

The Effect of Nutritional Status on Cognitive and Motor Development of Pre-School Children

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ABSTRACT. *Sound nutrition during early childhood period is an essential factor for all-round development of the child. The effect of nutritional status on the cognitive and motor development of the preschool children was the focus of the present study. The study was conducted using 100 children aged 36-54 months from five randomly selected preschools in Narahenpita area. The nutritional status was determined using weight and height measurements and the age of the children. The preschool version of the Early Screening Inventory-Revised (ESI-R) was the tool used for measuring the cognitive and motor abilities. Birth weight and socioeconomic data were collected using a questionnaire. The findings indicated that 40% of children in the sample were affected by protein energy malnutrition and the cognitive and motor abilities of these children were lower than that of normal children. The prevalence of underweight, wasting and stunting among these children were 16, 15 and 10%, respectively. Compared to normal children, cognitive abilities were lower in the stunted children whereas fine motor abilities and gross motor abilities were lower in wasted children. Considering the fine motor and cognitive abilities when low birth weight and under nutrition exist together in the same child, the negative effect was worse. Socioeconomic factors such as educational level of the mother, occupational status of the father and the family income were positively associated with the nutritional status of children in these families.*

INTRODUCTION

Greater attention and concern than ever before is now focused on the period of early childhood, which is the most important period when considering the nutritional status of children. Nutrition is found to be a decisive factor in almost all aspects of development of the child in the succeeding years. The preschool age, which is very important in the life cycle of a child, also falls within this period. During the early childhood period the child is vulnerable to diseases and malnutrition, the factors, which affect proper growth and development as well as day-to-day physical and mental functions.

Children gain skills and abilities according to a pattern related to their chronological age and there are critical developmental periods which provide readiness for gaining

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appropriate abilities (Meisels *et al.*, 1997). Abilities appropriate to age of preschool children are of two major types, *i.e.* cognitive abilities and motor abilities. If the children miss the opportunities of normal development due to influences of environmental factors they undergo the risk of future retardation. The undernourished children decrease their activity levels and become more apathetic. This in turn affects their social interactions and cognitive functioning (Larry Brown and Pollitt, 1998). The effect of undernutrition on cognition may occur even without having clinical signs of undernutrition but with retarded growth. Most of food supplementation experiments in developing countries are aimed at non-severely malnourished children (World Bank, 2004).

The UNICEF and the Government of Sri Lanka have initiated the Integrated Early Childhood Care and Development Program in 2002 with the objective of establishing the full potential of children by improving survival, nutrition and maximizing cognitive development and psychosocial development (Bekele, 2005). In line with this objective the present study aims at finding out how the age-appropriate cognitive and motor abilities develop in preschool children of different nutritional status.

In Sri Lanka, each year around 33,000 children enroll in formal school at the age of 5 years (Central Bank of Sri Lanka, 2004). Among them the majority are normal children. Nevertheless there are considerable numbers of children with learning disabilities, handicaps and those subjected to various deprivations. As a result of different levels of abilities in these children, problems are created in the classroom teaching-learning activities. These children need preventive as well as remedial interventions. A national policy on care and development of the young child is now being formulated with government initiatives. As such its time to look into the extent of the influence of nutritional factors on the young child in gaining developmental abilities appropriate to age. In this background the present study focuses on the effect of nutritional status on the development of cognitive and motor abilities of preschool children (36-54 months) and the relationship between their socioeconomic status and the nutritional status.

MATERIALS AND METHODS

Study subjects

Six preschools from Narahenpita area in the Colombo District were selected representing 10% of the total number of preschools in the area. A factor considered in selecting the schools was the number of children in the school within the age range of 36-54 months, which is the age range recommended by 'Early Screening Inventory-R' (Meisels *et al.*, 1997), which was the tool adopted in this study. The preschools that had an enrolment of more than 25 children between the ages of 36-54 months were considered for the final selection of the study sample. Out of the 6 selected schools, one was dropped due to insufficient sample size and the final sample consisted of five schools. Twenty children in the specified age range were selected randomly from each selected preschool.

Anthropometric screening

Height was measured in centimeters with a non-stretchable tape to the nearest 0.1 cm. Tape was fixed on to a leveled board with a horizontal base. The investigator took measurements with the assistance of a trained helper. When the child's position was correct

(line of sight parallel to the ground, heels and calves against the wall) the upper limit was marked by placing the ruler on the highest position of the head with enough pressure to compress hair (hair clips, ribbons, *etc.* were removed before taking the measurement). Weight was measured with an electronic weighing scale to the nearest 0.01kg. The scale was placed on a flat and even surface and the child was weighed with minimum clothing and bare-footed.

Age of the child was calculated to the nearest month considering the day on which measurements were taken. The date of birth of the child was obtained from the register of the preschool, recorded by referring to the birth certificates of the respective children.

The information on birth weight of the child, educational level and the occupation of the mother, occupation of the father and total monthly income of the family was collected using a pre-tested questionnaire administered to the mothers of the study sample.

The early screening inventory for preschool children (ESI-P)

Instruments specially prepared for the measurement of abilities of young children, for research purposes, are scarcely available in Sri Lanka. A recent research carried out by Talagala (2004) has focused on cognitive and motor abilities of preschool children in relation to age appropriateness. The tool used to measure the age-appropriate abilities of preschool children was the Early Screening Inventory for Preschoolers (ESI-P) which is a revised version of the Early Screening Inventory-Revised (ESI-R), the original instrument developed by Miesels *et al.* (1997) in the USA. Miesels S.J., the main developer of the instrument, is known as an expert in early childhood education and assessment in the United States.

Relevance of the ESI-P tool for measuring cognitive and motor abilities of preschool children

The ESI-P tool (Talagala, 2004) was used to measure the cognitive and motor abilities of preschool children in this study. This tool has already been modified to suit local conditions and has been validated by local experts/educationists and also piloted with Sri Lankan preschool children of the same age.

In application of the tool, children were taken individually, screened for each and every task in the tool and scores were given. Abilities were tested with the guidance of an educationist of the Department of Early Childhood Education and the assistance of preschool teachers. The investigator and the assistants were given a preliminary training to use the instrument prior to the commencement of the study. In the present study the whole instrument was not used and only those items, which measure cognitive and motor skills were selected.

Statistical Analysis

Children were assigned to 4 groups as normal, underweight, wasted and stunted according to cutoffs of WHO using EPI Info-6 software on the basis of z-scores of weight-for-age, weight-for-height and height-for-age. A child whose weight-for-age below -2 Z scores from the median of the WHO/NCHS reference population was classified as underweight and a child with weight-for-height below -2 Z scores from the median of the WHO/NCHS reference population was classified as wasted. Similarly a child with height-

for-age below -2 Z scores from the median of the WHO/NCHS reference population was considered as stunted. Score for each ability and the results of the questionnaire were analyzed using the statistical package SPSS 11.5 for Windows.

RESULTS AND DISCUSSION

Nutritional status of the study sample

In the study sample 40% of children were affected by Protein Energy Malnutrition (PEM) estimated according to WHO reference. Children who were affected by PEM performed significantly lower ($p < 0.05$) than normal children for cognitive abilities and fine motor abilities (Table 1).

Table 1. Cognitive and motor abilities of normal and PEM children.

| Nutritional status of children | Sample size * | Mean score (\pm SD) | | |
|--------------------------------|---------------|-------------------------------|-------------------------------|-------------------------------|
| | | Cognitive | Fine motor | Gross motor |
| Normal | 56 | 67.7 ^a \pm 17.1 | 72.7 ^a \pm 19.8 | 70.1 ^a \pm 26.2 |
| With PEM | 38 | 59.7 ^b \pm 15.2 | 62.2 ^b \pm 15.6 | 65.6 ^a \pm 22.9 |
| Underweight | 15 | 62.2 ^{ab} \pm 17.2 | 61.1 ^{ab} \pm 14.3 | 68.7 ^{ab} \pm 19.9 |
| Wasted | 14 | 57.5 ^{ab} \pm 08.9 | 57.4 ^b \pm 14.5 | 54.1 ^b \pm 25.1 |
| Stunted | 9 | 56.7 ^b \pm 13.5 | 60.9 ^{ab} \pm 15.3 | 55.3 ^{ab} \pm 21.4 |

Note: * the total sample included six overweight children and they were not used for the study; Mean values bearing the same superscript within a column are not significant ($p > 0.05$).

Effect of type of PEM on cognitive abilities

Based on types of PEM, the prevalence of underweight, wasting and stunting in the sample was 16, 15 and 10%, respectively. The mean score for cognitive abilities was significantly lower ($p < 0.05$) in the stunted children than the normal children (Table 1). Michaelson *et al.* (2000) stated that early nutritional stunting is associated with impaired cognitive function and school performances and delayed motor development. Present study also provides evidence that stunting has an effect on the development of cognitive abilities. These data confirm the previous findings that even sub-clinical PEM, as reflected by stunting, can have an effect on learning and behavior (Talagala, 2004). Furthermore, the results also show a tendency to have low cognitive abilities among the wasted children. Although an association between underweight and cognitive abilities was not evident in this study, in both Mexico and Guatemala, it was found that preschool children in the lowest quartile of weight-for-age had significantly poorer performances on various tests of inter-sensory perception compared to children in the highest quartile (Cravioto *et al.*, 1966).

Effect of type of PEM on motor abilities

Fine motor abilities

Fine motor controls are the ability to co-ordinate or regulate the use of eyes and hands together to produce precise, efficient and adaptive movements (Landers, 1994). The mean score for fine motor abilities obtained by the children affected by PEM was significantly lower ($p < 0.05$) than that of normal children (Table 1). Based on types of PEM, the fine motor abilities of wasted children were significantly lower than that of normal children (Table 1). Stunted and underweight children also showed a tendency to reduce fine motor abilities compared to normal children even though the differences were not significant. Therefore, the present study provides evidence to an association between the nutritional status and the development of fine motor abilities appropriate to the age of preschool children.

Gross motor abilities

Gross motor activities are body movements using parts of the body with large muscles (Landers, 1994). The present study indicated a lower gross motor ability in wasted children ($p < 0.05$) than in normal children (Table 1). Stunted children also showed a tendency to lower gross motor abilities. However, there was no evidence of lowering gross motor abilities with the underweight children. Wasting was a reflection of the magnitude of acute dietary shortage and/or disease process that produced substantial weight loss at the time of the study. These results indicate that the nutritional status had affected the development of gross motor abilities of the children in the study sample.

Birth weight, nutritional status and cognitive and motor abilities

The mean birth weight of the study sample was 3103 g (± 592). The prevalence of low birth weight (LBW) was 16% and this data is compatible with the prevalence of LBW (15%) reported by SLDHS, 2000. The LBW was higher among the children affected by current PEM (26%) than among normal children (12%). Among the LBW children, 50% were affected by current PEM (no catch up growth) while this figure was only 27% for the normal birth weight children. This finding indicates a greater chance for the development of PEM in LBW children compared to normal birth weight children. It was also observed that about half of the LBW children in the study sample had been able to grow well after birth and recover.

The fine motor abilities were higher in the children who have no current PEM irrespective of whether they were born with low birth weight or not. Among the children affected by current PEM, the fine motor abilities were significantly lower ($p < 0.05$) in LBW children than in normal birth weight children (Table 2). These findings indicate that even though the birth weight was low, if the children were to obtain good nutrition later, those children would be able to perform better. However, even though the birth weight was normal, if the nutritional status had deteriorated later (current PEM), it would have an effect on the development of fine motor abilities. When LBW and PEM exist together, the negative effect on the fine motor abilities were high. However, such a relationship could not be observed with gross motor or cognitive abilities.

Table 2. Relationship among birth weight, current nutritional status and cognitive and motor abilities.

| Birth weight type and current nutritional status | n* | Cognitive and motor abilities (Mean \pm SD) | | |
|--|----|---|------------------------------|------------------------------|
| | | Fine motor | Cognitive | Gross motor |
| Low birth weight children with PEM | 6 | 48.7 ^a \pm 16.1 | 60.0 ^a \pm 17.8 | 66.7 ^a \pm 10.2 |
| Normal birth weight children with PEM | 17 | 64.5 ^b \pm 14.6 | 60.9 ^a \pm 13.4 | 59.6 ^a \pm 24.4 |
| Low birth weight children with no PEM | 6 | 83.3 ^b \pm 16.7 | 66.7 ^a \pm 10.3 | 58.7 ^a \pm 2.5 |
| Normal birth weight children with no PEM | 45 | 70.4 ^b \pm 21.6 | 67.0 ^a \pm 17.8 | 72.3 ^a \pm 7.9 |

Note: n - sample size, * of the total sample birth weight of 20 children could not be verified; Mean values bearing the same superscript within a column are not significant ($p > 0.05$).

According to these data, LBW alone has no independent effect on the development of cognitive and motor abilities. King and Burgess (1995) reported that although LBW children had more tendencies to develop PEM, they had a chance for catch-up growth and develop their abilities. If those babies get enough breast milk, they would be able to grow very fast soon after birth and show catch-up growth reaching a weight within the normal range for their age within 6-9 months.

Socioeconomic factors and nutritional status

Educational level of mother

In the present study, the prevalence of PEM was higher among the children whose mothers were educated up to G.C.E O/L as compared to mothers educated up to GCE A/L and above ($p < 0.05$). Among the different PEM categories, stunting and underweight were lower in the children whose mothers' education was up to G.C.E A/L and above whereas wasting did not differ among the two maternal education categories ($p > 0.05$, $X^2 = 0.65$) (Table 3). According to the SLDHS 2000, mother's education has a milder influence on wasting than on stunting of preschool children and mother's education could bring about a noteworthy reduction in the incidence of underweight in preschool children (RETA 6007, 2003). The results of the present study are also in agreement with this finding.

Occupation of the mother

Mothers' occupational status had not affected the nutritional status of their children, according to the results of the present study (Table 3). A similar finding was reported by Chandrasekara *et al.* (2005) who explained that the mother substituted childcare system (care from grandparents) adopted by the Sri Lankan families might have masked any effect of mothers' employment on the nutritional status of children.

Occupation of the father

A higher prevalence of PEM among preschool children was observed in the group of lower paternal occupational status based on the occupational prestige scale (Gunawardena, 1990). Among the three occupational status categories, the prevalence of stunting and wasting was high among children of lower paternal occupational status (Table 3). Interestingly, stunting and wasting were not seen among the higher paternal occupational class, although some underweight children were observed. However, the sample size for higher occupational class is too small to draw any conclusion regarding its effect on the type of PEM.

Income level of the family

Income level has a close association with the occupational status. Children of all four nutritional categories were identified from middle (Rs. 10,000-15,000) and lower (< Rs. 10,000) monthly income families with a higher prevalence of PEM also in these two groups. Among the children belonged to higher income group (> Rs. 15,000) stunting and wasting were not observed although there were some underweight children (Table 3). However, the sample size is insufficient to make any conclusion regarding the type of PEM prevalent in the higher income families.

Table 3. Relationship among socioeconomic factors, nutritional status and cognitive and motor abilities.

| | Educational level of mother | | Occupation of mother | | Occupational status of the father (OPS, 1980) | | | Monthly total income (Rs.) | | |
|-----------------|-----------------------------|---------------------|----------------------|--------------|---|------------------------|----------------------|----------------------------|--------------|--------------|
| | Up to G.C.E O/L | G.C.E A/L or higher | Employed | Un Employed | Higher (Class I & II) | Middle (Class III & V) | Lower (Class V & VI) | Higher | Middle | Lower |
| Total | 60 (63.8) | 34 (36.2) | 26 (27.7) | 68 (72.3) | 9 (9.6) | 28 (29.8) | 57 (60.6) | 14 (14.9) | 23 (24.5) | 57 (60.6) |
| Normal | 32 (53.3) | 24 (70.6) | 14 (53.8) | 42 (61.8) | 7 (77.8) | 19 (67.9) | 30 (52.6) | 12 (85.7) | 13 (56.5) | 31 (54.4) |
| PEM | 28 (46.7) | 10 (29.4) | 12 (46.2) | 26 (38.2) | 2 (22.2) | 9 (32.1) | 27 (47.4) | 2 (14.2) | 10 (43.5) | 26 (45.6) |
| ST | 7 (11.7) | 2 (5.9) | 2 (7.7) | 7 (10.3) | 0 (0.0) | 2 (7.1) | 7 (12.3) | 0 (0.0) | 2 (8.7) | 7 (12.3) |
| W | 10 (16.7) | 4 (11.8) | 6 (23.1) | 8 (11.8) | 0 (0.0) | 2 (7.1) | 12 (21.1) | 0 (0.0) | 5 (21.7) | 9 (15.8) |
| UW | 11 (18.3) | 4 (11.8) | 4 (15.4) | 11 (16.2) | 2 (22.2) | 5 (17.9) | 8 (14.0) | 2 (14.2) | 3 (13.0) | 10 (17.5) |
| Mean FMA | 64.3 | 74.2 | 65.0 | 73.1 | 73.4 | 70.1 | 64.5 | 73.5 | 70.0 | 65.2 |
| Mean CA | 66.6 | 64.2 | 65.8 | 66.0 | 58.6 | 64.2 | 66.0 | 67.0 | 60.8 | 67.6 |
| Mean GMA | 71.3 | 62.8 | 68.0 | 70.3 | 55.0 | 70.9 | 68.9 | 72.0 | 72.2 | 67.7 |

Note: Figure within the parenthesis refers to the percentage of the total in each category. ST - stunted; W - wasted; UW - underweight; FMA - fine motor abilities; CA - cognitive abilities; GMA - gross motor abilities.

It is not surprising to find undernourished children even among high social class families, which would have been due to a number of reasons such as low attention to the diet of children and poor nutritional knowledge of parents, which were not investigated in this study.

Socioeconomic factors and cognitive and motor abilities

The mean score for fine motor abilities of children belonged to mothers educated up to G.G.E O/L and below, was lower than that of the children belonged to mothers educated up to G.C.E A/L or higher. However, there was no clear relationship observable between cognitive and gross motor abilities and mother's educational level (Table 3). There was no evidence for an association between parents' occupational status and monthly family income with the development of age-appropriate abilities in children.

CONCLUSIONS

This study indicated that cognitive abilities and motor abilities would be lower in the preschool children affected by undernutrition. Children with current PEM and low birth weight would be the worst affected. Chronic under nutrition (stunting) resulted in lowering the development of cognitive ability while the acute under nutrition (wasting) affected fine motor and gross motor abilities. Socioeconomic factors such as educational level of mother, occupational status of father and family income had a positive effect on the nutritional status of children. It is evident from this study that nutritional status is a crucial factor for the development of cognitive and motor abilities of the children of preschool age. These findings could serve as a foundation to plan remedial measures needed for the care and attention for children in this age group.

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