potential of nut intake to reduce systemic oxidative stress associated with obesity.

The study design, particularly the RCT design of the study, represents one of the major strengths of this report. In addition, the groups evaluated in this study were homogeneous regarding energy intake, macronutrients, and TDAC, which further strengthens the evidence that the observed effects were indeed associated with the intervention.

Some major limitations of the study are related to the short intervention-period and the availability of surrogate markers of body composition. Particularly, data obtained by using the bioelectrical impedance analysis (BIA) method need to be validated with the gold standard dual-energy X-ray absorptiometry (DXA) method. More importantly, authors reported a high rate of absenteeism during the first week of data collection and dropouts throughout the follow-up period, and thus new studies are needed to confirm the reported results.

While the exact role of nuts in obesity prevention and treatment is not fully understood, several mechanisms have been proposed to explain their benefits. These include incomplete energy absorption from nuts, increased feeling of fullness, and hunger regulation due to their high fiber content and prebiotic effects on gut microbiota [8]. Specifically, cashew nuts have been studied for their ability to modulate chronic and acute inflammatory and oxidative processes. Given their nutrient composition, incorporating nuts into a healthy diet may help control inflammation and oxidative stress in children and adolescents with obesity – a condition characterized by chronic low-grade inflammation [18,19].

Nutrition transition's latest stage: are ultra-processed food increases in low- and middle-income countries dooming our preschoolers' diets and future health?

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Comments: Over recent decades, global eating patterns have dramatically changed due to multiple influences such as sociocultural shifts, industrialization, technological progress, and the globalization of food production [20, 21]. In numerous countries, a distinct nutritional transition is evident, marked by the substitution of traditional and freshly cooked meals

with a rising consumption of highly processed products, known as ultra-processed foods (UPFs) [20, 21]. UPFs undergo extensive physical, chemical, or biological alterations from their original form, frequently including additives such as preservatives, flavorings, nutrients, and other approved food substances [20, 21]. These foods contain ingredients and additives rarely used in home cooking, aimed at enhancing taste, shelf life, and convenience. While their composition and examples differ by region, all share the trait of extensive processing. Designed for immediate consumption with minimal preparation, UPFs provide long shelf life, quick and easy preparation, and appealing taste, which make them competitive alternatives to whole or freshly prepared foods. However, nutritionally, they tend to be high in saturated fats, sugars, and sodium, and are calorie-dense but poor in essential nutrients, protein, fibers, and micronutrients [20, 21]. A large number of researches have linked UPF consumption to adverse health effects. Numerous cross-sectional and cohort studies have demonstrated that high intake of UPFs significantly contributes to the rise of noncommunicable diseases (NCDs), including obesity, type 2 diabetes, dyslipidaemia, and hypertension [22]. Alarmingly, Popkin and colleagues reported particularly concerning trends in low- and middle-income countries. Their findings show increased rates of overweight and obesity among women of reproductive age and children, with a greater impact observed in lower socioeconomic groups. Moreover, these countries have experienced rapid growth in sales of UPFs and sugary beverages, alongside early introduction of sugar-sweetened beverages (SSBs) to infants and young children. There has also been a significant rise in the purchase of infant and toddler foods, with ultra-processed products making up a large portion of toddlers' diets (aged 6–23 months) and maternal diets. These findings are cause for serious concern and, if confirmed by further research, demand urgent global intervention. Strong food policy measures are essential to mitigate these adverse effects.

Nutrition and Risk of Obesity-Related Comorbidities

Association between calcium intake from different food sources during childhood and cardiometabolic risk on adolescence: the Generation XXI birth cohort

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Comments: Evidence from pooled analysis of cross-sectional studies suggested an inverse association between total dairy consumption and obesity [23]. However, the relationship between dietary calcium intake and body mass measures in children remains inconclusive, with previous studies yielding mixed results. Notably, one

large-scale European cohort study reported that dietary calcium intake may influence body fat accumulation during developmental stages, with the association primarily driven by calcium derived from dairy sources, whereas no significant effects were observed for calcium from non-dairy sources [24]. The present study examines the longitudinal association between childhood calcium intake from various food sources and cardiometabolic risk in adolescence, utilizing data from the Generation XXI birth cohort – a large, well-established prospective study based in Portugal. The primary objective was to investigate the potential influence of total dietary calcium, and particularly calcium from dairy versus non-dairy sources, on later cardiometabolic outcomes, including obesity, blood pressure, lipid profile, and insulin resistance.

Overall, the results of this study support that total calcium intake has a protective effect on BMI, waist circumference, and diastolic blood pressure at 13 years of age, but is dependent on total energy intake. However, a protective effect on cardiometabolic risk was observed for calcium from vegetables, even after adjustment for energy intake.

A key strength of this study lies in its longitudinal design, which enables the assessment of temporal relationships between early dietary exposures and later health outcomes. The use of a large, population-based birth cohort enhances the robustness and generalizability of the findings within the Portuguese context. Dietary calcium intake was estimated using validated dietary assessment tools, and the analysis differentiated between specific food sources (e.g., milk, yogurt, cheese, and nondairy items), offering nuanced insights into their respective roles in shaping cardiometabolic health trajectories. The analyses were rigorously adjusted for a comprehensive set of sociodemographic, perinatal, and lifestyle factors.

Nonetheless, several limitations warrant consideration. The reliance on dietary recalls introduces the possibility of recall bias and misreporting. Despite extensive covariate adjustment, residual confounding – such as unmeasured parental dietary patterns or genetic predisposition to metabolic conditions – may still affect the results. Moreover, given that the cohort is based in Portugal, where dietary behaviors, calcium fortification policies, and food availability may differ from other contexts, caution is needed when generalizing the findings to other populations.

Overall, this study contributes meaningful evidence to the field of pediatric nutrition by underscoring that the health effects of calcium intake may differ according to food source. The findings support the notion that the food matrix and co-ingested nutrients influence cardiometabolic risk beyond the effects of calcium alone. Future research, including interventional trials and studies utilizing objective biomarkers, is warranted to confirm these findings and guide the development of dietary recommendations for early cardiometabolic risk reduction.

Dietary lipid profile in Spanish children with overweight or obesity: a longitudinal study on the impact of children's eating behavior and sedentary habits

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Comments: Childhood obesity has become a critical global health concern. In 2022, it was estimated that more than 390 million children and adolescents aged 5–19 were overweight or obese, along with 37 million children under the age of 5. Projections suggest that this trend will continue to worsen. If current patterns persist, by 2050, an additional 3.33 million children aged 5–14, 3.41 million adolescents aged 15–24, and 41.4 million adults aged 25 and older will be overweight or obese. The total number of affected children and adolescents could reach 43.1 million, and adults may reach 213 million by that time. Alarmingly, in most US states, one in three adolescents aged 15–24 is expected to have obesity by 2050 [25].

Obesity during childhood and adolescence may affect not only mental health, social interactions, and physical abilities (such as participation in sports and sleep quality), but can also lead to serious health conditions before adulthood. The growing prevalence poses both immediate health challenges and long-term consequences. In the United States, obesity has also determined a dramatic increase of several cardiovascular risk factors, such as dyslipidemia and hypertension, over the past 3 decades. In addition, type 2 diabetes rates have nearly doubled in the last 20 years. Childhood and adolescent obesity is rarely resolved naturally and is a strong predictor of adult obesity, making early intervention critical.

Monitoring overweight and obesity prevalence at the population level is essential for predicting future disease burden and implementing effective prevention strategies. Addressing this public health crisis requires a deep understanding of the factors contributing to obesity and related metabolic disorders. Sedentary behaviors, especially screen time and lack of physical activity, are now widely recognized as major risk factors for poor metabolic health in children. Diet is equally important. Eating behaviors are shaped by both intrinsic and extrinsic influences, including appetite regulation, food preferences, and environmental cues. These behaviors affect food selection, portion sizes, and overall dietary patterns, which in turn influence children's nutritional status and health outcomes.

Emerging research has emphasized the need to better understand how specific eating behaviors impact diet quality, energy balance, and nutrient intake. However, the connection between eating behaviors and dietary fat intake is still not well explored.

In the study by Silvia García et al., authors evaluated data obtained in a longitudinal randomized controlled trial conducted over 9 months, involving 90 children aged 2–6 years with overweight or obesity. Particularly, the results of this study have shown that reductions in screen-time-related sedentary habits are associated with a lower intake

of total fat and saturated fat. Conversely, increases in screen-time-related sedentary habits correlate with higher consumption of these dietary fats. This increased fat intake has been linked to a specific eating behavior in children, namely the "Desire to Drink", an understanding of which can help to manage children's eating and sedentary behaviors to improve their diets and, consequently, their overall health.

The major strengths of this study are the longitudinal design, which allows a possible cause-effect relationship between children's eating behaviors, screen time, and dietary lipid profiles, and the study's sample size and the inclusion of children from diverse backgrounds strengthen its generalizability and relevance to different populations. In addition, in the present study, authors evaluated a comprehensive assessment of dietary intake, including the measurement of essential fatty acids, which contributes to a more detailed understanding of children's lipid profile and overall nutritional status. Finally, the use of an established tool, such as the child eating behavior questionnaire, allowed for a comprehensive assessment of children's eating behaviors.

Despite these strengths, there are some limitations, particularly related to the self-reported data for certain behaviors, which may introduce biases related to recall accuracy or social desirability, as well as the lack of information regarding other factors, such as physical activity levels, sleep patterns, genetic background, or family environment, that could also be determinants of dietary habits in young children.

Childhood obesity is a multifactorial issue driven by energy imbalance and influenced by a complex interplay of biological, environmental, and socioeconomic factors. Children need varied and balanced diets not only to prevent obesity but also to establish healthy lifelong eating habits. Numerous determinants shape eating behaviors, ranging from physiological traits (e.g., satiety signals, taste sensitivity), psychological characteristics (e.g., emotional state, food preferences), and food literacy, to broader environmental and systemic factors, like food environments and supply chains.

Several theoretical models have outlined the diverse influences on food choices, which vary by age group and differ between children and adults [26]. A complete understanding of these determinants and their impact on metabolic outcomes is essential. Both academic research [27] and international organizations, such as the WHO [28], emphasize the importance of adopting a systems-thinking approach to improve children's diets and reduce the burden of obesity.

Skipping breakfast and nutrient density: influence on obesity, blood pressure, glucose, and cholesterol in elementary school students

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Comments: Healthy eating plays a vital role in preventing both malnutrition and non-communicable diseases. Modern dietary patterns, often high in refined carbohydrates, sugars, and trans fats, have significantly contributed to the increasing

prevalence of childhood obesity [28]. Overconsumption of energy-dense, nutrient-poor foods further worsens this issue. Across Europe, dietary habits vary considerably. For instance, WHO surveillance data shows lower consumption of savory snacks in Northern Europe, while vegetable intake is particularly low in Western Asia, especially among boys [28]. These differences are shaped by a complex mix of socioeconomic, cultural, and environmental factors, such as food accessibility, cultural traditions, and national dietary guidelines. The modern concept of a healthy diet emphasizes balanced macronutrient intake, along with increased consumption of fruits, vegetables, whole grains, legumes, and nuts, while reducing intake of salt, sugar, saturated fats, and highly processed foods. Traditional dietary models, like the Mediterranean diet, offer beneficial frameworks that support long-term health.

One dietary behavior of particular concern is breakfast skipping, which has been associated with an increased risk of overweight and obesity in children. A recent meta-analysis highlighted this trend across different regions, including Western, Asian, and Pacific populations, suggesting a protective role of regular breakfast consumption in maintaining healthy weight among children and adolescents [29]. Although the association between breakfast skipping and cardiometabolic risk is well-documented, the mechanisms remain poorly understood. Moreover, studies examining this association from the perspective of nutrient patterns are limited.

In the study by Mun et al., authors attempted to evaluate the possible associations between breakfast skipping, obesity, and cardiometabolic risk in elementary school students and identify its association with nutritional patterns. Interestingly, by evaluating data on 3,590 elementary school students obtained from the Korea National Health and Nutrition Examination Survey (2013–2020), authors were able to show that elementary school students who skipped breakfast had more frequently obesity and cardiometabolic risk factors. Of note, these associations might be assumed from dietary nutrient patterns characterized by higher fat and sodium density despite lower daily caloric consumption.

The major strength of this study is the use of the nationally representative KNHANES data, which allow a comprehensive analysis of all the possible associations of breakfast frequency with obesity parameters, cardiometabolic risk factors, and nutrient density in elementary school students.

Some limitations, however, need to be highlighted, particularly regarding the cross-sectional study design and the 24-h recall method, that might affect the associations reported. In addition, this study was conducted on a South Korean population. Further evaluation is required to determine whether these findings can be generalized to other ethnic groups.

Although there are some limitations, these data add relevant information on the hypothesized mechanisms linking skipping breakfast habits with obesity and overweight. In fact, the mechanisms linking breakfast skipping with obesity are complex. It is hypothesized that regular breakfast consumption improves metabolic function, enhances insulin sensitivity, and promotes better satiety, particularly when the meal is high in fiber. Skipping breakfast, on the other hand, may lead to increased total energy intake later in the day and reduced physical activity, both of which contribute to weight gain. There is also evidence that breakfast skipping disrupts circadian regulation of metabolism. It has been linked to impaired insulin secretion after meals, delayed insulin peaks, and reduced levels of insulin and C-peptide. Additionally, levels of GLP-1, a hormone that supports insulin secretion, are significantly lower when breakfast is skipped, while glucagon and free fatty acids are elevated. This disruption impairs glucose homeostasis and contributes to metabolic dysregulation throughout the day [30]. Moreover, skipping breakfast has

been associated with reduced expression of key clock genes, such as Per1, Cry1, Ror, Sirt1, and Clock, which are essential for regulating circadian hormone secretion and postprandial glycemia [30]. Other research has linked breakfast skipping to overactivity of the hypothalamic-pituitary-adrenal (HPA) axis and disrupted cortisol rhythms, further emphasizing its systemic effects on metabolic health [31]. Understanding these mechanisms is crucial for developing effective nutritional strategies to combat childhood obesity and support lifelong metabolic health.

Effect of Indo-Mediterranean diet versus calorie-restricted diet in children with non-alcoholic fatty liver disease: a pilot randomized control trial

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Comments: Increased body fat in children and adolescents with overweight and obesity is a key factor linked to the risk of developing nonalcoholic fatty liver disease (NAFLD). This condition affects approximately 4%–11% of all children, with a higher prevalence among those who are overweight or obese. Specifically, NAFLD's global prevalence reaches nearly 45% in specialized child obesity clinics and about 34% in the general population of overweight or obese youths aged 1–19 years, regardless of the diagnostic methods used. Besides obesity, other factors, such as genetic predisposition, epigenetic influences, gut microbiota, eating habits, and sedentary lifestyles, also contribute to the risk of NAFLD. Consequently, NAFLD has become one of the most common chronic liver diseases in both adults and children over recent years. Its rapid increase worldwide highlights the urgent need for new research focused on effectively counteracting this growing health issue.

In the study by Deshmukh et al., researchers investigated whether an Indo-Mediterranean diet is more effective than a standard caloric-restricted diet in treating NAFLD among overweight Indian children and adolescents with biopsy-confirmed disease. The study found that both diets improved various anthropometric, clinical, imaging, and biochemical parameters. However, the Indo-Mediterranean diet showed greater benefits in reducing controlled attenuation parameter (CAP) values and body weight/BMI over 180 days in these patients.

The main strength of this study is the opportunity to have patients with liver biopsy-proven NAFLD. On the other side, the single center design and shorter period of follow-up (6 months) represent the main limitations. However, these encouraging results warrant further research into dietary treatments across different stages of NAFLD. NAFLD represents a spectrum of liver damage that ranges from simple steatosis, characterized by triglyceride accumulation in more than 5% of liver cells or fat fraction above 5.6%, as measured by proton magnetic resonance spectroscopy (HMRS), to more advanced stages involving inflammation and fibrosis known as nonalcoholic steatohepatitis (NASH). Without treatment, the disease can progress to severe liver conditions such as cirrhosis and hepatocellular carcinoma (HCC), although recent evidence suggests that HCC can also develop in fatty liver without cirrhosis [32]. Given that many prenatal and postnatal factors influence

the development of NAFLD, a deeper understanding of its molecular mechanisms is essential. The goal is to design comprehensive strategies, including optimal dietary interventions, to alter the disease's progression and reduce related cardiovascular and metabolic complications. Although no definitive treatment currently exists, several drugs show promise in modifying liver steatosis, inflammation, and fibrosis. Nonetheless, more research is urgently needed, especially in pediatric populations, to identify the best multifactorial approaches for managing this significant condition in children and adolescents.

Conflict of Interest Statement

The authors report no conflict of interest.

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Author Contributions

Both authors have read and commented on the reviewed manuscripts.

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