

ORIGINAL ARTICLE

Sex-Specific Dietary Patterns and Early Nutritional Management of Attention Deficit Hyperactivity Disorder among Children in Amman, Jordan

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ABSTRACT

Background: Attention deficit hyperactivity disorder (ADHD) is a common neurodevelopmental disorder affected by multiple determinants, including nutrition. Dietary patterns may increase ADHD symptom severity, yet this relationship is still underexplored in Amman, Jordan. The current paper examined Jordanian children's dietary habits with and without ADHD, concentrating on specific trends in relation to sex and the potential protective role of early nutrition.

Methods: A case control design was utilized to achieve the study objectives. The sample was consisted of 67 ADHD-diagnosed children and 171 non-diagnosed children aged 6-12 years old. A validated food frequency questionnaire (FFQ) was used to collect and analyze dietary data, along with ADHD assessment of symptom scores via the Conners scale. Linear regression and Chi-square tests were used for statistical analysis.

Results: Compared with non-diagnosed peers, males with ADHD consumed significantly more sugary drinks ($p=0.008$) and fast food ($p=0.008$). However, the findings demonstrated no significant differences among females. There was also a correlation between processed meat intake and higher ADHD symptom scores among both sexes ($p=0.007$). The results also revealed a relationship between breastfeeding and reduced ADHD severity among males ($p=0.024$). Conversely, there was no relationship between breastfeeding and reduced ADHD severity among females.

Conclusion: ADHD management, especially among males, can be complemented by dietary interventions concentrating on nutrient-dense foods and decreasing processed food intake. These results emphasize the importance of sex-specific approaches and early nutritional strategies in mitigating ADHD symptoms.

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Introduction

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder that has garnered increased attention because of its possible long-term effects (1). The disorder is characterized by several symptoms, such as impulsiveness, self-regulation challenges, inattention, and hyperactivity that can significantly affect the life of a child (2) ADHD may develop with various repercussions in adulthood if left untreated (3). The occurrence of ADHD has increased globally, with 7.6% of cases having ADHD (2). A Jordanian study reported a 27.7% rate of prevalence, which exceeds international numbers (4). Using a parent-completed screening assessment, the study revealed a potential overestimation relative to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) diagnostic instrument. ADHD can have various causes, with several factors aiding its symptoms. Current treatments include behavioral therapies and pharmacological interventions; but concerns about the long-term negative effects of medication have prompted researchers to investigate safer alternatives, such as dietary approaches (4, 5).

The association of ADHD with nutritional quality is increasing with increasing evidences and researches. A research has indicated that psychiatric disorders, i.e., ADHD, are affected by nutrients that are vital for cognitive function (5). Discrepancies in the kynurenine pathway that manage the metabolism of the amino acid tryptophan are associated with ADHD risk (6). Numerous studies from several countries have indicated that some dietary patterns high in fats, sugar, and processed foods can increase ADHD symptoms. However, diets rich in fruits, vegetables, and lean proteins may provide preventive benefits (6, 7). Deficiencies in zinc, magnesium, and vitamin D are also related to ADHD symptoms, as supplementing these nutrients points to the potential to enhance behavioral symptoms (7, 8).

Furthermore, a research has shown that high intake of artificial colors and certain food additives may increase hyperactivity among children. A diet rich in necessary fatty acids, such as omega-3, is associated with increased neurotransmitter activity, possibly decreasing ADHD symptoms (9). The traditional “Western” diet, described by reduced omega-3 and high omega-6 fatty acids (10, 11), may increase ADHD symptoms due to this discrepancy (12). Moreover, studies on ADHD related to low birth weight, maternal stress, inadequate early nutrition, and environmental pollutants have made attempts of nutritional therapies as a potential method to relieve symptoms. For example, a “few-food” diet decreased ADHD symptoms in 63% of 79 male

participants in a trial (1). Increasing micronutrient consumption and reducing the consumption of inflammatory foods through leafy greens and fruits may help reduce behavioral problems (13-15). The relationship between diet and ADHD highlights the importance of much more future research, chiefly in new countries such as Jordan, where the disorder is widespread; but ineffectually investigated with respect to dietary influences. So this study was undertaken to determine the sex-specific dietary patterns and early nutritional management of attention deficit hyperactivity disorder among children in Amman, Jordan.

Materials and Methods

The methodology was a case-control study using the DSM-5 criteria as the gold standard for identifying ADHD in clinical settings and to validate ADHD diagnoses in the case group. The Conners scale, a fixed instrument used to measure ADHD-related behaviors, was utilized to evaluate the severity of symptoms, and highlight an unbiased comparison between the non-diagnosed control group and the ADHD-diagnosed group. With employment of a Conners scale cutoff score of ≤ 15 , the absence of ADHD symptoms was established by screening the children in the control group to guarantee the participants in the control group not to show any behavior alongside with ADHD and also to enhance the internal validity of the study. All procedures were in accordance with the ethical standards of the University of Jordan. This study applied the anonymized data, and an informed consent was not applicable.

The sample was consisted of 67 ADHD-diagnosed children and 171 non-diagnosed children aged 6-12 years. To ensure a representative sample, the study selected participants belonged to various settings, together with clinics, schools, and health centers in Amman, Jordan. To validate ADHD diagnoses in the case group, the Conners scale as a standardized instrument for assessing ADHD-related behaviors was used to determine the severity of symptoms. This approach allowed an unbiased comparison between the non-diagnosed control group and the ADHD-diagnosed group. A Conners scale cutoff score of ≤ 15 was applied to confirm the absence of ADHD symptoms in the control group, ensuring that these participants displayed no behaviors associated with ADHD, thereby strengthening the study's internal validity. Children in the case group were between 6 and 12 years old and had a confirmed ADHD diagnosis. Those receiving ADHD medication or with other diagnosed psychological disorders were excluded. The control group also comprised children

aged 6-12 years, but without any ADHD symptoms. Children in the control group were excluded if they scored above 15 on the Conners scale or had any diagnosed psychological disorder.

A structured online questionnaire was distributed among clinics, schools, and health centers to collate data, as the questionnaire had four key sections of (i) Consent form was taken from guardians or parents to safeguard the ethical commitment. (ii) Demographic information included variables such as sex, age, rank between siblings, and family background. (iii) Conners scale was adopted to assess ADHD symptoms and confirm group categories. (iv) Food frequency questionnaire (FFQ) was developed from validated dietary assessments to concentrate on foods possibly affecting ADHD symptoms, together with processed snacks, fast food, sugary drinks, vegetables, fruits, and dairy products.

Nutrition experts validated the FFQ by checking its face validity to ensure that the questionnaire precisely addressed the pertinent dietary data. The questionnaire's content validity was also checked to ensure that it broadly evaluated the scope of dietary factors related to ADHD in the past researches. To ensure that the questionnaire was clear, precise, and reliable, a pilot test was conducted on 5% of the targeted research population. The Statistical Package for Social Sciences (SPSS software, Version 25, Chicago, IL, USA) was used to process and analyze the data statistically. Descriptive statistics were used to review dietary and demographic variables for the targeted groups. Chi-square tests were utilized to evaluate relationships between categorical dietary factors, i.e., fast food and sugary drinks, and ADHD status, stratified by sex. Different statistical models were employed to determine the direction and strength of relationships between dietary patterns and the severity of ADHD symptoms. Accordingly, p values ≤ 0.05 were considered statistically significant, mainly considering trends in dietary behaviors among the sexes. The research proposal was submitted by Dr. Hadeel Ali Ghazzawi from the School of Agriculture and was authorized by the Institutional Review Board (IRB) at The University of Jordan (The IRB at the University of Jordan decision no.: 139/2023).

Results

The findings demonstrated significant sex-specific trends in dietary habits and their relationship with ADHD symptoms. These trends accentuated the differential effects of specific dietary factors on both ADHD-diagnosed sexes. ADHD-diagnosed males and daily intake of sugary drinks were more common among those diagnosed with ADHD

than among their non-diagnosed peers (45.2% vs. 20.3%); while infrequent or no intake was less common (19.0% vs. 43.8%). Males consumed significantly more sugary drinks than their non-diagnosed counterparts ($p=0.008$). In contrast, the pattern among females did not show a statistically significant difference ($p=0.561$). Daily consumption was reported by 52.0% of females with ADHD when compared with 40.2% of those without; whereas infrequent or no intake was reported by 24.0% and 29.9%, respectively.

Frequent fast-food consumption was significantly associated with ADHD symptoms in males ($p=0.008$), while consuming fast food more regularly. On the other hand, the findings indicated no significant relationship between ADHD diagnosis and fast-food consumption among females ($p=0.445$). Practices regarding breastfeeding had also sex associations. Compared with non-diagnosed males, males had lower breastfeeding rates among ADHD-diagnosed males (59.5% vs. 79.7%; $p=0.024$). Breastfeeding appeared to be considerably less in the ADHD group; whereas 79.7 percent of males who were not diagnosed with ADHD were breastfeeding. On the contrary, among females, breastfeeding rates were not significantly different between the diagnosed and non-diagnosed groups ($p=0.554$). It was shown that ADHD-diagnosed males were significantly more likely to consume sugary drinks and fast food frequently than their non-diagnosed counterparts. Breastfeeding may have a protective effect on males, with higher rates related to the decreased prevalence of ADHD. The results demonstrated the significance of sex-specific dietary interventions, with a focus on decreasing fast-food consumption and sugary drinks, chiefly among males with ADHD.

Discussion

Dietary pattern can play a crucial role to maintain health status of an individual, while an excessive ingredient or a deficient one can lead to an imbalance and a disease or disorder (16-18). Our findings demonstrated the relationships between ADHD symptoms and dietary patterns among 6-12 years old children in Amman, Jordan. The results highlighted the closely detailed relationship between ADHD symptomatology and nutrition that illustrated the effects of fast food, sugary drinks, and breastfeeding among males and females. These findings are contextualized within the current literature (6, 13). The findings revealed the significant consumption of sugary drinks among ADHD diagnosed males than their non-diagnosed counterparts. The result is in line with past studies suggesting that high intake of sugar can increase inattention and hyperactivity,

probably due to its effect on dopamine regulation and blood glucose levels (6, 13). However, the findings did not indicate to any significant difference among females that signifies sex differences in susceptibility to dietary triggers.

A past research showed that hormonal and genetic factors may modulate the role of sugar in ADHD symptomatology (7). For example, males may face more pronounced behavioral responses to changing glucose level, elucidating the stronger relationships that were found in this study. The few significant results among females may demonstrate hormonal buffering differences or the effects on dietary patterns that were not captured by the FFQ. The results also revealed a significant relationship between frequent fast-food consumption and ADHD symptoms among males. Additionally, high levels of refined carbohydrates, trans fats, and artificial additives in fast foods play key roles in deteriorating behavioral and cognitive outcomes in children (8). These elements, accordingly, may increase oxidative stress and neuroinflammation, as they are related to ADHD pathophysiology.

Notably, the lack of a significant relationship in females may mirror sex differences in dietary compensation or metabolic responses. For example, fast food consumption may offset healthier dietary desires among females, such as higher intakes of fruits or vegetables that can decrease adverse effects. However, in Jordan, sociocultural factors may affect dietary habits differently among males and females, which is a hypothesis that requires new future qualitative researches. Moreover, the findings demonstrated a significant relationship between lower breastfeeding rates and ADHD among males; but not among females. This finding is consistent with the hypothesis that early-life nutrition plays a key role in development of the nervous system, as breast milk delivers vital nutrients such as immunoglobulins and omega-3 fatty acids, which are sources of support for behavior and cognitive regulation (13, 14).

Furthermore, the results indicated the protective effect of breastfeeding to impact stress regulation and early brain development. It was shown that breastfed children had a decreased risk of neurodevelopmental disorders and enhanced executive function, primarily among males, where early-life stressors may have more pronounced impacts (6). The absence of significance among females in our study could reflect developmental pathways or differing hormones, highlighting the necessity for sex-specific research into the long-term effects of breastfeeding.

This article highlighted significant perceptions of the associations between ADHD symptoms and

dietary patterns in children. However, this study had certain limitations. The cross-sectional case–control design limited the ability to create causal associations between ADHD symptoms and dietary habits. Longitudinal studies are necessary to determine whether specific dietary patterns increase in the development or exacerbation of ADHD symptoms or whether these patterns are a result of preexisting behavioral traits related to the disorder. Depending on self-reported dietary data can provide possible inconsistencies, as FFQs are subject to social desirability effects and recall bias. Caregivers or parents may inadvertently misrepresent the quantity or frequency of certain foods, especially unhealthy foods, leading to misclassification of dietary patterns and relationships with ADHD symptoms.

Although the sample size is appropriate for identifying significant trends, it may not completely embody the presence of ADHD across the wider population of children and the variety of dietary behaviors in Jordan. Increasing the sample size together with various participant groups in future research can enhance the generalizability of the findings. Furthermore, this study concentrated on diverse dietary groups, such as fast food and sugary drinks, without a thorough analysis of food components or specific nutrients. However, micronutrients such as zinc, magnesium, and omega-3 fatty acids, which are known to affect behavioral and cognitive health (19, 20), were not directly evaluated, leaving a novel critical venue for analysis. Other possible confounding factors, i.e., screen time, physical activity level, socioeconomic status, and sleep quality, were not considered in this study. These variables can be interrelated with dietary patterns and self-sufficiently affect ADHD symptoms, possibly confusing the observed relationships. Additionally, although sex-specific dietary trends were identified in this study, the causal mechanisms driving these differences are still unexplored. Genetic, hormonal, or cultural factors play a significant role in moderating the relationship between ADHD symptoms and diet, and further investigations and analyses are needed. Importantly, analyzing breastfeeding as a protective factor provides valuable perceptions.

However, it does not include variations in breastfeeding duration, maternal diet during lactation, or exclusivity, as they could affect its long-term impacts on neurodevelopment. These distinctions are necessary to understand the protective role of breastfeeding more expansively. More importantly, considering these limitations in future studies and research can reinforce the evidence concerning the role of diet in managing ADHD. Longitudinal studies

integrating objective measures of dietary intake, considering broader environmental factors, and biochemical evaluations of nutrient levels are essential to corroborate and develop upon the study findings.

Conclusion

Our findings validated the critical role of nutrition in managing ADHD and revealed a high consumption of fast food and sugary drinks among males with ADHD. However, these relationships were not observed among females, indicating the role of sex in mediating the effects of diet on ADHD symptoms. In addition, breastfeeding had a protective effect on males, highlighting the importance of early-life nutrition in reducing long-term neurodevelopmental risk. Dietary changes were shown to contribute to improvement of emotional stability, cognitive function, and overall quality of life among ADHD-diagnosed children. The protective role of breastfeeding underlines the importance of encouraging early-life nutritional interventions. Our findings highlighted the importance of using all-inclusive approaches to manage ADHD and incorporating dietary modifications, along with pharmacological and behavioral therapies. Exploring dietary factors, chiefly in sex-specific contexts, can help families and clinicians empower ADHD-diagnosed children to achieve symptom control and better-quality well-being.

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Authors' Contribution

T.A adapted the questionnaire from an earlier version, carried out the research and data collection, developed the methodology, and prepared the initial draft of the manuscript with subsequent revisions. H.J contributed to the conceptual framework of the study and provided guidance and oversight throughout the process. H.A conducted statistical analyses and interpreted the results. H.G supervised the project, supported conceptual development, coordinated resources, managed data handling and validation, and revised the manuscript critically for important intellectual content. All authors reviewed and approved the final manuscript.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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