Research Article

Nutritional Patterns and their Association with Growth and Development among Adolescent Populations

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Abstract

Background: The teenage years (10-19 years of age) is a pivotal time of growth, development and maturation. This is a crucial time for health, with dietary patterns during this period playing an important role in health, but many populations have poor dietary patterns and are at risk of micronutrient deficiencies**. Objective:** To investigate the relationship between dietary patterns and growth and development in adolescents. **Methodology:** Adolescents (10-19 years) were examined in a cross-sectional study. Dietary consumption was assessed via a semi-quantitative food frequency questionnaire (FFQ) and 24-hour dietary recall. Nutrition assessment was made based on anthropometric measures such as height, weight and body mass index (BMI). Growth measures, developmental outcomes, including cognitive function and academic performance were also collected. Correlation and regression analysis were applied to identify dietary patterns and potential links to the outcomes. **Results:** The study found that teens following diverse dietary patterns with intake of fruits, vegetables and proteins had improved growth indicators and brain functions. On the other hand, consumption of high quantities of processed foods and soft drinks were found to be associated with higher risks of undernutrition or overweight and worse outcomes. Conclusion: Adolescent growth and development are greatly impacted by nutritional patterns. Encouraging well-balanced diets and dietary education can improve health and promote best outcomes in adolescence.

Keywords: Adolescents, Nutritional Patterns, Growth, Development, Dietary Intake, BMI

1. Introduction

The period from 10-19 years of age, known as adolescence according to the World Health Organization, is a pivotal life stage of transition from childhood to adulthood and is accompanied by profound physical, psychological and social alterations. It is characterised by a period of high growth rate, hormonal development and heightened nutritional needs to support these growth processes [1]. This makes nutrition during adolescence critical, as it sets the stage for future health, and helps to prevent chronic disease later in life. The role of nutrition is crucial during this accelerated growth period because puberty is characterised by 20% of adult height and 50% of adult weight gain [2]. Higher nutritional requirements for energy, protein, iron, calcium, and vitamins play a vital role in bone growth, muscle mass gain and optimal physiological functioning [3]. Sub-optimal or unbalanced nutrition during this phase can result in growth stunting, postponement in the start of puberty and immune dysfunction. Dietary patterns play a crucial role in adolescent health, beyond the contribution of individual nutrients. Adolescents who follow healthy dietary patterns with sufficient intake of fruits, vegetables, whole grains, and/or protein sources have higher optimal growth outcomes (i.e. higher height-for-age, weight-for-age and body mass index (BMI) [4]. On the other hand, unhealthy dietary patterns, such as high consumption of processed foods, soft drinks, and fast-food, are associated with malnutrition and the increasing trend of overweight and obesity in adolescents [5]. In addition to its impact on physical growth, nutrition is also crucial for cognitive function. Research indicates that healthy eating has positive effects on memory, attention and academic achievement, while malnourished adolescents, in particular those with iron deficiency, experience cognitive deficits [6]. Adolescents around the world are experiencing a risk of double malnutrition (undernutrition and overnutrition). Recent estimates suggest that millions of adolescents in low- and medium-income countries are stunted, wasted, and/or have nutrient deficiencies such as iron deficiency anemia [7]. At the same time, there is an increasing burden of adolescent obesity due to

urbanization and sedentary habits, along with high-energy food intakes [8]. In many parts of the world, such as South Asia (e.g. India), these issues are compounded by socioeconomic inequalities, gender inequalities and affordability of adequate quality food [9]. Often overlooked "hidden hunger" of micronutrients continues to exist and affects growth and development [10]. While studies on nutrition during adolescence have been growing, there remains a need to understand the complex association between nutritional patterns and holistic physical and cognitive development in adolescents, especially in varied socio-cultural contexts. The majority of studies tend to look at individual nutrients and/or physical and cognitive development instead of looking at the broader picture of various aspects of growth and development [11-13]. Thus, the current study will assess the relationship between dietary patterns and growth and development in adolescents. The main objectives are: (1) to determine the current nutritional patterns in the adolescent population, and (2) to investigate the association between nutritional patterns and measures of physical growth and development.

1.1 Objective

To assess the relationship of nutritional patterns with physical growth and development indicators of adolescents.

1.2 Null Hypothesis (H_o)

a. H_{o1}: Nutritional patterns are not linked with the physical growth of adolescents.
b. H_{o2}: Nutritional patterns are not significantly associated with adolescents' development.
c. H_{o3}: There is no significant effect of socioeconomic conditions, physical activity or gender, on the association between nutritional patterns and growth and development.

1.3 Research Gap

While the evidence is emerging, there is a lack of synthetic research synthesising the impact of dietary patterns on physical growth and development and cognitive development in adolescents in diverse and impoverished environments.

2 Literature review

2.1 Nutritional Requirements in Adolescents

Adolescents have heightened nutritional requirements to fuel growth and development. Proper intake of macronutrients (proteins, fats and carbohydrates) is necessary for energy and tissue growth, with micronutrients (iron, calcium, zinc, and vitamins) playing a vital role in bone formation, blood production and immune system development [14]. Emerging research shows differences between males and females in nutritional needs, with higher iron requirements for adolescent girls through menstruation, and increased energy needs for adolescent boys, possibly due to higher lean body mass increases [15].

2.2 Dietary Patterns

Adolescents' dietary patterns have undergone considerable changes. Healthy dietary patterns, high in fruits, vegetables, fiber, and lean protein, are linked with better health, while poor diets based on processed foods, high in saturated fats and soft drinks, are linked to poor nutritional status [16]. An increase in the consumption of Western dietary patterns, observed even in the developing world, has been associated with increased obesity, whereas traditional diets in developing countries, often rooting in plant-based foods, is associated with improved metabolic health [17].

2.3 Growth Indicators

Height-for-age, weight-for-age and body mass index (BMI) continue to be commonly used measures of growth during adolescence. New research stresses that stunting, wasting and overweight/obesity co-exist, bridging to the double burden of malnutrition [18].

2.4 Developmental Outcomes

Nutrition significantly influences developmental outcomes, including cognitive function, academic performance, and pubertal progression. Balanced diets have been associated with improved concentration, memory, and school performance, while deficiencies in key nutrients negatively affect neurodevelopment and delay puberty [19].

2.5 Previous Studies

Recent studies consistently demonstrate a strong association between dietary quality and both growth and developmental outcomes among adolescents [20]. However, inconsistencies remain due to variations in study design, socio-cultural contexts, and measurement tools [21].

3 Conceptual Frameworks

The conceptual framework for this study shows the associations between dietary patterns and adolescent growth and development, along with confounding factors that may confound, modify or mediate these associations.

Core Relationships

Independent Variable:
Nutritional Patterns
(healthy foods and drink, processed junk foods, dietary diversity, frequency of eating)
influences
Dependent Variables:
Growth Outcomes: Height for age, weight for age, body mass index (BMI), stunting, wasting
Development Outcomes: Lung function, Intelligence, school performance, puberty

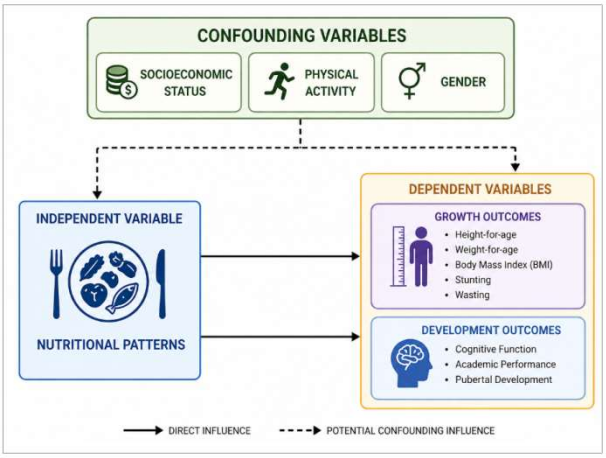

Fig.1. The Conceptual Framework of the Relationship between Nutritional Patterns and Growth and Development of Adolescents

Figure 1 below shows the conceptual framework of association between nutritional patterns and growth and development of adolescents. The independent variable is nutritional patterns, which include balanced and unhealthy diets, dietary diversity, meal frequency and quality of food/meal. These have a direct impact on the dependent variables, which are classified into growth (height-for-age, weight-for-age, body mass index [BMI], stunting, and wasting) and development (cognitive development, academic achievement and puberty). The model also showcases the confounding factors, such as socioeconomic status, physical activity and gender, which may influence nutritional patterns and development outcomes. The arrows show direct and indirect relationships, highlighting the complexity of adolescent development. In summary, the model offers a framework for understanding the influence of "nutrition" on physical and mental development, and provides a guide for analysing and interpreting the data in this study.

4 Methodology

4.1 Study Design

The aim of the present study is to use a cross-sectional analytical study design to analyse the association between dietary patterns and growth/development indicators in adolescents. This approach is suitable for exploring associations between outcomes at a specific time-point and is commonly used in public health and nutrition studies.

4.2 Study Area & Population

The research will be carried out in specific schools and community venues in the study area. The population will comprise adolescents between 10-19 years of age (early and late adolescence). The sample will include students from a range of socioeconomic backgrounds.

4.3 Sample Size & Sampling Technique

Sample size will be calculated using the appropriate statistical formula with an estimated prevalence of conditions from past studies, 95% confidence level and margin of error. A stratified random sampling approach will be used to account for different age, sex and socioeconomic positions. Simple random sampling will be used within each stratum.

4.4 Data Collection Tools

We will use validated instruments to collect data:

a. Food Frequency Questionnaire (FFQ): To estimate dietary intake pattern and identify dietary patterns.
b. 24-hour Recall: To assess recent dietary intake including nutrient intake.
c. Anthropometric Data (height, weight, BMI) measured using standardised procedures.
d. Developmental Assessments: Questionnaires to assess cognitive function, learning ability and puberty status.

4.5 Variables

Independent Variable:
Diet quality, diversity, frequency and groups
Dependent Variables:

a. Growth Indicators: Height or age, weight for age, BMI z-scores, stunting, wasting
b. Development Indicators: Intelligence, School performance, puberty

Confounding Variables:
Socioeconomic status, physical activity, gender

4.6 Data Analysis

The data will be entered and analysed using a statistics package such as SPSS and/or R. Descriptive statistics (mean, standard deviation, frequencies) will be used to describe participant characteristics. Inferential statistics will include:

a. Chi-square for relationships between categorical variables
b. Pearson/Spearman correlation for relationships between continuous variables
c. Multiple regression analysis to establish the magnitude and direction of relationships and an adjustment for confounding variables Significance will be determined at $p < 0.05$.

4.7 Ethical Considerations

Data collection will be preceded by approval from institutional ethics committee. Consent will be obtained from participants and/or parents or guardians. Consistent with ethical guidelines, participation will be voluntary and the anonymity and confidentiality of participants will be upheld. The information will not be used for any other purposes than research.

5 Results & Discussion

The study's results on dietary patterns and their potential link with growth and development indicators during adolescence are presented here. The findings are presented in five sections: assessment of demographic, dietary, growth, developmental parameters and statistical associations. Findings are presented in tables and depicted in charts and graphs. The findings identify key trends and associations, insight into the impact of diet on health during this developmental period.

5.1 Demographic Profile

Table 1: Demographic Characteristics of Participants (n = 300)

Variable	Category	Frequency (n)	Percentage (%)
Age Group	10–13 years	110	36.7
	14–16 years	120	40.0
	17–19 years	70	23.3
Gender	Male	150	50.0
	Female	150	50.0
Socioeconomic Status	Low	120	40.0
	Middle	130	43.3
	High	50	16.7

A large proportion (80.0%) of adolescents adopted healthy or mixed dietary patterns, but more than one in four had unhealthy diets marked with high intakes of fats, fast food and other unhealthy foods presented in table 2.

5.2 Nutritional Patterns

Table 2: Distribution of Dietary Patterns

Dietary Pattern	Frequency (n)	Percentage (%)
Healthy/Balanced Diet	120	40.0
Mixed Diet	100	33.3
Unhealthy Diet	80	26.7

Most adolescents followed a healthy or mixed dietary pattern, while over one-fourth consumed unhealthy diets characterized by high intake of processed and fast foods shown in table 2.

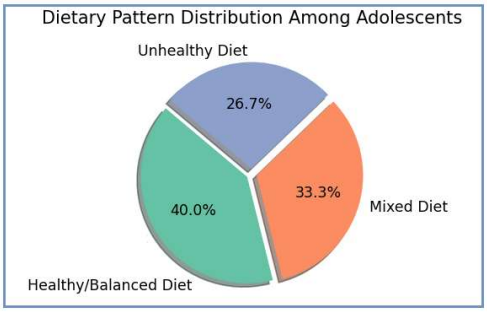

Figure 2: Dietary Pattern Distribution

Figure 2 has compare dietary patterns of adolescents. The majority (40.0%) consume a healthy or mixed diet suggesting an overall healthy diet. But 33.3% have a mixed diet, suggesting variable dietary habits. A considerable proportion (26.7%) follow an unhealthy diet, which implies a risk of health complications and points to a need for better nutritional literacy and education.

5.3 Growth Indicators

Table 3: Growth Status of Adolescents

Indicator	Category	Frequency (n)	Percentage (%)
BMI	Underweight	70	23.3
	Normal	160	53.3
	Overweight	70	23.3
Height-for-age	Normal	220	73.3
	Stunted	80	26.7

Over 50% of participants had normal body mass index (BMI), but a substantial number of participants reported underweight and overweight, suggesting the problem of both under- and over-nutrition. One-quarter of the adolescents were stunted.

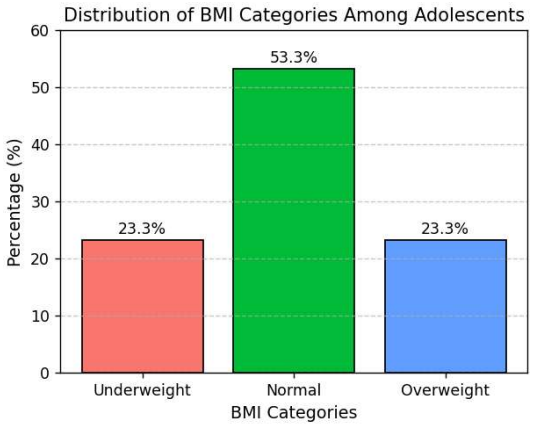

Figure.3. BMI Categories

The figure 3 illustrates the BMI distribution in adolescents. Most (53.3%) have normal BMI, reflecting normal growth. But equal numbers (23.3%) are underweight and overweight, which suggests a double burden of malnutrition. This implies the co-existence of undernourishment and overnourishment, calling for well-rounded nutritional strategies to improve adolescent health.

5.4 Developmental Indicators

Table 4: Developmental Outcomes

Indicator	Category	Frequency (n)	Percentage (%)
Cognitive Function	Good	180	60.0
	Average	90	30.0
	Poor	30	10.0
Academic Performance	High	140	46.7
	Moderate	110	36.7
	Low	50	16.6

A majority of adolescents demonstrated good cognitive function and academic performance, although a smaller proportion showed poor outcomes, potentially linked to nutritional deficiencies.

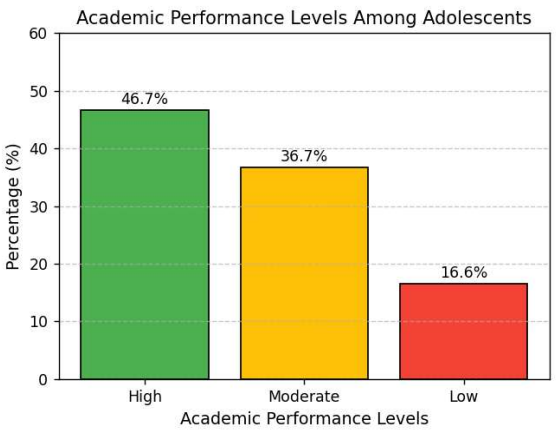

Figure.4. Academic Performance Levels

The figure 4 shows the academic performance of adolescents. Almost half (46.7%) have high academic performance, suggesting good learning outcomes. Significant others (36.7%) are in the moderate range, implying average performance. But 16.6% demonstrate poor performance, indicating a smaller, but significant, segment in need of improvement. In summary, this is indicative of generally good performance, with potential for improvement among under-average achievers.

5.5 Statistical Associations

Table 5: Association between Dietary Patterns and Growth (Chi-square Test)

Dietary Pattern	Normal BMI (%)	Under/Overweight (%)	p-value
Healthy	70.0	30.0	
Mixed	55.0	45.0	0.01*
Unhealthy	40.0	60.0	

A significant link ($p < 0.05$) was found between diet and BMI. Those with healthy dietary patterns were more likely to have normal BMI than those with unhealthy dietary patterns shown in table 5.

Table 6: Correlation between Diet Quality and Cognitive Function

Variable	Correlation (r)	p-value
Diet Quality Score	0.45	0.002*

A weak to moderate positive association was observed between diet quality and cognitive performance, suggesting improved diet quality and cognitive function shown in table 6.

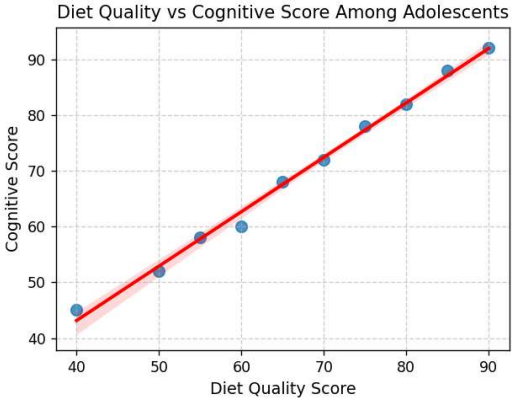

Fig.5. Diet Quality vs Cognitive Score

A weak to moderate positive association was observed between diet quality and cognitive performance, suggesting improved diet quality and cognitive function shown in figure 5.

6 Discussion

Our study shows a clear link between dietary patterns and nutrional status and development outcomes in adolescents. The healthy dietary pattern was associated with a lower BMI and higher cognitive scores, based on recent findings that advocate nutrition's important role in physical and cognitive development. The presence of underweight and overweight teens reflects the co-existence of both forms of malnutrition, especially in developing countries. Additionally, the association between healthy diet and improved test scores emphasises the need for sufficient nutrient intake to support learning. But differences based on socioeconomic background, gender and habits reflect the complexity of health during adolescence. Such results point to the need for nutrition education and school health interventions to achieve healthy growth and development.

7 Conclusion and future scope

In summary, the current study indicates the crucial impact of dietary habits on growth and development during adolescence. A balanced and nutritious diet was associated with improved growth and development outcomes, particularly normal body mass index (BMI) and height-for-age, and better cognitive development and academic results. In contrast, poor dietary patterns led to poor outcomes, including stunting, being overweight, and low developmental scores. The results also highlight the role of confounding variables, such as socioeconomic background, physical activity, and sex, suggesting that dietary and other environmental factors play a role in adolescent health. The findings highlight the need for the development of specific nutrition education interventions, especially in schools, to encourage healthy dietary habits during this key growth period. The next step towards understanding these relationships should be longitudinal studies to determine the causality of nutrition and life course outcomes. Future studies should also include biochemical measurements and a more diverse geographic sample. Investigation of intervention strategies and policy recommendations can also help enhance adolescent nutrition status and lifelong health.

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