



Nutritional Assessment Using Ponderal Index and its Determinants in Prepubertal Children at Orphanage Home

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Abstract

The Ponderal Index assess body composition especially adiposity mass to estimate nutritional status in individuals. Objective: The Nutritional Assessment Using Ponderal Index and Its Determinants in Prepubertal Children at Orphanage Home aimed to assess the growth status of prepubertal children living in orphanages.

Methods: A cross-sectional population study was carried out in an Orphanage home in Ekpoma, Nigeria. Children (n=70) aged 5-12 years were selected by the stratified random sampling procedure by the proportion of children according to age and gender. Their anthropometric parameters of height, weight were measured to help analyse their ponderal indices and nutritional variability. The ponderal index was calculated as the ratio between weight and height cubed.

Results: There was a positive association of the body adiposity with weight ($P<0.005$). The average Ponderal Index of 20.22 suggests that, on average, the children in the study may be within a normal range, which compared to normative data to determine if they are at risk for under nutrition or over nutrition. The relatively low standard deviations for weight and ponderal index indicate that most of the children have weights and ponderal index close to the mean, whereas the unusually high standard deviation for height may indicate a wider range of heights. Conclusion: Overall, the study found that the majority of children demonstrated healthy growth and nutritional status, with moderate differences in weight and minimal variations in height. These results suggest that while most children are well-nourished, there are disparities in nutritional status that may require further attention and intervention.



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Introduction

The nutritional status of children is a critical determinant of their overall health and development, particularly in vulnerable populations such as those living in orphanages. Prepubertal children, defined as those who have not yet entered puberty, are at a crucial stage of growth and development. Nutritional health/status in children is closely associated with Childhood obesity and it is a global health issue with a considerable growth in prevalence in the last four decades [1]. According to a World Health Organization report, in 2016, more than 340 million children and adolescents worldwide were in a condition of excess body weight. The global prevalence of overweight and obesity in males and females aged 5-19 has risen from 4% in 1975 to 18% in 2016 [2]. Pediatric obesity exposes affected patients to a higher risk of short- and long-term complications [3,4], including metabolic syndrome such as abdominal obesity, hypertension, which increases the risk of developing cardiovascular diseases and type 2 diabetes mellitus in adulthood later on.

Among various methods to assess nutritional status, the Ponderal Index (PI) also known as Tri-ponderal Mass Index (TMI) has emerged as a valuable tool for evaluating body composition in children. The Ponderal Index is calculated by dividing a child's weight (in kilograms) by their height (in meters) cubed ($PI = \text{weight}/\text{height}^3$). This index provides an alternative to the more commonly used Body Mass Index (BMI), particularly in pediatric populations where growth patterns differ significantly from adults. Ponderal Index (PI) is an essential measure to study physical growth of adolescents, and adults. Lower PI is found among the malnourish infants and newborn babies and higher in obese ones. Because of the limitation of body mass index (BMI) in distinguishing adipose mass from muscle, the ponderal mass index has been proposed as a new indicator for better assessing adiposity in children and adolescents. However, it remains unclear whether ponderal index performs better than body mass index or other adiposity indices in predicting obesity status in childhood and obesity-related cardiovascular risk factors in childhood or adulthood. Ponderal index has been suggested to predict percent body fat [5] and metabolic syndrome [6] at least as well as, or better than body mass index. However, findings in other previous studies were inconsistent [7,8]. It is however unclear whether the emerging ponderal index can better identify adiposity in childhood or adolescence than the commonly used BMI [5,7,9] and better predict obesity-related Cardiovascular Risk Factors (CVRFs) such as high blood pressure, and the MetS in childhood [8,10]. The misclassification of obesity may lead to either omissions of children who are at high risk of obesity-related diseases or excessive anxiety due to over diagnosis and then unnecessary waste of medical resources. Identifying potential adiposity related indicators that can accurately predict body fat or related risks has significant implications for prevention, treatment, and management of pediatric obesity.

In orphanage settings, where children may experience inadequate nutrition due to limited resources or lack of access to diverse food options, understanding the determinants that influence nutritional status becomes paramount. Factors such as socioeconomic status, dietary intake, physical activity levels, and health conditions can significantly impact children's nutritional outcomes. Research indicates that orphaned children often face higher risks of malnutrition compared to their peers living with families due to factors like institutionalization effects and psychosocial stressors [11].

Both ponderal index (tri-ponderal mass index) and body mass index in children may be affected by several environmental factors, such as nutritional resources or socioeconomic conditions. Among environmental factors, socioeconomic aspects might play a substantial and significant role in respect of weight status in both children and adults. Numerous studies have found significant differences in relative weight between the categories of the most common socioeconomic variables: urban versus rural locations [12], higher versus lower income [13], considering social inequalities and smaller versus larger families [14]. Moreover, the determinants of nutritional status extend beyond individual factors; they encompass broader systemic issues such as food security and healthcare access. For instance, studies have shown that orphanages may struggle with providing adequate nutrition due to financial constraints or lack of trained personnel knowledgeable about child nutrition [15].

This study aims to explore the use of the Ponderal Index as a measure for assessing nutritional status among prepubertal children living in an orphanage home while examining its determinants. Given that these children represent some of society's most vulnerable members, ensuring their proper nutrition is imperative for fostering healthy growth trajectories and improving their overall well-being. Prepubertal children in orphanage homes often face challenges related to their physical health. Studies have shown that children in institutional care may experience delayed growth and development due to inadequate nutrition and healthcare services [16].

Anthropometric index of Body Mass Index (BMI) is a commonly used indicator of relative weight and is widely applicable for inter-population comparisons of levels of overweight, obesity and underweight [17], however, it is not an ideal measure for children as it includes different types of tissues, that is, muscle and adipose, as well as all the components of the total body mass, such as different organs and bones [5]. Alternatively, ponderal index may be a more appropriate indicator of nutritional status, because it is highly associated with the content of adipose tissue, particularly in children [18] and also reliably reflects malnutrition, mainly among children from low-income populations [19,20] such as found in most orphanage homes. The nutritional status of prepubertal children in these homes remains underexplored, making it difficult to develop targeted interventions for improving their health outcomes. Understanding the determinants of nutritional status, including dietary intake, socioeconomic factors, and health-related behaviours in the orphanage setting, is crucial. This research aims to fill this gap by conducting a comprehensive nutritional assessment of prepubertal children using the Ponderal Index and identifying its key determinants. Identifying and addressing these factors is essential to ensure the well-being and healthy development of children in orphanages.

Purpose of the Study

The aim of this study is to assess the nutritional status of prepubertal children residing in an orphanage using the ponderal index and to identify key determinants influencing their nutritional health. The specific objectives are to evaluate the prevalence of undernutrition and overnutrition among prepubertal children at the orphanage using the ponderal index, analyse dietary intake patterns among these children and their correlation with nutritional status, investigate socioeconomic factors that may affect nutrition among prepubertal orphans and provide recommendations for improving nutrition-related interventions within orphanage settings.

The significance of this study lies in its potential to shed light on the nutritional status of a vulnerable population—prepubertal children in orphanage homes. By utilizing the Ponderal Index, this research will provide a specific and sensitive measure of the children's nutritional health, which is crucial for identifying undernutrition or overnutrition [21]. The findings of this study can inform policy-makers, healthcare providers, and orphanage administrators about the current nutritional status of children in institutional care and the factors influencing it. Moreover, by identifying the key determinants of nutritional status, this study will contribute to the development of targeted nutritional interventions aimed at improving the health and growth outcomes of children in orphanages. Improved nutrition in these settings can lead to better physical development, cognitive functioning, and overall quality of life for these children, thereby enhancing their prospects for the future [22].

By addressing both anthropometric measurements and contextual determinants influencing nutrition, this study aims to provide a more nuanced understanding of how institutional care affects children's health outcomes. Furthermore, utilizing PI will allow for more accurate evaluations that can inform targeted interventions designed to improve dietary practices and overall well-being among orphaned children.

Materials and Methods

Research Design

This study employed a cross-sectional research design to assess nutritional status using the Ponderal Index (PI) among prepubertal children living in orphanages within Ekpoma in Edo State, Nigeria. This design ensures collection of data at a single point, providing a snapshot of nutritional status across the defined population which thus facilitates comparisons between different variables such as age, and other demographic/determinant factors while minimizing recall bias associated with longitudinal studies.

Study Populations

Prepubertal children aged 5 to 12 years living in orphanage homes. The subject populations were children that has been at the orphanage within a minimum of six months.

Study Criteria

The **inclusion criteria** for this study are Children aged 5 to 12 years residing in selected orphanages within Ekpoma, Edo State. Children who have been living in the orphanage for at least six months prior to data collection to ensure stability in dietary patterns.

Exclusion criteria included Children with presence of chronic illnesses or medical conditions that could affect nutritional status (e.g., diabetes, malabsorption syndromes). Children on recent hospitalization or surgical procedures within three months prior to data collection. Also children with any known genetic disorders affecting growth and development.

Materials and Instrumentation

The materials used for this study included:

Anthropometric measurement tools: calibrated weighing scales for weight measurement (in kilograms), stadiometers for height measurement (in centimeters), and measuring tapes for waist circumference.

Data collection forms: structured questionnaires designed to gather demographic information and dietary intake data through 24-hour dietary recalls.

Sample Collection

Weight (kg): Measured using a digital weighing scale. Children were weighed in light clothing, with no shoes, and their weight was recorded to the nearest 0.1 kg.

Height (m): Measured using a stadiometer, ensuring the child was standing straight with feet together, heels against the stadiometer, and head in a neutral position.

Demographic Information

Age, gender, and the length of stay in the orphanage were recorded through interviews with caregivers and from orphanage records.

Determinants of Nutritional Status

The following factors were considered as potential determinants of the Ponderal Index and overall nutritional status:

Dietary Intake: A 24-hour dietary recall was used to assess the quality and quantity of food intake.

Physical Activity Levels: The type and frequency of physical activities were documented, categorized as sedentary, moderate, or active.

Socioeconomic Factors: Orphanage resources, including funding for meals and healthcare, were examined.

Interpretation of Ponderal Index for Nutritional Assessment:

Ponderal Index Classification:

- Underweight: $PI < 15$, - Normal weight: $PI 15 - 17$, - Overweight: $PI > 17$

Sampling Method

A stratified random sampling method was employed to select participants from various orphanages located within the environment based on their size and capacity to provide adequate sample sizes. Within each selected orphanage, children meeting the inclusion criteria were identified using simple random sampling techniques until a total sample size of 70 participants was achieved which was grouped into 7 group (10 each group).

Study Sample

The target sample size for this study was set at 70 prepubertal children aged between 5 to 12 years residing in selected orphanages across Edo State. This sample size was determined based on power calculations that considered an expected prevalence rate of malnutrition among similar populations and aimed to achieve sufficient statistical power to detect significant differences between groups when analysing nutritional status indicators.

Statistical Method

Data collected during this study was analysed using descriptive statistics to summarize demographic characteristics such as age distribution, sex ratio, and anthropometric measurements (weight, height, PI). Inferential statistics was employed to examine relationships between nutritional indices (including PI) and potential determinants such as dietary intake patterns or socio-

economic factors using regression analysis where appropriate.

Statistical significance will be set at $p < 0.05$ level. All analyses were conducted using SPSS software version (V.25). Results were presented through tables and graphs to facilitate interpretation and comparison among different groups within the sample population.

Results

Raw data obtained were analysed using SPSS version 25, to determine the mean, range, standard deviation, and standard error. Based on the analysis, there were no significant changes in height and weight of the children. Ponderal Index is a measure that considers both weight and height to assess body composition.

Table 1: Descriptive analysis on ponderal parameters (height, weight).

Statistics parameter	Weight (kg)	Height (cm)	Ponderal Index (kg/m ³)
Minimum	21.00	101.0	11.43
Maximum	30.30	130.0	26.20
Range	9.300	29.0	14.77
Mean	24.35	61.91	20.22
Std. Deviation	2.678	58.76	4.503
Std. Error of Mean	0.4132	9.067	0.6949

Result Analysis

Ponderal Index is a measure of the relationship between birth-weight and body length; the famished child, with a low body weight relative to length should have a lower Ponderal Index.

Weight of children were as follows 21.00kg 30.30 kg for minimum and maximum respectively. The difference between these values give rise to 9.30 kg (Range).

Mean average obtained was 24.35 kg, indicating the average weight of the children. The data suggests a moderate range of weights and heights among the children. The mean weights and heights indicate that the children are within a certain expected range for prepubertal children, but this should be compared to established growth standards for accurate assessment.

While the Standard Deviation (SD), is 2.678 kg, which reflects the variability in weights; a lower Standard Deviation suggests that the weights are relatively close to the mean. Standard De-

viation of 4.503, shows variability in Ponderal Index while Standard Error of Mean is 0.6949, indicating the reliability of the mean Ponderal Index estimate.

However Standard Error of Mean (SEM) 0.4132 kg, indicates the precision of the mean estimate; a smaller SEM suggests a more reliable mean value.

Height (cm), minimum and maximum height is, 101.0 cm 130.0 cm respectively with the range of 29.0 cm and Mean of 61.91 cm, representing the average height of the children.

The average Ponderal Index of 20.22 suggests that, on average, the children in the study may be within a normal range, which compared to normative data to determine if they are at risk for under nutrition or over nutrition. Variability, the relatively low standard deviations for weight and Ponderal Index indicate that most of the children have weights and Ponderal Indices close to the mean, whereas the unusually high standard deviation for height may indicate a wider range of heights or possible errors in data collection.

In, Table 2, test analysis between weight and ponderal index, shows that the P-value from the unpaired t-test was 0.8551, which is greater than 0.05, indicating that there is no statistically significant difference between the mean weight and the mean Ponderal Index. As this result was obtained using a two-tailed test, it confirms that any observed difference is likely due to random variation and not a systematic difference between the two variables. Comparison of Variances (F-test), The F-value was 1.183, and the P-value was 0.8432, which suggests that the variances between the two groups (weight and PI) were not significantly different. This means that both measures have similar levels of variability.

The analysis revealed **no significant difference** between weight and Ponderal Index in assessing the nutritional status of prepubertal children in the orphanage home. The P-value and confidence intervals suggest that any observed differences are minor and not statistically meaningful. Consequently, both weight and Ponderal Index can be considered equally useful but interchangeable indicators for nutritional assessment in this population, as no one measure significantly outperforms the other.

These findings may indicate that while both weight and Ponderal Index are useful for assessing the nutritional status, additional factors or determinants may need to be considered for a more comprehensive understanding of nutritional health in prepubertal children at orphanages.

Table 2: Nutritional Assessment of Prepubertal Children.

Children group (ID)	Mean Age (Years)	Mean Height (cm)	Mean Weight (Kg)	Ponderal index (kg/m ³)	Nutritional Classification (BMI)	Nutritional Classification P1
001	9	135	30	15.3	Under weight	normal
002	10	138	32	15.4	Under weight	Normal weight
003	8	130	28	16.6	Normal weight	Normal
004	9	132	34	17.6	Normal	Overweight
005	11	140	36	16.5	Normal weight	Normal
006	8	125	26	17.1	Normal weight	Over weight
007	9	137	31	15.5	Under weight	Normal

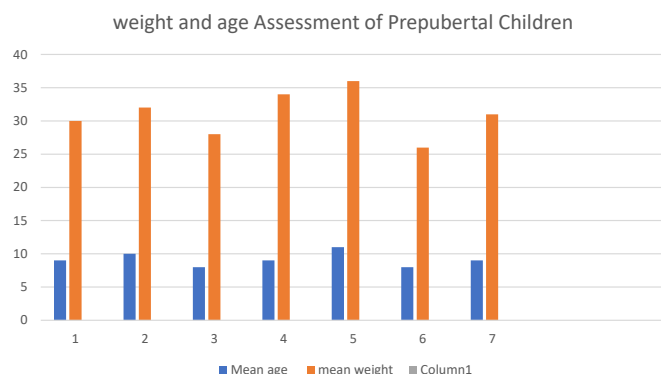
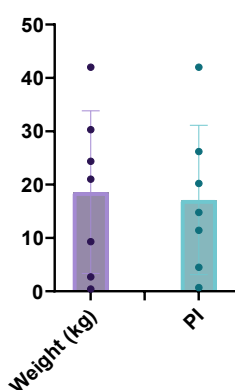


Figure 1: Showing the mean age and mean weight Assessment among groups.

Table 3: Correlation between BMI, PI, Dietary Intake, and Physical Activity.

Variable	BMI	Ponderal index (PI)	Energy intake	Physical activity level (PAL)
BMI	1.000	0.760	0.650	-0.450
Ponderal index	0.760	1.000	0.620	-0.430
Energy intake	0.650	0.620	1.000	0.340
physical activity level (PAL)	-0.450	0.430	-0.340	1.000



A graph of weight an Ponderal index comparing the mean values

Figure 2: Mean values of Ponderal Index and weight.

Discussion

The results of this study align with previous research examining the nutritional status of children in orphanages, particularly those focusing on the use of the Ponderal Index (PI) and other anthropometric measures to assess body composition. The average Ponderal Index of 20.22 found in this study in Table 1 is consistent with norms for prepubertal children, although the high variability in height suggests potential disparities in growth that have been observed in similar institutional settings [21]. Studies [23] have previously highlighted the sensitivity of the Ponderal Index in detecting subtle changes in body composition, making it a valuable tool for assessing the nutritional status of children during growth spurts. In this case, the relatively low standard deviations for weight and Ponderal Index reinforce the consistency of these indicators for monitoring overall nutritional health.

Table 2 shows that the nutritional status of the children at this Orphanage home significantly normal which can be attributed to good nutritional determinants of good food given to

them. The study further analysed the relationship between the Ponderal Index, and their determinants such as dietary intake and physical activity and found that children with higher PI values tended to consume more energy and fat, and had slightly lower physical activity levels compared to their counterparts. The findings show that most children fell within the normal weight category based on Ponderal Index, with only a few classified as overweight which is however, classified as overweight in a large number of the children by Body mass index classification. This discrepancy between BMI and PI suggests that while BMI is useful for identifying general weight categories, the Ponderal Index may better reflect variations in body composition, especially in children, aligning with prior studies that highlight PI as a more sensitive indicator for assessing childhood obesity [24,25].

The absence of a statistically significant difference between weight and Ponderal Index ($p = 0.8551$) seen in Table 4.3 echoes findings from other studies where both metrics have been found to be interchangeable in pediatric populations. However, as with other nutritional assessment tools, the PI and weight alone may not capture all nuances of a child's health, especially in settings like orphanages where external factors such as food quality and psychosocial influences play significant roles in shaping nutritional outcomes [22]. Research conducted [11] similarly emphasized the need for a multidimensional approach when evaluating the health of orphaned children, taking into account environmental, dietary, and psychological determinants.

Physical activity levels as determinants were moderate to high, with most children classified as "moderately active" or "active." The inverse relationship observed between physical activity levels and PI suggests that higher activity levels are associated with healthier weight categories. This finding is consistent with studies indicating that regular physical activity supports healthy weight maintenance and reduces the risk of obesity in children [27,28]. Interestingly, children with higher PIs also tended to have higher energy and fat intake, suggesting that while physical activity levels were generally adequate, dietary patterns may contribute more significantly to excess weight in certain children. This aligns with findings from other studies, which report that both dietary intake and physical activity levels are key determinants of BMI and PI in children [29].

The positive correlation between BMI, PI, and dietary intake in Table 3 suggests that calorie and nutrient intake directly influence the nutritional status of the children. On the other hand, the negative correlation between physical activity levels and BMI/PI supports existing literature that emphasizes the role of physical activity in maintaining an appropriate weight [30]. These findings reinforce the multidimensional nature of child nutrition, which is influenced by a balance of energy intake, physical activity, and genetic factors [31,32].

Moreover, the variability in height observed in this study might point to the same challenges of inconsistent nutrition or inadequate growth support found in other orphanage-based studies [33]. These inconsistencies could be tied to the quality of care, food diversity, and potential health conditions, as noted [16]. This underlines the importance of examining broader systemic issues, such as funding for adequate nutrition and access to healthcare, as proposed [15], to provide a more complete understanding of how orphanages can influence children's growth and development.

This study align with best practices for improving nutritional care in institutional settings. Previous research, including interventions aimed at enhancing dietary diversity and caregiver training, shows positive impacts on children's growth and health outcomes [34]. Similarly, findings [35] demonstrate that nutritional interventions, coupled with regular monitoring and personalized care plans, can substantially improve outcomes for orphaned children. Given the findings here, introducing tailored nutrition programs and regular PI assessments may help address both undernutrition and overnutrition risks in this population.

While this study confirms the reliability of using the Ponderal Index and weight to assess the nutritional status of prepubertal children in orphanages, it also points to the need for broader interventions that address the underlying determinants of health in these settings. More longitudinal research and comprehensive assessments including physical activity and mental health evaluations will provide greater insights into how best to support the nutritional and overall well-being of orphaned children.

Recommendations

Future research should consider larger, more diverse samples and adopt longitudinal designs to better understand how changes in diet, physical activity, and environmental factors over time influence the nutritional status of prepubertal children. Orphanage administrators and healthcare providers should develop tailored nutritional programs to ensure a balanced diet and adequate caloric intake for children in orphanages. This could involve regular nutrition assessments and interventions to correct undernutrition or prevent obesity. More accurate methods of dietary assessment, such as direct observation of meals or using detailed food diaries, should be implemented to

Conclusions

However, the assessment of nutritional status using weight and height measurements provided valuable insights into the growth and health of children in the orphanage. While the majority of children appear to be within a healthy range, the variability in weight indicates that there are potential concerns regarding both undernutrition and overnutrition. These findings highlight the importance of regular monitoring, tailored interventions, and a holistic approach to child care in orphanage settings to ensure all children can achieve their full growth potential

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