INTRODUCTION

A balanced diet, able to provide sufficient nutrition, leads to a good state of health (Vieira et al., 2020). Malnutrition specifically affects children below the age of 6 years with symptoms concerning physical to cognitive involvement. It affects the child during the most important developmental phase, which can result in permanent impairment in later life (Bhutia, 2014). In India, child malnutrition accounts for 22 per cent of the country’s disease burden (Gragnolati et al., 2005). Protein Calorie Malnutrition (PCM) or Protein Energy Malnutrition (PEM) is a prevalent...
Nutritional disorder in developing countries, especially in India. According to the National Family Health Survey (NFHS-3) conducted in 2005-06, 40 per cent of children under the age of three in India are underweight, 45 per cent are stunted, and 23 per cent are wasted. Comparable NFHS-2 (1998-99) estimates are 43 per cent, 51 per cent, and 20 per cent respectively (Debnath and Parulekar, 2014).

Nutrition has a significant effect on the development of brain structure and function, and malnutrition may contribute to disease and developmental impairment in later life (Dauncey and Bicknell, 1999). Particularly significant is the impact of early nutrition on hippocampus growth, which is essential for memory and learning, and hence cognitive performance (Dauncey and Bicknell, 1999; Matariya et al., 2016). Evidence suggests that cognitive performance can be improved through early feeding, and recent advances in cognitive neuroscience and developmental neurobiology have suggested multiple mechanisms that mediate this effect (Dauncey and Bicknell, 1999). Evidence on the neurochemical, neurophysiological, and behavioural impact of PEM has shown that restricted diets in early development impair the division of brain cells, disrupt myelination, and decrease their output in learning tasks relative to controls fed ad libitum. Malnutrition induces brain growth retardation and changes in dendritic arborization. During early growth, the germinal neuron population is inactive, rendering it difficult to produce new neurons if the sub-stratum is only available after the crucial time has elapsed (Matariya et al., 2016; Bhutia, 2014). Malnutrition can result in a decrease in the number and size of the anterior horn cells and degenerative changes in the spinal cord. This condition was named ‘kwashiorkor myelopathy’. In PEM, the velocity of motor nerve conduction is found below. The minimum duration of admission to the paediatric ward was 2 weeks and anthropometric parameter along with developmental assessment was performed 1 week following complete recovery from acute illness and establishment of feeding.

**Aim**

The purpose of the research was to determine the relationship of protein-energy malnutrition with motor development and cognition among malnourished children.

**MATERIALS AND METHODS**

**Study design and site**

This research was designed as a cross-sectional observational study of a prospectively recruited paediatric population admitted to the Department of Pediatrics of the Acharya Vinobha Bhave Rural Hospital at Sawangi, Wardha, India.

**Sample characteristics and size**

The study sample consisted of 273 male and female children aged 6 to 60 months enrolled at the in the city of Wardha, state of Maharashtra, India. The study included the children between 6 months to 5 years with Grade II, III, IV (as per IAP classification) malnutrition, who were admitted in the paediatric ward, and excluded those with Neurological problems, syndromes and chronic diseases affecting development. The minimum duration of admission to the paediatric ward was 2 weeks and anthropometric parameter along with developmental assessment was performed 1 week following complete recovery from acute illness and establishment of feeding.

**Procedure**

Dietary history was asked in details from the parents of the children. The method used for the calculation of the diet was “24 hours recall with emphasis on the diet of a representative day” (Hupp and Jewell, 2019). Test weighing of the child before and after breastfeeding for one day in children on breastfeeding was noted for calculation of calories from breast milk. Calories and proteins were measured and were compared with total calorie, and protein intake recommended for each age and deficit was calculated. Developmental assessment of patients was done using DASII (Developmental assessment of Indian infants) scale minimum 1 week after recovery of the child from acute illness (National Family Health Survey, 2005). If the child was not cooperative, it was postponed to the next day. In this motor and mental development was assessed according to the manual. Total mental and motor scores were considered and based on this the developmental and deviation quotient were calculated. All the above information was entered in a pre-tested and validated proforma.

**Statistical analysis**

Results for quantitative variables are presented as...
mean and standard deviation, and for qualitative variables as percentages. Pearson's chi-square test was used for calculating the statistical significance. Developmental Assessment was done using DASII scale, which is an Indian version of Bayley's scale. From this group those conditions, which can affect development has been removed. Hence, the total number where DASII scale was applied is 273. As a 50% pass level has been taken normal so for calculation purpose, 91-100% of a quotient is considered as normal for both development and deviation. A statistical significance level of p < 0.05 was determined. The software version SPSS Statistics 17.0 was used for the data analysis.

RESULTS AND DISCUSSION

The developmental assessment was done using DASII scale in 273 children. Only 14.80% of children had normal mental DQ in grade II, whereas motor DQ was normal in 29.78% of grade II children. None of the patients with grade III and IV had normal mental or motor DQ. Developmental mental quotient was more frequent and severely affected than motor quotient in all the grades of malnutrition and both worsened as the severity of malnutrition increased (P<0.0001). About 34.57% of grade II patients had a normal motor deviation quotient (above 90) whereas none of the malnourished children had a normal mental deviation quotient. None of the patients with grade III and IV had normal mental or motor deviation quotient. Deviation in mental quotient was more common than the motor in all the grades of malnutrition and deviation increased with increasing severity (P<0.0001). About 72.16% of malnourished children had motor DQ below 90%, 29.78% of children with grade II malnutrition had DQ between 91-100% and none was below 50%, and the children in grade III and IV had DQ below 90%. 26.66% of children in grade III had DQ less than 50%, indicating that malnutrition affects motor milestones and involvement increases with severity. The results showed that grade II patients were having good developmental motor score in comparison with grade III and grade IV (P<0.0001). Table 1 shows the relationship between motor Deviation Quotient and Malnourished children, wherein only 34.57% of grade II children had motor deviation quotient near 100(at par) while all the children in grade IV and 38.66% of the children grade III had deviation quotient below 50. Grade II patients showed less deviation of motor score from normal in comparison with grade III and grade IV(P<0.0001). Grade IV patients showed more deviation in comparison with other grades. These results showed that the severity of malnutrition leads to more deviation from normal, and no child was above Par.

Table 3 shows the relationship between mental Developmental Quotient (DQ) and Malnourished children, wherein only 14.89% of malnourished children had their score between 91-100%. Grade II patients presented good developmental mental score in comparison with grade III and grade IV (P<0.0001). None of the children of grade II had mental quotient <50% whereas in grade III 38.66% of children had mental DQ below 50%. In grade III and IV, none of the children had a score above 90%. If we compare motor and mental quotient, mental affection is more than motor as in motor scale 29.78% were normal, who were in grade II, whereas in mental scale only 14.89% were normal, who were in grade II. The mean scores of abnormal children in grade II were 79.07, in grade III was 66.78, and grade IV was 54.06. This shows that performance came down with increasing severity. Table 4 shows the relationship between Deviation Quotient (Mental) and Malnourished children, wherein none of the patients had deviation quotient between 91-100. All of the malnourished children had deviation quotient below 90. Deviation of the mental score was more severe and frequent as compared to motor score. Frequency of poor mental quotient deviation increased with the severity of malnutrition. All grade IV children had a severe deviation.

Malnutrition is very common in developing countries like India. The complications may be related to developmental delay and hence they tremendously increase the magnitude of the problem. As per NFHS 3, (National Family Health Survey, 2005) overall prevalence of malnutrition in India is 40% and wasting was found to be 23%. This shows whatever malnutrition we get in hospital is only the Tip of Iceberg and rest lies in the community. A nationwide study of malnutrition in the hospitalized patient was done in Netherland and they found a prevalence of 20% whereas in other European countries it varied from 14-24% (Sullivan, 2010). This difference from ours may be due to less frequent utilization of the facility. Using DASII scale, Motor development was found to be affected in 72% of malnourished children and more severe was the malnutrition more children

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Table 1: Showing the relationship between Developmental Quotient (Motor) and Malnourished children

| Quotient (%) | Grade II Patients | Grade III Patients | Grade IV Patients |
|--------------|-------------------|--------------------|-------------------|
|              | Mean Score and Range | Mean Score and Range | Mean Score and Range |
| 0-50 (n=20)  | 00 (00%)          | 20 (26.66%)        | 00 (00%)          |
|              | 0 (00%)           | 46.66 (44.18-52.10)| 00 (00%)          |
| 51-90 (n=197)| 132 (70.21%)      | 55 (73.33%)        | 10 (100%)         |
|              | 80 (72.5-87)      | 72.83 (57-84.16)   | 56 (48.11-61.10)  |
| 91-100 (n=56)| 56 (29.78%)       | 00                 | 00 (100%)         |
|              | 93.74 (92.08-95.42)| 00                 | 00 (100%)         |
| >100 (n=273) | 00                 | 75                 | 10                |

$X^2=120.7, P<0.0001, \text{Significant}$

Table 2: Showing the relationship between Deviation Quotient (Motor) and Malnourished children

| Quotient (%) | Grade II Patients | Grade III Patients | Grade IV Patients |
|--------------|-------------------|--------------------|-------------------|
|              | Mean Score and Range | Mean Score and Range | Mean Score and Range |
| 0-50         | 00 (00%)          | 29 (38.66%)        | 10 (100%)         |
| 51-90        | 123 (65.42%)      | 46 (61.33%)        | 00                |
| 91-100       | 65 (34.57%)       | 00                 | 00                |
| >100         | 00                 | 00                 | 00                |
| Total (n=273)| 188                | 75                 | 10                |

$X^2=242.8, P<0.0001, \text{Significant}$

Table 3: Showing the relationship between Developmental Quotient (Mental) and Malnourished children

| Quotient (%) | Grade II Patients | Grade III Patients | Grade IV Patients |
|--------------|-------------------|--------------------|-------------------|
|              | Mean Score and Range | Mean Score and Range | Mean Score and Range |
| 0-50         | 00 (00%)          | 29 (38.66%)        | 00 (00%)          |
| 51-90        | 160 (85.10%)      | 46 (61.33%)        | 10 (100%)         |
| 91-100*      | 28 (14.89%)       | 91.33 (91.02-93)  | 54.06 (51.67-58.02) |
| >100         | 00                 | 00                 | 00                |
| Total (n=273)| 188                | 75                 | 10                |

$X^2=117.4, P<0.0001, \text{Significant}$
Table 4: Showing the relationship between Deviation Quotient(Mental) and Malnourished children

| Quotient | Grade II Patients | Grade III Patients | Grade IV Patients |
|----------|------------------|--------------------|------------------|
| 0-50     | 67 (35.63%)      | 58 (77.33%)        | 10 (100%)        |
| 51-90    | 121 (64.36%)     | 17 (22.66%)        | 00               |
| 91-100   | 00               | 00                 | 00               |
| >100     | 00               | 00                 | 00               |
| Total (n=273) | 188              | 75                 | 10               |

X²=102.1, P<0.0001, Significant

had DQ below 90%. Grantham-McGregor et al in 1978 found that DQ is lower at admission in malnourished children and improves with improving nutrition. We have not seen the development after treatment in this study (Grantham-McGregor et al., 2008). Agrawal et al (Agarwal et al., 1992) used Gesell's inventory for motor, adaptive, language, and personal social areas and found DQ decreases with the severity of malnutrition in all areas except personal social. El-khayat H et al used BSID II and found definite neurodevelopment problem in malnourished children. Deviation from normal Tables 1 and 2 also increased with increasing severity of malnutrition in this study (El-khayat et al., 2007; Cakir et al., 2019).

Most studies found like us that mental scores are more affected than motor (El-khayat et al., 2007; Grantham-McGregor et al., 2008; Kar et al., 2008). Some found the duration of malnutrition and lower age of the child also was associated with cognitive delay (Udani, 1992). Children with early age malnutrition, when followed up, found to have lower IQ, poor cognitive function, and behavioural problems during school age (Grantham-McGregor, 1995). Bhoomika and Shobhini used NIMHANS neuropsychological battery and found ongoing cognitive development is affected in stunted children (Kar et al., 2008). Wechsler's scale was used by Agrawal and Upadhyay and found poor performance in many tasks in malnourished children (Agarwal et al., 1992). Liu and Raine (Liu and Raine, 2006) described externalizing behaviour in these children. Most of the above studies found more severity with increasing duration and severity of malnutrition (Owor et al., 2000). These findings (Tables 3 and 4) suggest that mental delay and behavioural problems are common in malnourished children.

CONCLUSIONS

The research demonstrates a significant relationship between malnutrition and developmental status of the malnourished children. Malnutrition affected mental development more than motor development, and the impact increases with increasing severity. When the motor and mental quotients were compared, mental affection was more than the motor. The mental and motor performance reduces with the increase in the severity of malnutrition. The deviation of the mental score was more severe and frequent than the motor score. The frequency of poor mental quotient deviation increased with the increase in the severity of malnutrition. These findings will guide further studies in the direction of improving the nutritional status and development of children.

Funding Support

There was no direct funding from any private or public organizations. DMIMS University provided necessary aids for the research.

Conflict of Interest

The authors have no conflicting interest for this study.

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