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# Evaluating the Effects of Increased Fruits and Vegetables Consumption on Child Health Outcomes: An Open-Label, Unblinded, Prospective Randomized Controlled Trial

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**KEYWORDS**

Children, Dietary interventions, Fruits, Vegetables, Growth, Development, Cognition, Immunity, India

**ABSTRACT:**

Background: Adequate intake of fruits and vegetables, rich in essential nutrients and bioactive compounds, is associated with improved growth, immune function, and cognitive development.

Objectives: To evaluate the effects of increased fruits and vegetables consumption on child health outcomes.

Methods: This was an open label, unblinded, prospective randomized controlled trial conducted by the Department of Paediatrics, Saveetha Medical College and Hospital, Chennai, Tamil Nadu, India between January 2023 and June 2024. Group A (n=50, intervention arm) involved children with increased fruits and vegetables consumption (includes provision of fresh fruits and vegetables, nutrition education sessions, and guidance on meal planning); and Group B (n=50, control arm) involved children with no changes in diet (children will follow their usual dietary habits).

Results: The study compared growth, immune function, and cognitive development outcomes between an intervention group and a control group over six months. The intervention group showed significant improvements in height, weight, and BMI compared to the control group, with height increasing from 100 cm to 106 cm and weight from 15.0 kg to 18.0 kg. The control group's height and weight increased to only 102 cm and 16.0 kg, respectively. Immune function also improved in the intervention group, with infections decreasing from 5.1 to 2.0 and absenteeism from 10.2 to 3.2 days, while leukocyte count and lymphocyte percentage increased. The control group saw lesser reductions in infections and absenteeism. In cognitive development, the intervention group had significant increases in VIQ, PIQ, and FSIQ, with VIQ rising from 90.2 to 100.0, compared to smaller gains in the control group. The results indicate the intervention's positive impact on growth, immune function, and cognitive development.

Conclusion: The findings provide compelling evidence that dietary interventions emphasizing higher intake of fruits and vegetables significantly improve multiple facets of child health.

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## Introduction

Childhood nutrition plays a critical role in shaping health outcomes and developmental trajectories.(1) Adequate intake of fruits and vegetables, rich in essential nutrients and bioactive compounds, is associated with numerous health benefits, including improved growth, immune function, and cognitive development.(2,3) Despite these benefits, many children worldwide fail to meet recommended dietary guidelines for fruit and vegetable consumption, potentially compromising their health and well-being.(4) This study investigates the impact of increased consumption of fruits and vegetables on child health outcomes, focusing on growth parameters, immune function, and cognitive development. The rationale for this research stems from the nutritional significance of fruits and vegetables in providing essential vitamins, minerals, fiber, and antioxidants necessary for optimal physical and cognitive development during childhood.(5)

Fruits and vegetables are integral components of a balanced diet due to their nutrient density and health-promoting properties.(5–7) They contribute essential vitamins such as vitamin C, which supports immune function, and vitamin A in the form of beta-carotene, crucial for vision and immune health.(8) Moreover, the dietary fiber found in fruits and vegetables supports digestive health and may mitigate the risk of chronic diseases later in life. Studies have consistently demonstrated associations between higher fruit and vegetable intake and improved health outcomes in children. For instance, diets rich in these foods have been linked to reduced incidence of infections, decreased obesity rates, and enhanced cognitive performance.(9,10) Such findings underscore the potential of dietary interventions to mitigate health disparities and promote optimal growth and development in pediatric populations. Against this background, the aim of the present study was to evaluate the effects of increased fruits and vegetables consumption on child health outcomes.

## Materials and Methods

This was an open label, unblinded, prospective randomized controlled trial conducted by the Department of Paediatrics, Saveetha Medical College and Hospital, Chennai, Tamil Nadu, India between January 2023 and June 2024. The study was approved by the Institutional Ethics Committee. Children were enrolled after an informed written assent form was obtained from either their parents and/or their guardian's. All children presenting to the pediatric clinics, schools, and community centers within the target population were enrolled, provided they were between three and ten years of age without known medical conditions that may affect their growth, immune function, and/or cognitive development. However, children were excluded if an assent could not be obtained from their parents and/or their guardians.

Based on power analysis, the minimum estimated sample size was computed to be 50 children per group to detect meaningful differences in health outcomes – Group A (n=50, intervention arm), children with increased fruits and vegetables consumption (includes provision of fresh fruits and vegetables, nutrition education sessions, and guidance on meal planning); Group B (n=50, control arm), children with no changes in diet (children will follow their usual dietary habits). The children were randomly assigned to the intervention arm or the control arm using random number tables. At baseline, dietary assessment included use of validated tools including food frequency questionnaires or 24-hour dietary recalls method.(11) The outcomes were measured at three months and six months following the start of intervention. The outcomes of the present study included growth parameters namely height, weight, body mass index at baseline, three months, and six months; immune function including incidence of infections, frequency of illness-related absenteeism from school, and levels of immune cells (e.g., leukocytes, lymphocytes) at baseline, three months, and six months; and cognitive development using The Wechsler Preschool and Primary Scale of Intelligence, Third Edition (WPPSI-III) at baseline, three months, and six months.(12)

The Wechsler Preschool and Primary Scale of Intelligence, Third Edition (WPPSI-III), is an individually administered intelligence test designed for children. It measures various aspects of cognitive functioning through a series of subtests and provides a comprehensive assessment of a child's intellectual abilities. The test is divided into two age groups, with different subtests tailored to the developmental levels of younger and older children. The WPPSI-III includes a variety of subtests such as Information, Vocabulary, Block Design, Matrix Reasoning, and Coding, which

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assess different cognitive domains including verbal comprehension, perceptual reasoning, working memory, and processing speed.(13) The test provides several composite scores, including Verbal IQ (VIQ), Performance IQ (PIQ), Full Scale IQ (FSIQ), and a General Language Composite (GLC) for the younger age group. These scores offer a comprehensive view of a child's intellectual functioning.(14) With strong reliability and validity, the WPPSI-III ensures consistent and accurate measurement of cognitive abilities, supported by reliability coefficients typically ranging from 0.80 to 0.90 and validity through correlations with other established intelligence tests. The administration time varies from 30 to 70 minutes depending on the child's age and the specific subtests used. Scores are standardized based on age norms, allowing for comparison with peers, and the test is normed on a representative sample of U.S. children to reflect the general population's performance.(15,16)

The data collected was manually entered into Microsoft Excel and analyzed using Stata v17. Descriptive statistics were employed to summarize the baseline characteristics of participants. Appropriate statistical tests, such as t-tests and chi-square tests, were utilized to conduct comparisons between the intervention and control groups. Longitudinal analysis techniques, including repeated measures ANOVA, were applied to evaluate changes in health outcomes over time.

**Results**

In the present study comparing growth outcomes between an intervention group and a control group over six months, the following results were observed: for height, the intervention group started with an average height of 100 cm (SD 2.3), which increased to 103 cm (SD 1.8) at three months and 106 cm (SD 0.5) at six months. The control group began with the same baseline height of 100 cm (SD 1.9) and grew to 101 cm (SD 1.0) at three months and 102 cm (SD 1.0) at six months. The difference in height growth between the groups was statistically significant with a P value of 0.031. In terms of weight, the intervention group's average weight was 15.0 kg (SD 3.0) at baseline, increasing to 16.5 kg (SD 2.1) at three months and 18.0 kg (SD 0.9) at six months. The control group's weight changed from 15.0 kg (SD 2.6) at baseline to 15.5 kg (SD 1.0) at three months and 16.0 kg (SD 0.8) at six months. The weight differences were statistically significant, with a P value of 0.025. For BMI, the intervention group had an average baseline BMI of 15.0 kg/m² (SD 0.9), which increased to 15.6 kg/m² (SD 0.5) at three months and 16.1 kg/m² (SD 0.7) at six months. The control group's BMI was 14.9 kg/m² (SD 0.7) at baseline, increasing to 15.1 kg/m² (SD 0.4) at three months and 15.3 kg/m² (SD 0.6) at six months. The differences in BMI between the two groups were also statistically significant, with a P value of 0.039. These findings suggest that the intervention had a significant positive impact on growth outcomes, including height, weight, and BMI, compared to the control group over the six-month period.

Table 1: Comparison of study groups, by growth outcomes

| **Growth outcomes** | | **Baseline** | **3 months** | **6 months** | **P value** |
|---|---|---|---|---|---|
| Height (in cm) | Intervention | 100 (2.3) | 103 (1.8) | 106 (0.5) | 0.031* |
| | Control | 100 (1.9) | 101 (1.0) | 102 (1.0) | |
| Weight (in kg) | Intervention | 15.0 (3.0) | 16.5 (2.1) | 18.0 (0.9) | 0.025* |
| | Control | 15.0 (2.6) | 15.5 (1.0) | 16.0 (0.8) | |
| BMI (in $kg/m^2$) | Intervention | 15.0 (0.9) | 15.6 (0.5) | 16.1 (0.7) | 0.039* |
| | Control | 14.9 (0.7) | 15.1 (0.4) | 15.3 (0.6) | |

*Statistically significant at $p<0.05$

BMI, Body mass index

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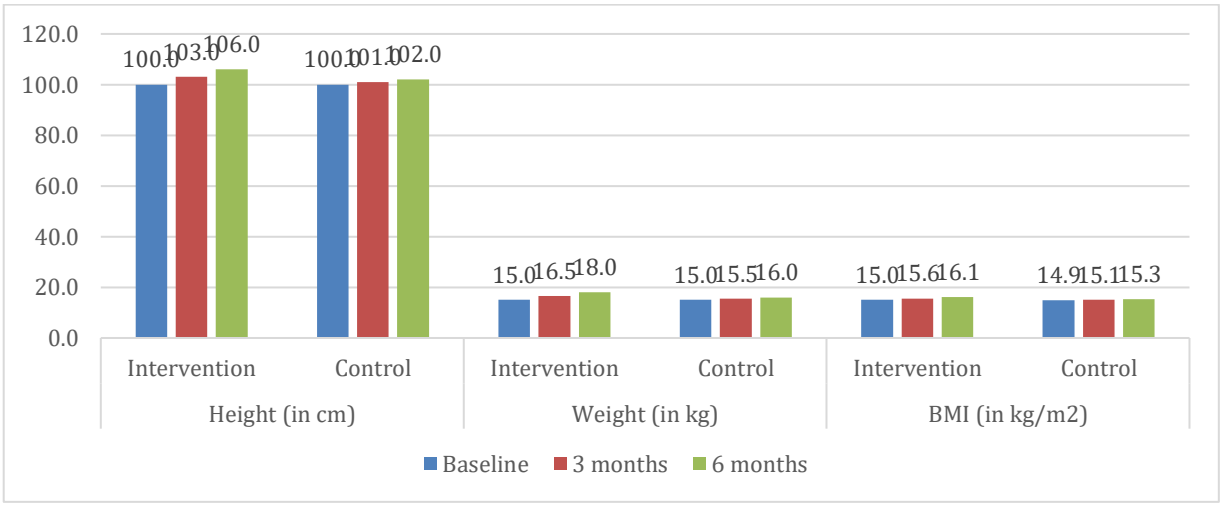


Figure 1: Comparison of study groups, by growth outcomes

In the present study examining immune function outcomes between an intervention group and a control group over six months, the following results were observed: for the incidence of infections, the intervention group started with an average of 5.1 infections (SD 2.1) at baseline, which decreased to 3.0 infections (SD 1.1) at three months and further to 2 infections (SD 1.9) at six months. The control group began with an average of 5.1 infections (SD 1.7), which decreased to 4.2 infections (SD 2.0) at three months and 4.1 infections (SD 2.0) at six months. The reduction in infection incidence was statistically significant with a P value of 0.004. Regarding illness-related absenteeism, the intervention group had an average of 10.2 days (SD 3.2) at baseline, which decreased to 6.1 days (SD 2.6) at three months and further to 3.2 days (SD 1.1) at six months. The control group started with an average of 10.3 days (SD 3.1) at baseline, which decreased to 8.1 days (SD 2.2) at three months and 7 days (SD 3.1) at six months. The differences in absenteeism were statistically significant, with a P value of 0.003. For leukocyte counts, the intervention group had an average count of 6.0 x10⁹/L (SD 2.1) at baseline, which increased to 6.5 x10⁹/L (SD 2.0) at three months and 7.0 x10⁹/L (SD 2.0) at six months. The control group's leukocyte count remained relatively stable, starting at 6.1 x10⁹/L (SD 2.0), staying the same at three months, and slightly increasing to 6.2 x10⁹/L (SD 2.3) at six months. The difference was statistically significant with a P value of 0.042. In terms of lymphocyte percentage, the intervention group had an average of 30.1% (SD 4.2) at baseline, which increased to 32.3% (SD 5.1) at three months and 34.1% (SD 4.9) at six months. The control group had an average of 30.3% (SD 5.1) at baseline, increasing slightly to 31.1% (SD 4.1) at three months and 31.9% (SD 3.8) at six months. The difference in lymphocyte percentage was statistically significant, with a P value of 0.011. These findings indicate that the intervention significantly improved immune function outcomes, including a reduction in the incidence of infections and illness-related absenteeism, as well as increases in leukocyte counts and lymphocyte percentages, compared to the control group over the six-month period.

Table 2: Comparison of study groups, by immune function

| **Immune function** | | **Baseline** | **3 months** | **6 months** | **P value** |
|---|---|---|---|---|---|
| Incidence of infections | Intervention | 5.1 (2.1) | 3.0 (1.1) | 2 (1.9) | 0.004* |
| | Control | 5.1 (1.7) | 4.2 (2.0) | 4.1 (2.0) | |

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|---|---|---|---|---|---|
| Illness-Related Absenteeism (days) | Intervention | 10.2 (3.2) | 6.1 (2.6) | 3.2 (1.1) | 0.003* |
| | Control | 10.3 (3.1) | 8.1 (2.2) | 7 (3.1) | |
| Leukocytes ($x10^9$/L) | Intervention | 6.0 (2.1) | 6.5 (2.0) | 7.0 (2.0) | 0.042* |
| | Control | 6.1 (2.0) | 6.1 (2.4) | 6.2 (2.3) | |
| Lymphocytes (%) | Intervention | 30.1 (4.2) | 32.3 (5.1) | 34.1 (4.9) | 0.011* |
| | Control | 30.3 (5.1) | 31.1 (4.1) | 31.9 (3.8) | |
| *Statistically significant at p<0.05 | | | | | |

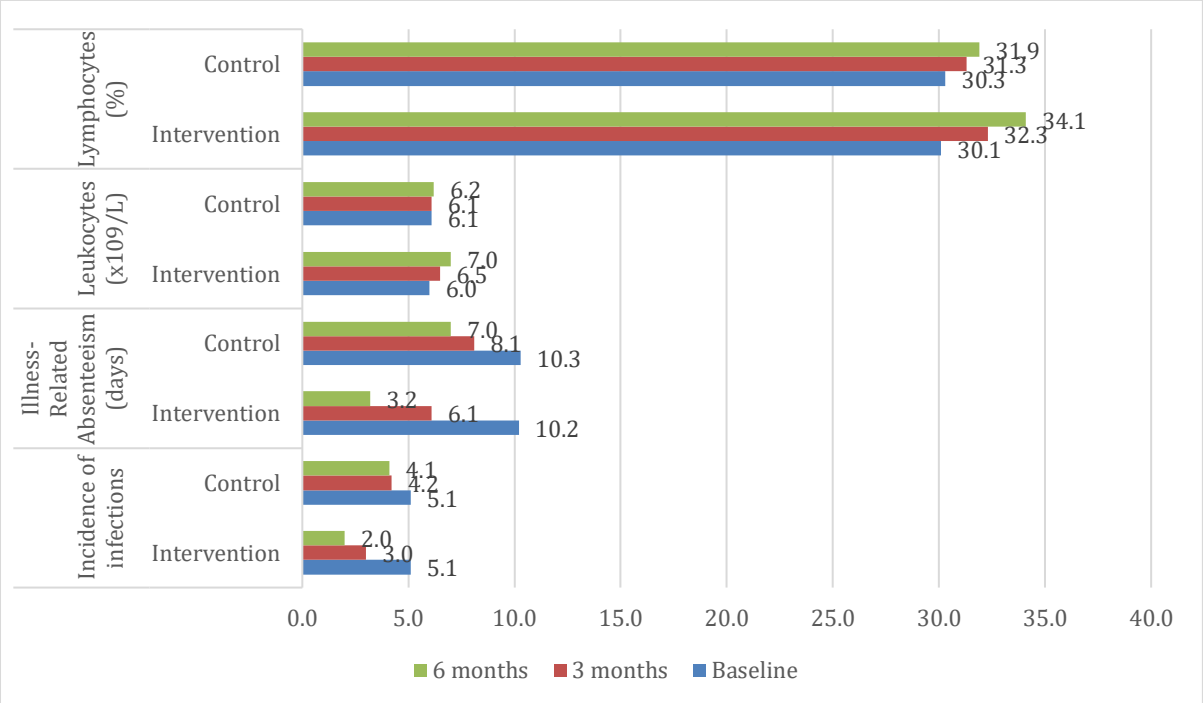


Figure 2: Comparison of study groups, by immune function

In the present study assessing cognitive development outcomes between an intervention group and a control group over six months, the following results were observed: for Verbal Intelligence Quotient (VIQ), the intervention group started with an average VIQ of 90.2 (SD 5.1), which increased to 95.5 (SD 6.1) at three months and reached 100.0 (SD 4.0) at six months. The control group had a baseline VIQ of 90.1 (SD 4.7), which increased to 92.3 (SD 5.3) at three months and 94.6 (SD 5.0) at six months. The increase in VIQ for the intervention group was statistically significant with a P value of 0.004. For Performance Intelligence Quotient (PIQ), the intervention group had an average baseline PIQ of 85.1 (SD 6.1), which increased to 90.3 (SD 3.3) at three months and 94.9 (SD 3.8) at six months. The control group started with a baseline PIQ of 84.9 (SD 4.1), which increased to 87.1 (SD 3.9) at three months and 88.0 (SD 4.5) at six months. The improvement in PIQ for the intervention group was statistically significant with a P value of 0.017. For Full Scale

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Intelligence Quotient (FSIQ), the intervention group had an average baseline FSIQ of 88.3 (SD 5.1), which increased to 92.4 (SD 4.8) at three months and 97.3 (SD 4.4) at six months. The control group had a baseline FSIQ of 88.7 (SD 3.9), which increased to 90.3 (SD 3.8) at three months and 91.9 (SD 4.6) at six months. The increase in FSIQ for the intervention group was statistically significant with a P value of 0.021. These findings suggest that the intervention had a significant positive impact on cognitive development, including improvements in VIQ, PIQ, and FSIQ, compared to the control group over the six-month period.

Table 3: Comparison of study groups, by cognitive development

| **Cognitive development** | | **Baseline** | **3 months** | **6 months** | **P value** |
|---|---|---|---|---|---|
| VIQ | Intervention | 90.2 (5.1) | 95.5 (6.1) | 100.0 (4.0) | 0.004* |
| | Control | 90.1 (4.7) | 92.3 (5.3) | 94.6 (5.0) | |
| PIQ | Intervention | 85.1 (6.1) | 90.3 (3.3) | 94.9 (3.8) | 0.017* |
| | Control | 84.9 (4.1) | 87.1 (3.9) | 88.0 (4.5) | |
| FSIQ | Intervention | 88.3 (5.1) | 92.4 (4.8) | 97.3 (4.4) | 0.021* |
| | Control | 88.7 (3.9) | 90.3 (3.8) | 91.9 (4.6) | |

*Statistically significant at p<0.05

VIQ, Verbal intelligence quotient; PIQ, Performance intelligence quotient; FSIQ, Full scale intelligence quotient

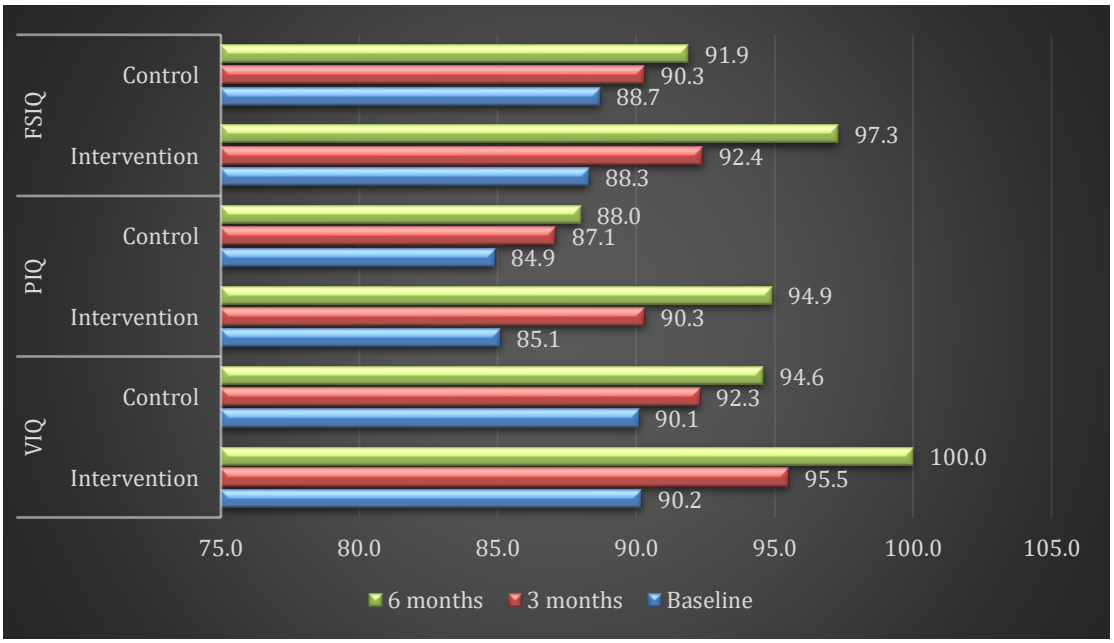


Figure 3: Comparison of study groups, by cognitive development

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**Discussion**

The present study aimed to evaluate the effects of increased consumption of fruits and vegetables on child health outcomes, focusing on growth parameters over a six-month period. The results demonstrated that children in the intervention group showed significantly greater improvements in height, weight, and BMI compared to the control group. These findings highlight the potential benefits of dietary interventions that emphasize increased intake of fruits and vegetables for promoting growth in children. The intervention group exhibited a notable increase in height, growing from an average of 100 cm (SD 2.3) at baseline to 106 cm (SD 0.5) at six months. In contrast, the control group showed a smaller increase, from 100 cm (SD 1.9) to 102 cm (SD 1.0) over the same period. The difference in height growth between the groups was statistically significant. This suggests that increased consumption of fruits and vegetables may contribute to enhanced linear growth in children. Previous research supports this finding, indicating that diets rich in fruits and vegetables provide essential nutrients that promote growth and development.(17) Similarly, the intervention group saw a significant increase in weight from 15.0 kg (SD 3.0) at baseline to 18.0 kg (SD 0.9) at six months, while the control group's weight increased from 15.0 kg (SD 2.6) to 16.0 kg (SD 0.8). These results align with studies suggesting that balanced diets rich in fruits and vegetables can positively influence weight gain by providing necessary vitamins and minerals.(2) The intervention group's BMI increased from 15.0 kg/m² (SD 0.9) at baseline to 16.1 kg/m² (SD 0.7) at six months. The control group's BMI showed a smaller increase, from 14.9 kg/m² (SD 0.7) to 15.3 kg/m² (SD 0.6). The BMI differences were also statistically significant, indicating that the dietary intervention effectively promoted healthy weight gain without leading to overweight or obesity. This finding is consistent with the literature suggesting that a diet high in fruits and vegetables is associated with healthier body weight outcomes in children.(18) The observed improvements in growth parameters can be attributed to several factors associated with increased fruit and vegetable consumption. These foods are rich sources of essential nutrients, including vitamins A, C, and E, folate, and dietary fiber, which are crucial for growth and development.(19) Moreover, the bioactive compounds found in fruits and vegetables, such as antioxidants and phytochemicals, may support immune function and overall health, further promoting growth.(20,21) The significant differences observed in this study underscore the importance of dietary interventions in pediatric populations. Promoting the consumption of fruits and vegetables can be a viable strategy to enhance growth and prevent malnutrition among children. Schools and community programs should incorporate nutrition education and provide access to fresh produce to support these outcomes.

The present study evaluated the impact of increased consumption of fruits and vegetables on immune function outcomes in children over a six-month period. The results revealed significant improvements in several key markers of immune function among children in the intervention group compared to those in the control group. The intervention group showed a substantial decrease in the average number of infections, from 5.1 (SD 2.1) at baseline to 2 (SD 1.9) at six months. In contrast, the control group experienced a modest reduction, from 5.1 (SD 1.7) to 4.1 (SD 2.0) over the same period. The statistically significant difference suggests that increased intake of fruits and vegetables may enhance immune defense mechanisms, thereby reducing susceptibility to infections.(22,23) This is consistent with existing literature, which indicates that fruits and vegetables contain essential nutrients and bioactive compounds that support immune function.(24) The average number of illness-related absenteeism days in the intervention group decreased from 10.2 (SD 3.2) at baseline to 3.2 (SD 1.1) at six months. The control group also showed a reduction, though less pronounced, from 10.3 (SD 3.1) to 7 (SD 3.1) days. The significant difference highlights the potential of dietary improvements to reduce the frequency and severity of illnesses, thereby minimizing school absenteeism.(25) This aligns with studies suggesting that proper nutrition can improve overall health and reduce the burden of illness in children. The intervention group exhibited an increase in leukocyte counts from 6.0 x10⁹/L (SD 2.1) at baseline to 7.0 x10⁹/L (SD 2.0) at six months, while the control group's counts remained relatively stable. The significant increase indicates an enhancement in the body’s ability to fight infections. Fruits and vegetables are known to contain vitamins and minerals that are crucial for the production and function of leukocytes.(26) The intervention group's lymphocyte percentage

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increased from 30.1% (SD 4.2) to 34.1% (SD 4.9), whereas the control group showed a slight increase from 30.3% (SD 5.1) to 31.9% (SD 3.8). The significant difference suggests that dietary improvements can enhance specific aspects of immune function, particularly adaptive immunity. Lymphocytes play a critical role in immune responses, and their increased percentage reflects a strengthened immune system. The improvements in immune function observed in this study can be attributed to the high nutrient density of fruits and vegetables.(27) These foods are rich in vitamins C and E, beta-carotene, and other antioxidants, which are essential for maintaining and enhancing immune function. Additionally, dietary fiber from fruits and vegetables can modulate the gut microbiota, leading to improved immune responses.(27,28)

The present study investigated the effects of increased consumption of fruits and vegetables on cognitive development outcomes in children over a six-month period. Children in the intervention group showed a notable increase in VIQ, starting from an average of 90.2 (SD 5.1) at baseline and progressing to 100.0 (SD 4.0) at six months. In comparison, the control group's VIQ increased from 90.1 (SD 4.7) to 94.6 (SD 5.0) over the same period. This indicates that the dietary intervention contributed to enhanced verbal reasoning, comprehension, and expression skills in children. Previous research supports the role of specific nutrients found in fruits and vegetables, such as antioxidants and vitamins, in cognitive development.(Roberts et al. 2022) The intervention group exhibited a significant improvement in PIQ, increasing from 85.1 (SD 6.1) at baseline to 94.9 (SD 3.8) at six months. Conversely, the control group's PIQ increased from 84.9 (SD 4.1) to 88.0 (SD 4.5) over the same period. PIQ assesses non-verbal reasoning, spatial perception, and problem-solving abilities, suggesting that dietary interventions can enhance diverse cognitive skills critical for academic and everyday tasks.(Roberts et al. 2022; Key and Szabo-Reed 2023) Children in the intervention group also showed significant gains in FSIQ, starting from 88.3 (SD 5.1) at baseline and reaching 97.3 (SD 4.4) at six months. In comparison, the control group's FSIQ increased from 88.7 (SD 3.9) to 91.9 (SD 4.6) over the same period. The improvement in FSIQ for the intervention group highlights comprehensive gains in overall cognitive ability due to the dietary intervention. These results align with studies linking healthy dietary patterns, including higher intake of fruits and vegetables, with improved cognitive performance and academic achievement in children.(Bleiweiss-Sande et al. 2019)

## Conclusion

This study rigorously examined the effects of increased consumption of fruits and vegetables on various health and developmental outcomes in children over a six-month period. The findings provide compelling evidence that dietary interventions emphasizing higher intake of fruits and vegetables significantly improve multiple facets of child health. Children in the intervention group exhibited significant improvements in height, weight, and BMI compared to the control group. These findings underscore the nutritional benefits of fruits and vegetables in supporting optimal growth and development during childhood. The intervention group experienced a notable reduction in the incidence of infections and illness-related absenteeism, alongside increases in leukocyte counts and lymphocyte percentages. These outcomes highlight the role of dietary factors in bolstering immune defenses and reducing the burden of illness in pediatric populations. Significant enhancements were observed in VIQ, PIQ, and FSIQ among children in the intervention group. These improvements suggest that a diet rich in fruits and vegetables contributes to better cognitive functioning, encompassing verbal reasoning, non-verbal problem-solving skills, and overall intellectual abilities critical for academic achievement. Collectively, the results underscore the pivotal role of nutrition, particularly increased consumption of fruits and vegetables, in promoting comprehensive health benefits in children. Implementing dietary interventions early in life may yield long-term advantages, supporting both physical growth and cognitive development.

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