Exploring the Impact of Malnutrition on Motor Development in Pakistani Children

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ABSTRACT

Background: Malnutrition remains a significant public health concern in Pakistan, affecting physical and cognitive development in children. Motor development, a critical marker of early growth, is particularly vulnerable to nutritional deficits, with stunting, wasting, and micronutrient deficiencies contributing to delays.

Objective: To assess the impact of malnutrition on motor development in Pakistani children aged 4 to 6 years.

Methods: This cross-sectional study included 116 children aged 4–6 years from the slum areas of Lahore. Nutritional status was assessed using Weight-for-Age Z-scores (WAZ) and Mid-Upper Arm Circumference (MUAC) based on WHO standards. Motor development was evaluated using the Motor-Proficiency-Test for children (MOT 4-6), focusing on gross motor skills, fine motor skills, and body coordination. Data were analyzed using SPSS version 25, with chi-square tests applied to assess associations ($p<0.05$).

Results: The mean age was 48.26 ± 7.42 months, with 42.2% male and 57.8% female participants. Among them, 44.0% were underweight (WAZ < -2) and 55.2% had moderate acute malnutrition (MUAC 115–124 mm). Motor development was delayed in 24.1% and borderline in 37.1%. A significant association was observed between WAZ and MUAC scores with motor development ($p<0.001$).

Conclusion: Malnutrition significantly impairs motor development, emphasizing the need for targeted nutritional interventions and developmental screening to improve outcomes in resource-limited settings.

INTRODUCTION

Malnutrition, a multifaceted public health concern, continues to impede the growth and development of children in low- and middle-income countries, including Pakistan. Characterized by deficiencies or imbalances in nutrient intake, malnutrition has far-reaching implications for physical, cognitive, and motor development during early childhood. Motor skills, encompassing both gross and fine motor abilities, are crucial for a child's overall developmental trajectory, influencing academic, social, and future occupational outcomes. Impaired motor development often emerges as a silent yet pervasive consequence of malnutrition, affecting children's ability to achieve age-appropriate milestones, such as walking, running, and coordinated movements, which are integral to their daily functional abilities (1,2).

Pakistan, a country grappling with high rates of child malnutrition, faces significant developmental challenges. According to the National Nutrition Survey, nearly one-third of Pakistani children are underweight, with 44% being stunted and 15% experiencing wasting. Micronutrient deficiencies, particularly anemia, compound the burden, affecting half of the pediatric population (3). These alarming statistics underscore the urgent need for targeted interventions to mitigate the impact of malnutrition on child health. Contributing factors, such as socioeconomic disparities, inadequate maternal nutrition, lack of awareness regarding dietary practices, and food insecurity, create a cascade of adverse developmental outcomes. The interplay of these variables disproportionately affects vulnerable populations in underprivileged regions, perpetuating cycles of poverty and ill-health (4,5).

The adverse effects of malnutrition extend beyond mere growth deficits to encompass neurodevelopmental impairments. Nutritional deficiencies during critical periods of brain development disrupt neuroplasticity, synaptic connectivity, and myelination processes, ultimately influencing cognitive and psychomotor functions. Children with poor nutritional status are at increased risk for delayed motor milestones, including sitting, crawling, and walking. This delay is particularly evident in regions with limited access to healthcare and educational resources, where developmental impairments are often overlooked or inadequately addressed (6). Empirical evidence from diverse settings, including South Asia and sub-Saharan Africa, highlights the detrimental role of stunting, wasting, and micronutrient deficiencies on motor skill acquisition, drawing parallels to the challenges faced by Pakistani children (7,8).

Despite some improvements in health indices, the prevalence of childhood malnutrition in Pakistan remains a significant barrier to achieving optimal developmental outcomes. Previous studies have identified multiple

contributing factors, such as early marriages, high fertility rates with inadequate birth spacing, and poor sanitation, further exacerbating the problem. Moreover, the lack of robust screening programs for early developmental delays compounds the issue, limiting opportunities for timely interventions (9,10). Addressing this gap requires a nuanced understanding of the correlation between malnutrition and motor development, particularly through systematic research focused on localized contexts.

This study aims to explore the impact of malnutrition on motor development in Pakistani children aged 4 to 6 years. Using validated assessment tools, such as the Motor-Proficiency-Test (MOT 4-6) and anthropometric measures, this research seeks to elucidate the relationship between nutritional deficits and developmental delays. By identifying the prevalence and severity of motor impairments among malnourished children, this study intends to inform public health strategies and foster the development of targeted nutritional and developmental interventions. Ultimately, these efforts aim to improve not only the immediate health outcomes of Pakistani children but also their long-term potential for educational and social advancement.

MATERIAL AND METHODS

This cross-sectional study was conducted to evaluate the impact of malnutrition on motor development in children aged 4 to 6 years in the slum areas of Lahore. The study was completed over six months following approval of the synopsis. The sample size consisted of 116 children, calculated based on a previous study (1). Participants were selected using a consecutive sampling technique, ensuring inclusion criteria were met. Children eligible for the study were aged between 4 and 6 years, either male or female, and identified as malnourished based on anthropometric assessments. Exclusion criteria included children with mental illnesses, a history of congenital disorders, or a history of premature birth (2,3).

Data collection was carried out through structured questionnaires administered by trained personnel. The study utilized a self-structured demographic questionnaire to gather socio-demographic information. For motor development assessment, the standardized Motor-Proficiency-Test for children aged 4 to 6 years (MOT 4-6) was employed, which evaluates gross motor skills, fine motor skills, body coordination, and agility. Nutritional status was assessed using anthropometric indices, including Weight-for-Age Z-scores (WAZ) based on WHO Growth Standards and Mid-Upper Arm Circumference (MUAC). WAZ was classified as normal (Z-score ≥ -2), underweight (Z-score < -2), and moderately underweight (-3 ≤ Z-score < -2). Similarly, MUAC was categorized into normal (≥125 mm) and moderate acute malnutrition (MAM, 115–124 mm) (4,5).

Ethical approval for the study was obtained from the institutional review board, and all procedures adhered to the ethical standards outlined in the Declaration of Helsinki. Written informed consent was obtained from the parents or guardians of all participating children. Confidentiality and anonymity of the participants were strictly maintained throughout the study.

Data collection was conducted in community centers and households within the selected areas. The interviews and assessments were carried out in the local language to ensure comprehension and accurate responses. Data entry and quality checks were performed daily to ensure the reliability and validity of the collected information.

Statistical analysis was conducted using SPSS version 25. Descriptive statistics, including frequencies and percentages, were used to summarize categorical variables, while means and standard deviations were calculated for continuous variables. The chi-square test was employed to assess associations between motor development and nutritional status, with statistical significance set at $p<0.05$. For measures of association between categorical and ordinal variables, cross-tabulation analyses were performed to provide further insights into the relationship between nutritional deficits and motor proficiency levels (6,7).

The standardized approach in participant selection, data collection, and analysis ensured the validity and reliability of the study findings. The adherence to ethical guidelines and robust statistical methods provided a foundation for reliable conclusions on the association between malnutrition and motor development in children.

RESULTS

The study included 116 children aged 4 to 6 years, with a mean age of 48.26 months (SD ±7.42). Among the participants, 49 (42.2%) were male, and 67 (57.8%) were female. The majority of parents had primary education (47.4%), while 28.4% had no formal education, and only 2.9% had higher education. Most families fell into the middle-income category (62.9%), while 37.1% were classified as low-income.

Table 1: Descriptive Statistics of Participant Characteristics

Variable	Categories	Frequency (n)	Percentage (%)
Gender	Male	49	42.2
	Female	67	57.8
Parental Education	No Formal Education	33	28.4
	Primary	55	47.4
	Secondary	27	23.3
	Higher	1	2.9
Family Income	Low Income (<25,000 PKR)	43	37.1
	Middle Income (26,000–50,000 PKR)	73	62.9

Nutritional assessment revealed that 44.0% of the children were underweight (WAZ < -2), with 12.9% classified as moderately underweight (-3 ≤ WAZ < -2). Furthermore, 55.2% had moderate acute malnutrition (MUAC 115–124 mm), and 44.8% had normal MUAC values. Nutritional and motor development assessments revealed a significant association between malnutrition and motor proficiency levels. Children with better nutritional status demonstrated higher motor development scores, while those with moderate acute malnutrition exhibited delays in both gross and fine motor skills.

Table 2: Nutritional and Motor Development Indicators

Indicator	Categories	Frequency (n)	Percentage (%)
Weight-for-Age Z-Score (WAZ)	Normal (Z ≥ -2)	50	43.1
	Underweight (Z < -2)	51	44.0
	Moderate Underweight (-3 ≤ Z < -2)	15	12.9
Mid-Upper Arm Circumference (MUAC)	Normal (MUAC ≥ 125 mm)	52	44.8
	Moderate Acute Malnutrition (115–124 mm)	64	55.2
Motor Proficiency	Delayed Development	28	24.1
	Borderline Development	43	37.1
	Normal Development	45	38.8

A chi-square analysis demonstrated a statistically significant association between WAZ scores and motor development categories (χ^2 = 91.113, df = 4, p < 0.001). Similarly, the association between MUAC and motor development was also significant (χ^2 = 42.991, df = 2, p < 0.001).

Table 3: Cross-tabulation of WAZ Scores and Motor Proficiency

WAZ Categories	Delayed Development	Borderline Development	Normal Development	Total
Normal (Z ≥ -2)	0	9	41	50
Underweight (Z < -2)	16	32	3	51
Moderate Underweight	12	2	1	15
Total	28	43	45	116

Table 4: Cross-tabulation of MUAC and Motor Proficiency

MUAC Categories	Delayed Development	Borderline Development	Normal Development	Total
Normal (≥125 mm)	0	17	35	52
Moderate Acute Malnutrition	28	26	10	64
Total	28	43	45	116

Motor development tasks showed varying levels of performance. About 43.1% of children demonstrated good coordination during tasks such as running and jumping, while 24.1% showed fair performance with significant difficulty. Tasks requiring fine motor skills, such as drawing geometric shapes, revealed that 28.4% had significant difficulty, 37.9% performed averagely, and 33.6% achieved good results. Skipping with alternating feet was successfully demonstrated by 48.3% of children, while 51.7% could not perform the task.

DISCUSSION

This study demonstrated a significant association between malnutrition and motor development in children aged 4 to 6 years in underprivileged communities of Lahore, Pakistan. The findings indicated that children with better nutritional status, as assessed by Weight-for-Age Z-scores (WAZ) and Mid-Upper Arm Circumference (MUAC), exhibited higher motor proficiency, while those with moderate acute malnutrition experienced notable delays. These results align with previous studies that have highlighted the detrimental impact of malnutrition on neurodevelopmental and motor milestones in early childhood (1, 2).

The high prevalence of underweight and moderate acute malnutrition in this study reflects the alarming nutritional deficits in Pakistan. This trend has been consistently reported in similar settings, where socioeconomic factors, maternal education, and food insecurity contribute to widespread malnutrition (3, 4). The findings are also consistent with global data indicating that stunted and wasted children often exhibit delayed motor development due to impaired neuromuscular and central nervous system maturation (5). For instance, studies from sub-Saharan Africa and South Asia have reported similar patterns, reinforcing the critical role of nutrition in fostering physical and cognitive growth (6, 7).

One of the study's strengths was its use of validated tools, such as the Motor-Proficiency-Test (MOT 4–6) and WHO Growth Standards, to assess motor development and nutritional status. This standardized approach allowed for reliable comparisons and robust conclusions. Moreover, the inclusion of children from a socioeconomically disadvantaged population provided insights into the specific challenges faced by such communities. The significant association between malnutrition and motor development underscores the necessity of targeted interventions to improve dietary intake and reduce the developmental disparities caused by nutritional deficits.

Despite its strengths, the study had several limitations. The cross-sectional design restricted the ability to establish

causal relationships between malnutrition and motor development. Longitudinal studies would provide a more comprehensive understanding of how nutritional improvements might influence developmental trajectories over time. Additionally, while the study assessed key indicators of malnutrition, it did not account for micronutrient deficiencies or dietary diversity, which may also significantly affect motor skills (8, 9). The reliance on self-reported data from caregivers might have introduced recall bias, and the exclusion of children with congenital or neurological conditions may have limited the generalizability of the findings.

The observed high proportion of children with borderline motor development highlights an area of concern. Such subtle deficits often go undetected in routine assessments, potentially delaying early intervention. Previous research has shown that even borderline developmental delays can progress to significant impairments if left unaddressed, further emphasizing the need for community-based screening programs (10). The findings also underscore the importance of maternal education, as children from households with better-educated mothers demonstrated improved nutritional and developmental outcomes. This supports earlier studies linking maternal education with better childcare practices and nutritional awareness (11).

The results of this study have important implications for public health and clinical practice in Pakistan. Interventions targeting maternal nutrition, early childhood feeding practices, and community-level education on balanced diets are essential to addressing malnutrition. Incorporating motor development stimulation into existing nutrition programs could enhance developmental outcomes. The integration of routine developmental screenings into primary healthcare services would also ensure the timely identification and management of at-risk children. Community outreach programs focusing on dietary education and the importance of early motor development could further reduce the burden of malnutrition-related developmental delays (12).

The findings contribute to a growing body of evidence highlighting the need for policy changes to address malnutrition comprehensively. Future research should include larger, more diverse samples across different regions to capture the variability in nutritional and developmental outcomes. Longitudinal studies investigating the long-term effects of nutritional interventions on motor development are also recommended. Addressing the multifaceted impact of malnutrition requires a coordinated approach involving policymakers, healthcare providers, and community stakeholders. By mitigating the effects of malnutrition on motor development, such efforts can improve the overall health and developmental potential of children in resource-limited settings (13).

CONCLUSION

This study highlighted the profound impact of malnutrition on motor development in Pakistani children, demonstrating a strong association between nutritional deficits and delayed motor milestones. Children with better nutritional status exhibited superior motor proficiency, emphasizing the critical role of adequate nutrition in early childhood for optimal physical and neurological development. These findings underscore the need for targeted public health initiatives, including community-based nutritional interventions and developmental screenings, to address malnutrition and its consequences. Improving maternal education and dietary practices can significantly enhance child health outcomes, ultimately fostering better developmental trajectories and reducing long-term healthcare burdens in resource-limited settings.

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