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Adequate Zinc Intake Is Associated with a Lower Risk of Childhood Obesity: Findings From NHANES 2017-2018

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Abstract

Background: *Childhood obesity is an escalating global health concern, with nutrient intake emerging as an important modifiable factor. Zinc plays a key role in the metabolic and inflammatory pathways; however, its relationship with childhood obesity remains underexplored. This study investigated the association between zinc intake and obesity in U.S. children aged 2–18 years.*

Methods: *A secondary analysis was conducted using data from the National Health and Nutrition Examination Survey (NHANES) 2017–2018. The variables were analyzed using logistic regression to estimate odds ratios and 95% confidence intervals for the association between childhood obesity and dietary zinc intake. Children were categorized as "obese" or "non-obese" based on age- and sex-adjusted BMI percentiles. Zinc intake was categorized as "adequate" or "inadequate" based on the recommended daily intake according to age and sex. Confounding variables, including race/ethnicity, dietary fiber, fat, and protein intake, comorbidities, and the poverty-to-income ratio, were controlled for in the adjusted model.*

Results: *Among 2,704 children (mean age 9.63 $\pm$ 4.84 years), 16.8% were classified as obese. In the unadjusted analyses, adequate zinc intake was not significantly associated with obesity (OR = 0.73; 95% CI: 0.41–1.29; $p = 0.285$). However, after adjustment for confounders, adequate zinc intake was significantly associated with reduced odds of obesity (OR = 0.50; 95% CI: 0.26–0.97; $p = 0.042$). Higher income and certain racial/ethnic groups were also protective, whereas higher fat and protein intake and comorbidities were associated with increased obesity risk.*

Conclusion: *Adequate dietary zinc intake is independently associated with lower odds of obesity in U.S. children. These findings support further exploration of zinc's role in obesity prevention strategies and underscore the importance of addressing micronutrient deficiencies in pediatric populations.*

Introduction

Childhood obesity has emerged as a major global health challenge, with its prevalence increasing significantly over the past 30 years (Lee & Yoon, 2018; Franks et al., 2010; Ng et al., 2014). In the United States, approximately 19.7% of children and adolescents are classified as obese (Centers for Disease Control and Prevention, 2022). This alarming prevalence has significant implications, as it predisposes children to chronic diseases such as cardiovascular disorders, type 2 diabetes, and mental health issues that often persist into adulthood (World Health Organization, 2024; Huang & McCall, 2013). The origins of obesity are multifaceted, encompassing ge-

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netic, behavioral, and environmental factors, yet dietary elements, particularly micronutrient deficiencies, have emerged as crucial areas of study (Ogden et al., 2015; Ward et al., 2021). Among these, zinc has attracted research attention due to its roles in regulating metabolic and inflammatory processes associated with obesity (Verma et al., 2023; Wang & Lobstein, 2006).

Zinc plays a pivotal role in immune function, hormone regulation, and energy metabolism, all of which are integral to weight management (Gunanti et al., 2016; Shankar & Prasad, 1998). Low dietary zinc levels are correlated with increased fat accumulation, metabolic dysfunction, and reduced insulin sensitivity, which may contribute to obesity risk (Franco & Canzoniero, 2024; Gunanti et al., 2016). A study by Wang et al. (2023) found that higher zinc intake was significantly associated with reduced odds of childhood obesity [OR = 0.70, 95% CI: (0.54, 0.92), $P < 0.05$]. Beyond metabolic effects, zinc's influence on appetite regulation highlights its potential relevance in obesity prevention (Bakirhan, 2023). However, there is limited understanding of the biological mechanisms through which zinc influences obesity, and gaps remain in its understanding, as well as its interactions with other risk factors (NHANES, 2022; Ward et al., 2021).

Using data from the 2017-2018 National Health and Nutrition Examination Survey (NHANES), this study examined whether adequate dietary zinc intake is associated with reduced odds of childhood obesity. The insights gained from this study can inform public health policies aimed at reducing obesity rates and improving long-term health outcomes among children.

Materials and Methods

This cross-sectional secondary analysis utilized data from the NHANES 2017–2018 dataset, which provides detailed health, nutritional, and demographic data on a representative sample of the U.S. population (NHANES, 2017–2018). Participants included children aged 2–18 years with available data on BMI, zinc dietary intake, race/ethnicity, total fiber intake, total fat intake, total protein intake, presence of comorbidities, and poverty-to-income ratio (PIR). Children with missing data for these variables were not accounted for in the analyses and were considered to be missing at random.

Variables and Measurements

Obesity was defined using the CDC's age- and sex-specific BMI-for-age percentiles, which provided six BMI categories. Children with BMI values at or above the 95th percentile were classified as "obese," and those below the 95th percentile as "non-obese." The primary independent variable was dietary zinc intake, categorized as "adequate" or "inadequate" based on the recommended daily intake according to age and sex (National Institutes of Health, 2022). Zinc adequacy varied by age and sex, with thresholds set as 3 mg/day for ages 1–3, 5 mg/day for ages 4–8, and 8 mg/day for ages 9–13; for adolescents aged 14–18, the threshold was 11 mg for males and 9 mg for females.

Covariates

To account for potential confounding factors, variables such as race/ethnicity, total daily fat intake (grams), dietary fiber intake (grams), protein intake (grams), comorbidities, and the PIR were included. Race/ethnicity was categorized into five categories: Mexican American, other Hispanic, non-Hispanic white, non-Hispanic black, and other races (Weng et al., 2024). The poverty-to-income ratio (PIR) was categorized into low (PIR ≤ 1), middle (PIR > 1 to < 4), and high-income levels (PIR ≥ 4), to estimate and adjust for socioeconomic disparities and their association with dietary intake and obesity (Fryar et al., 2016). Since the literature provided evidence for Asthma as a significant covariate in this model (Abdollahi, 2019; Cheng, 2024), we evaluated the collinearity variance inflation factor (VIF) vs. "at least one comorbidity", which provided an unacceptable level of collinearity. We incorporated "At least one comorbidity", which was categorized as binary: "no comorbidities" / "at least one comorbidity", given its relevance to obesity through more than one metabolism pathway (Abdollahi, 2019).

Data Collection

The NHANES dietary intake data were obtained through 24-hour recall interviews. The BMI and other body measurements were collected by trained personnel using the Mobile Examination Center (MEC) and by trained health technicians (National Health and Nutrition Examination Survey, 2017). Additional demographic and socioeconomic information was collected through household interviews (Centers for Disease Control and Prevention, 2022). Dietary data captured recent intake levels of zinc, supplemented with NHANES laboratory data when available (NHANES, 2017-2018).

Statistical Analysis

Continuous data were summarized using mean and

	Obesity		
	Not obese	Obese	Total
N	2,251 (83.2%)	453 (16.8%)	2,704 (100.0%)
Gender			
Male	1,117 (49.6%)	224 (49.4%)	1,341 (49.6%)
Female	1,134 (50.4%)	229 (50.6%)	1,363 (50.4%)
Age at Screening	9.241 (4.877)	11.543 (4.149)	9.626 (4.839)
Race			
Mexican American	364 (16.2%)	101 (22.3%)	465 (17.2%)
Other Hispanic	162 (7.2%)	42 (9.3%)	204 (7.5%)
Non-Hispanic White	716 (31.8%)	126 (27.8%)	842 (31.1%)
Non-Hispanic Black	509 (22.6%)	119 (26.3%)	628 (23.2%)
Other Race - Including Multi-Racial	500 (22.2%)	65 (14.3%)	565 (20.9%)
Dietary Fiber (gm)	1.469 (1.928)	1.836 (2.576)	1.534 (2.061)
Total fat (gm)	6.346 (10.517)	8.197 (13.537)	6.673 (11.130)
Protein (gm)	5.538 (8.293)	7.436 (11.249)	5.874 (8.915)
At Least One Comorbidity			
No	1,902 (84.5%)	362 (79.9%)	2,264 (83.7%)
Yes	349 (15.5%)	91 (20.1%)	440 (16.3%)
Ratio of Income to Poverty			
Low-income level	562 (27.7%)	123 (31.1%)	685 (28.3%)
Middle-income level	1,063 (52.5%)	236 (59.7%)	1,299 (53.7%)
High-income level	401 (19.8%)	36 (9.1%)	437 (18.1%)
Zinc intake			
Not adequate	1,750 (95.2%)	381 (96.5%)	2,131 (95.4%)
Adequate	88 (4.8%)	14 (3.5%)	102 (4.6%)

Table 1: *Demographics and clinical characteristics.*

standard deviation (SD), and categorical data were described using frequency and proportion. Because this was a secondary data analysis, statistical power calculations were not conducted before the study, and the sample size was determined solely from the existing data. Statistical analyses were performed using STATA Statistics and Data Science (version 18.5, Copyright 1985–2023, StataCorp LLC, College Station, TX, USA). A two-tailed p-value < 0.05 was used to indicate statistical significance.

Logistic regression was used to assess the association between dietary zinc intake and childhood obesity status. Obesity was modeled as a binary outcome (obese = 1, non-obese = 0) using the egen mica function available in STATA and ZAnthro anthropometric curves (CDC). Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. Regression analysis was conducted in two models: unadjusted and adjusted models, accounting for the aforementioned covariates. VIFs were also examined to rule out multicollinearity among predictors. A high VIF for an independent variable suggests a strong collinear relationship with other variables, which should be addressed or considered when structuring the model and selecting independent variables. Missing data were considered to be randomly missing and were not accounted for in the analyses.

Ethical Considerations

Since the NHANES data are publicly available and de-identified, institutional review board (IRB) approval was not required. This study adheres to ethical guidelines for secondary data analysis, as outlined by the National Center for Health Statistics (NCHS) (National Center for Health Statistics, 2022).

Results

Sample characteristics

The baseline characteristics of the patients are summarized in Table 1. Of the 9,254 respondents who completed the survey, 2,704 were children (individuals aged 2 to 18 years old) with a mean age of 9.63 years (SD= 4.84). Among them, 1,363 (50.4%) were females and 1,341 (49.6%) were males. The cohort included children of diverse racial and ethnic backgrounds, with 31.1% being non-Hispanic white, 23.2% non-Hispanic black, 20.9% other race, 17.2% Mexican American, and 7.5% other Hispanic. Obesity was observed in 16.8% of the children. Zinc intake values were collected from 2,223 individuals, with 95.4% having inadequate intake based on the NIH-recommended values for age and sex.

Unadjusted models

The univariable logistic regressions evaluated the independent associations of single factors, such as race/ethnicity, dietary fiber, total fat, protein intake, at least one comorbidity, income level, and zinc intake, with obesity. Results indicated that zinc adequacy had no significant effect on childhood obesity in the univariate model (OR = 0.73; 95% CI: [0.41–1.29]; $p = 0.285$). In addition, dietary fiber intake (OR = 1.08; 95% CI: [1.03–1.13]; $p = 0.002$), total fat (OR = 1.01; 95% CI: [1.01–1.02]; $p = 0.003$), protein intake (OR = 1.02; 95% CI: [1.01–1.03]; $p = 0.000$) and having at least one comorbidity (OR = 1.37; 95% CI: [1.06–1.77]; $p = 0.016$) had higher significant odds of obesity. Higher income levels were significantly associated with lower odds of being obese (OR = 0.4; 95% CI: [0.28–0.61]; $p = 0.000$) (Table 2). These findings highlight the importance of adjusting for confounders in multivariate analyses to uncover more accurate associations than in univariate models.

Adjusted models

The multivariate logistic regression accounted for the aforementioned potential confounders, revealing a more nuanced picture. For instance, zinc adequacy was significantly associated with reduced odds of obesity (OR = 0.50, $p = 0.042$) when adjusted for other variables. Additionally, the confounders in the model revealed that high-income status significantly lowered the odds of obesity (OR = 0.45; 95% CI: [0.29–0.69]; $p < 0.001$), and certain racial categories also showed protective effects when analyzed along the other variables (Figure 1). VIF results as part of the analysis confirm that multicollinearity is not an issue with the current variable. Considering that the VIF for the variables was less than 5, we conclude that the variables included were not highly correlated.

Discussion

This study examined the relationship between zinc intake and childhood obesity in a diverse sample of children aged 2–18 years using NHANES 2017–2018 data. Our findings revealed that children with adequate zinc intake had significantly lower odds of being obese compared to those with inadequate intake, even after adjusting for confounders such as socioeconomic status (SES), dietary factors, and comorbidities. These results underscore the potential importance of zinc as a modifiable dietary factor for addressing childhood obesity.

The prevalence of zinc inadequacy in our cohort (95.4%) is alarming, reflecting broader nutritional deficiencies in pediatric populations. Zinc's critical roles in growth, metabolism, and immune function may explain its association with obesity (Shankar & Prasad, 1998; Gunanti et al., 2016). It is hypothesized that zinc deficiency contributes to metabolic dysregulation and fat accumulation, which are key features of obesity (Franco & Canzoniero, 2024; Wang et al., 2023). However, the biological mechanisms linking zinc and obesity warrant further investigation in longitudinal studies (Wang & Lobstein, 2006).

Our findings are consistent with prior research demonstrating the protective role of zinc against obesity. For instance, a cross-sectional analysis of NHANES data by Wang et al. (2023) found that higher zinc intake was significantly associated with reduced odds of obesity (OR = 0.70, 95% CI: [0.54–0.92]). Similarly, Gunanti et al. (2016) observed that zinc supplementation improved body composition and reduced adiposity among children in a systematic review. These studies support the notion that zinc plays a regulatory role in metabolic and inflammatory processes and may mitigate obesity risks. However, some studies have reported mixed results, possibly due to variations in study populations, methodologies, or confounding factors. For example, Hartono et al. (2021) found that the impact of zinc supplementation on obesity outcomes varied according to dietary habits and baseline zinc levels. Despite these differences, the consistency of findings regarding the association between zinc adequacy and obesity reduction highlights its potential relevance in nutritional interventions.

In our adjusted model, the confounder of higher SES was associated with significantly reduced odds of obesity (OR = 0.45; 95% CI: [0.29–0.69]; $p < 0.001$), a finding consistent with existing literature highlighting the role of SES in shaping access to nutritious foods (NHANES, 2022; Franks et al., 2010). Similarly, race and ethnicity were significant in the multivariable model, with certain groups demonstrating lower odds of obesity, potentially reflecting complex interactions between cultural dietary practices, SES, and genetic predispositions (Huang & McCall, 2013). However, as SES and race were included as confounders to control for their influence on the primary variable of interest, zinc adequacy, these relationships should be interpreted as exploratory rather than independent associations. Further research is necessary to validate these patterns and develop culturally tailored interventions to address such disparities (Weng

Variable	Obesity Unadjusted Analysis n=2,233		
	OR	**95% CI**	**P**
Zinc*	0.73	[0.41–1.29]	0.285
Race/ethnicity			
Other Hispanic	0.93	[0.62-1.4]	0.74
Non-HispanicWhite	0.63	[0.47-0.85]	**0.002**
Non-Hispanic Black	0.84	[0.63-1.13]	0.26
Other race	0.47	[0.33-0.66]	**0**
Dietary fiber (g)	1.08	[1.03-1.13]	**0.002**
Total fat (g)	1.01	[1.01-1.02]	**0.003**
Protein (g)	1.02	[1.01-1.03]	**0**
At least one comorbidity	1.37	[1.06-1.77]	**0.02**
Income			
Middle-income	1.01	[0.8-1.3]	0.9
High-income	0.41	[0.28-0.61]	**0**

Abbreviations: OR, odds ratio; CI, confidence interval; P, p-value; g, grams. *Zinc was classified as a binary variable according to recommended consumption for age and sex.

Table 2: *Unadjusted analysis for obesity and zinc.*

Variable	Obesity Adjusted Analysis n = 2,223		
	OR	**95% CI**	**P**
Zinc*	0.5	[0.26–0.97]	**0.04**
Race/ethnicity			
Other Hispanic	0.85	[0.50-1.45]	0.554
Non-hispanic White	0.67	[0.48-0.93]	**0.016**
Non-hispanic Black	0.91	[0.64-1.28]	0.582
Other Race	0.61	[0.41-0.90]	**0.014**
Dietary fiber (g)	1.05	[1.00–1.12]	0.072
Total fat (g)	1	[0.98–1.01]	0.603
Protein (g)	1.02	[1.00-1.04]	0.66
At least one comorbidity	1.22	[0.91-1.64]	0.19
Income			
Middle-income	0.98	[0.76–1.28]	0.899
High-income	0.45	[0.29–0.69]	**0**

Abbreviations: OR, odds ratio; CI, confidence interval; P, p-value; g, grams. *Zinc was classified as a binary variable according to recommended consumption for age and sex.

Table 3: *Adjusted analysis for obesity and zinc.*

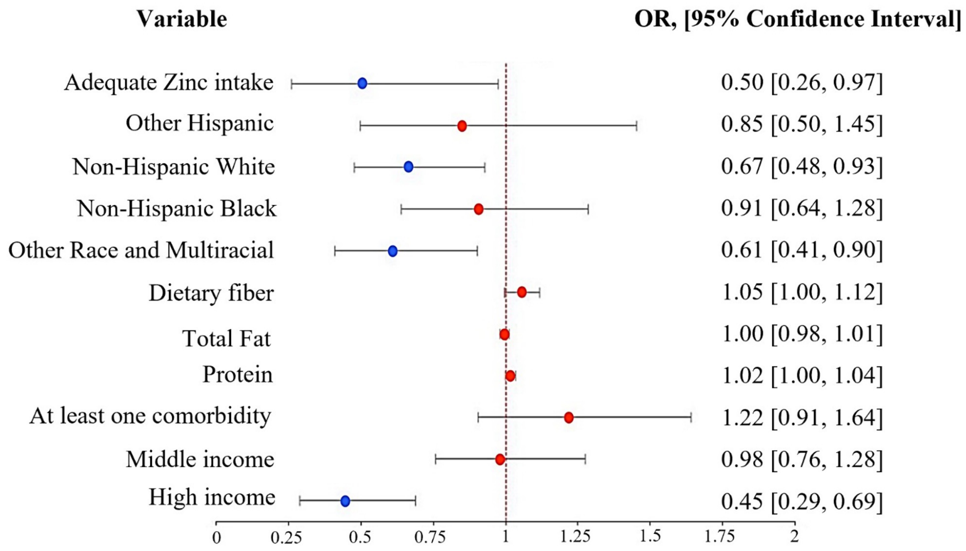

Figure 1: *Zinc intake and risk of obesity in children. P-values are represented by circles within each confidence interval bracket. Statistically significant p-values (p=< 0.05) in blue circles, Nonsignificant in red. CI: confidence intervals; OR: odds ratio.*

et al., 2024).

Conclusion

Our findings suggest that adequate zinc intake is associated with reduced odds of childhood obesity, highlighting its potential role in nutritional interventions. These results emphasize the need for further research to understand the mechanisms linking micronutrient intake and obesity. Policymakers and healthcare providers should consider zinc adequacy as part of comprehensive strategies to combat childhood obesity, particularly in populations with high zinc deficiency prevalence.

Limitations

This study has several limitations. First, the cross-sectional study design precludes causal inferences between zinc intake and obesity. Longitudinal studies are needed to confirm the temporal relationships and elucidate the underlying mechanisms (Wang & Lobstein, 2006; Ng et al., 2014). Second, reliance on 24-h dietary recall data introduces potential recall bias and measurement error. Future studies should consider incorporating biomarkers of zinc status for more accurate assessments (Gunanti et al., 2016).

Additionally, although our analysis adjusted for key confounders, residual confounding from unmeasured factors (e.g., physical activity levels) could not be ruled out. The exclusion of children with missing data may also introduce selection bias, which limits the generalizability of our findings. The NHANES dataset reflects the U.S. population and may not capture global variations in dietary patterns and obesity prevalence (CDC, 2022).

Despite these limitations, our study provides valuable insights into the association between zinc intake and childhood obesity. Public health initiatives targeting zinc adequacy through dietary recommendations or supplementation could play a role in obesity prevention. However, such strategies should be integrated with broader efforts to address the socioeconomic and cultural determinants of health (Ogden et al., 2015).

Supplementary Materials

STATA code

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Conflicts of Interest

The authors declare no conflict of interest.

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