

## Study of ankle reflex grades in protein energy malnourished children aged between 1 and 5 years

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### ABSTRACT

**Background:** Malnutrition among children is a major health issue throughout India and South East Asia presenting with stunting and wasting. Many research studies have been conducted to establish the signs, symptoms, corresponding effects of malnutrition on child health, growth, and development. **Objective:** The objective of the current study is to find a difference in grading of Ankle reflex between children with Protein Energy Malnourishment (PEM) and normal healthy subjects. This will help draw a conclusive relationship between hyporeflexia and PEM. **Methods:** The study design is an observational case-control type of study conducted in two teaching hospitals in India. Cases of PEM ( $n = 30$ ), children with Mid Upper Arm Circumference (MUAC)  $<12.5$  and weight for height Z score (WHZ) score of lesser than  $-2$  along with control group of normal healthy children ( $n = 30$ ), all aged between 1 and 5 years were selected for the study. Ankle reflexes were noted using a simple knee hammer on 3 consecutive days of cases and control group, graded based on the NINDS Reflex Grading Scale to determine any differences between cases and controls. **Results:** A Chi-square test was performed and a P value result of 0.002 was obtained rejecting the null hypothesis which states that there is no relation between ankle reflex grades and presence of malnutrition. **Conclusion:** A conclusion could be drawn where a significant association was observed between lower ankle reflex grades and cases of PEM as compared to those noted in the control group. The Achilles Tendon reflexes obtained from cases was significantly reduced. Eliciting the Deep Tendon reflexes and drawing a relation with PEM children can be used as an initial diagnosis for neurological deficits associated with PEM.

**Key words:** Ankle reflex grades, PEM in India, Protein energy malnourishment, Reflexes and PEM, Severe acute malnutrition

Major parts of Africa and Asia including India witnesses lack of proper balanced and nutritious diet for its young citizens. The National Family Health Survey 5 in India states that 35.5%, 19.3%, and 7.7% of children under the age of 5 years are stunted, wasted, and severely wasted, respectively. Hence, there is a dire need for studies related to Malnutrition in India. Undernutrition leads to a widespread public-health issue called protein-energy malnutrition (PEM) in children during very crucial stages of their development [1] and is also a cause of child mortality [2]. It may lead to lifelong impairments including susceptibility to infections like HIV. Children with PEM are generally underweight, have stunted growth and have moderate to severe muscle wasting [3]. Muscle wasting is seen due to the extraction of amino acids needed for the functioning of the body from muscle proteins. Since skeletal muscle bulk is affected, there might be an influence on the deep tendon reflexes. One important

method of diagnosing PEM is by measuring the mid-arm circumference [4] which tends to be reduced due to significant muscle wasting. An observation of the any deep tendon reflex in patients with PEM could be fruitful.

In a certain study on rats with progressing PEM, they displayed muscular dysfunction [5]. However, studies on humans in this aspect have been limited. It is known that neuromuscular diseases which include muscular dysfunctions elicit altered deep tendon reflexes [6]. Hence, a study eliciting deep tendon reflexes in PEM might yield a useful observation for follow-up in PEM patients for future neuromuscular disorders.

Deep tendon reflexes are elicited using a simple knee hammer and have been proven to be reliable in certain studies [7] while have been questioned due to its subjective nature in others [7]. However, it remains an important tool for diagnosis amongst most medical practitioners. In this study the conventional methods to elicit ankle reflex will be used [7]. The current study was conducted in 60 children, 30 malnourished and 30 healthy

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children. Among the malnourished children, six children were severely malnourished while 24 children were moderately malnourished.

**MATERIALS AND METHODS**

This case-control study was conducted at the paediatric out-patient and in-patient blocks of two teaching hospitals in Hyderabad, India between April 2021 and June 2021. This research project was carried forward after obtaining the Institutional Ethics Committee Approval of both these hospitals and taking written consent from guardians of subjects who were aged between 1 and 5 years during the research study.

Children aged between 1 and 5 years who were recently diagnosed with PEM, based on MUAC value of <12.5 cm, and WHZ score of -2 or less and non-rehabilitated were chosen as cases excluding any neurological, neuromuscular, neuro-psychiatric disorders, muscle wasting disorders, genetic disorders, paralyzing disorders following Cerebro-Vascular Accidents, Spinal cord trauma or muscular trauma and children with metabolic disorders were excluded from the study. Control group included healthy children from the age group of 1 to 5 years.

The basis of diagnosis of PEM in the 30 children chosen as cases is as follows:

- Complete and detailed medical history of the child and the child’s dietary history.
- Complete physical examination and measurements of anthropometric indices.
- MUAC value of <12.5 cm [8,9].
- Plasma Total albumin of <3.8 g/dl [10].

Every child was examined on three consecutive days and the grades of their ankle reflex were noted against the numbers assigned to them. The ankle reflex of the healthy children in the control group was also monitored.

The reflexes were graded according to the following conventional observations in the NINDS scaling [7].

Description	Score
No reflex appreciated	0
Mild reflex seen, lesser than expected: trace response maybe present which maybe brought about by reinforcement only	+1
Reflex seen in lower half of normal expected range	+2
Reflex seen in upper half of normal expected range	+3
Exaggerated reflex/hyper reflex: A clonus is included	+4

For eliciting the reflex, a taylor reflex hammer was used and the broad end of the rubber head was stroked on the Achilles tendon of the leg with the feet dorsiflexed. Every day, the reflex was elicited thrice with gaps of 10 min on both the legs of the subject. Hence, the total number of reflex grades noted from every subject was 18, 9 from the right limb and 9 from the left. In the study, mode reflex grade was used as a measure of central tendency.

The Ankle reflex had been chosen for this study because it is a reliable screening tool for peripheral neuropathy as indicated

by certain studies [11] and reflex grading of lower extremities is more reliable as compared to upper extremities [12]. It is also an easily demonstrable and interpretable deep tendon reflex.

**Statistical Analysis**

The statistical tool, SPSS was used to analyze and tabulate the data into appropriate representations. To draw a relationship between reflex grades of cases and controls, a Chi-square test was applied. *P* < 0.05 was considered statistically significant.

**RESULTS**

Children belonged to two age groups, the toddler group consisting of children aged 1–3 years and the school going age group from 3–5 years. 19 malnourished children were toddlers, while 11 malnourished children belonged to the school going age group. In the control group, 17 children were toddlers while 13 children were school going. 14 females who were Malnourished were chosen as cases and eight females were assigned to the control group. Similarly, there were 16 males in the malnourished group and 22 males in the control group. All the children belonged to Hyderabad and were chosen according to the inclusion and exclusion criteria.

The anthropometric details of the children were as follows:

The mean weight of malnourished children in this study was 8.25 kg, mean height was 80.73 cm, and mean MUAC value was 11.85 cm. The mean weight of the control group was 11.58 kg, mean height 85.36 cm and mean MUAC value was 13.7 cm.

The cases and controls were age and gender matched as follows:

Age matching			
Age_group	Case_control		Total
	Case	Control	
Toddler	19	17	36
School_going	11	13	24
Total	30	30	60

Gender matching			
Gender	Case_control		Total
	Case	Control	
Female	14	8	22
Male	16	22	38
Total	30	30	60

The above data and chi squares tests on them show that there is no bias in data selection by gender and age group.

The children with malnourishment (cases) were further classified as severely malnourished and moderately malnourished based on their MUAC values where values <11.5 cm corresponded to severely malnourished and values between 11.5 cm and 12.5 cm corresponded to moderately malnourished. Among the cases six children were severely malnourished, while 24 children were moderately malnourished.

The association between ankle reflex grades and malnourishment is obtained as follows:

Anthropometric data of cases						
Case Assigned Number	Age (year)	Gender	Height (cm)	Weight (kg)	WHZ score	MUAC (cm)
CA001	1.5	F	72	6.5	≤3	11
CA002	4	M	95	12	-2	11
CA003	1.5	M	71	7.6	≥2, ≤1	12.5
CA004	3	F	90	9	≤3	11
CA005	3	F	91	9	≤3	12.5
CA006	5	F	91	10	-3	12.5
CA007	2	F	77	4.5	≤3	9.5
CA008	1.5	M	79	5.5	≤3	10.5
CA009	1.5	M	74	6	≤3	12
CA0010	1.3	M	70	5.5	≤3	12
CA0011	2	M	76	8.4	-2	11.5
CA0012	3	F	86	9	-3	12.5
CA0013	2.5	M	85	10	-2	12.5
CA0014	1.5	M	69	5	≤3	11
CA0015	1.3	F	71	6	≥3, ≤2	11.5
CA0016	1.7	F	75	7	≥3, ≤2	11.5
CA0017	4	M	90	10	≤3	12.5
CA0018	1.5	M	66	6.1	≥2, ≤1	12
CA0019	4	F	84	10	≥1, ≤0	12
CA0020	1	M	72	7.5	-3	11.5
CA0021	4	M	97	11	≤3	12
CA0022	2	F	79	8	≥3, ≤2	12.5
CA0023	5	F	106	15	≥2, ≤1	12
CA0024	5	M	87	10	≥3, ≤2	12
CA0025	3	F	83	8	≤3	12
CA0026	1.8	M	84	10	≥2, ≤1	12.5
CA0027	1.6	F	73	7	-2	12.5
CA0028	1.4	M	76	8	≥3, ≤2	12.5
CA0029	2	M	82	9	≥3, ≤2	12
CA0030	1.4	F	71	7	-2	12.5

The left ankle reflex grades obtained from 30 cases and 30 controls were analyzed using a Chi-Square test and a significance of 0.002 was obtained which indicates that there is a statistically significant difference between the reflex grades from the two groups.

Similarly, a significance value of 0.002 was obtained when right ankle reflex grades of case group and control group was analyzed using a Chi-square test, indication statistically significant difference in Reflex grade obtained from the two groups.

From Figs. 1 and 2, it is derived that cases had lower reflex grades as compared to controls indicating that the Achilles Tendon reflex was reduced.

The primary objective of this study was to find a difference in reflex grade between cases and controls.

The Null hypothesis: There is no difference of reflex grades between cases and controls.

The null hypothesis was rejected using Chi-square test and Tables 1 and 2, Figs. 1 and 2, show that there was a significant difference obtained between reflex grades of malnourished children and normal healthy children. It was observed that 3.33%

of cases obtained a reflex grade of 1, 53.33% of cases obtained a reflex grade of 2, and 43.33% of cases obtained a reflex grade of 3. Among controls, 13.33% of the children obtained a reflex grade of 2 and 86.66% obtained an ankle reflex grade of 3.

A significance value of 0.002 is indicative of the above-mentioned result of reduced ATRs.

### DISCUSSION

The results give conclusive evidence of reduced ATRs in PEM children aged between 1–5 years.

In an electromyographic study conducted on 13 children, with pseudomyopathic motor deficits in association with malnutrition caused by primary PEM or due to chronic disease, it was revealed that there was a significant decrease in nerve conduction velocity in some subjects. This could be another cause of hyporeflexia.

According to studies on serum electrolyte levels in Protein Energy Malnourished children, it was observed that many present with decreased serum potassium levels [13] and hypokalemia is associated with decreased reflex grades, hence a reduced ATR is obtained [14].

Anthropometric data of control group						
Control Assigned Number	Age (year)	Gender	Height (cm)	Weight (kg)	WHZ Score	MUAC (cm)
CO001	2	M	84	11.5	>0, <1	13.5
CO002	1.5	M	81	10.5	>0, <1	13.5
CO003	4	F	95	11	≥2, ≤1	3
CO004	2	M	80	10	≥1, <0	13
CO005	2.5	M	88	12	≥1, <0	16
CO006	1	M	73	9.7	>0, <1	13.5
CO007	3	M	88	14	>1, <2	16
CO008	4	F	92	12	-1	14
CO009	2.25	F	90	10	>1, <2	14
CO0010	5	M	95	15	>0, <1	14.5
CO0011	3	M	82	10	-1	15
CO0012	5	F	98	14	≥1, <0	13
CO0013	2.5	M	79	10	>0, <1	13
CO0014	1	M	74	9.7	>0, <1	13.5
CO0015	2	F	79	9	≥1, <0	13.5
CO0016	1.2	M	71	8	-1	14
CO0017	1.4	M	72	10	>1, <2	13
CO0018	1.3	M	76	10	>0, <1	14
CO0019	3	F	84	14	>2, <3	16
CO0020	4	M	104	17	>0, <1	15
CO0021	5	F	100	15	≥1, <0	14
CO0022	2.5	M	81	10	≥1, <0	13
CO0023	2	M	81	10	≥1, <0	14
CO0024	4	M	101	16	>0, <1	16
CO0025	4	M	88	10.5	≥2, ≤1	14
CO0026	1.5	M	74	9.7	>0, <1	13
CO0027	1.5	M	79	10	≥1, <0	14
CO0028	3	F	100	15	≥1, <0	14.5
CO0029	2	M	74	10	>0, <1	14
CO0030	4	M	98	14	≥1, <0	13.5

M: Male, F: Female

Age Matching					
Chi-square tests					
	Value	df	Asymptotic significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-square	0.278 <sup>a</sup>	1	0.598		
Continuity Correction <sup>b</sup>	0.069	1	0.792		
Likelihood ratio	0.278	1	0.598		
Fisher's exact test				0.792	0.396
Linear-by-linear association	0.273	1	0.601		
N of valid cases	60				

<sup>a</sup>0 cells (0.0%) have expected count <5. The minimum expected count is 12.00. <sup>b</sup>Computed only for a 2x2 table

Gender Matching					
Chi-square tests					
	Value	df	Asymptotic significance (2-sided)	Exact sig. (2-sided)	Exact sig. (1-sided)
Pearson Chi-square	2.584 <sup>a</sup>	1	0.108		
Continuity correction <sup>b</sup>	1.794	1	0.18		
Likelihood ratio	2.609	1	0.106		
Fisher's exact test				0.18	0.09
No. of valid cases	60				

<sup>a</sup>0 cells (0.0%) have expected count <5. The minimum expected count is 11.00. <sup>b</sup>Computed only for a 2x2 table

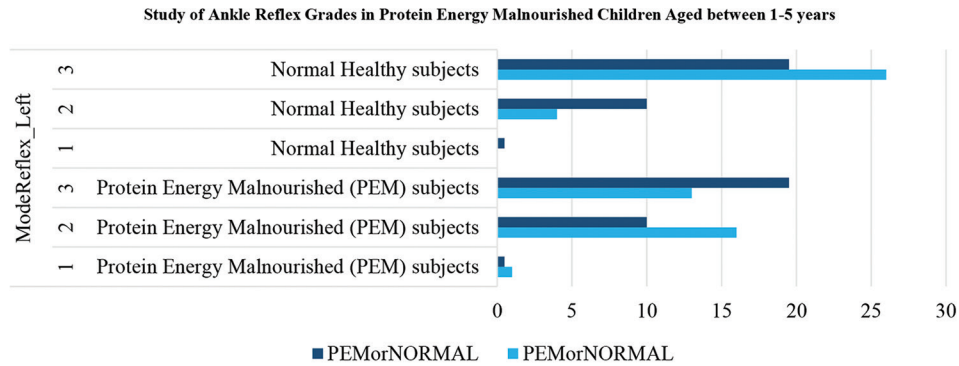


Figure 1: Left ankle reflex grades in cases and controls

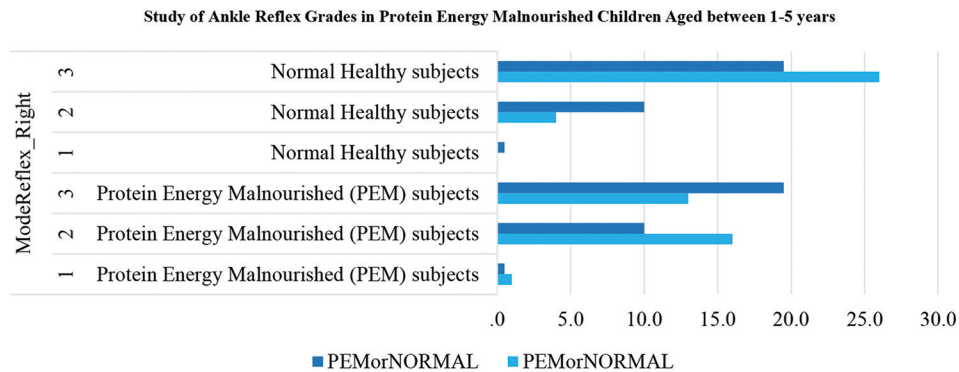


Figure 2: Right ankle reflex grades in cases and controls

Table 1: Difference in left ankle reflex grades between cases and controls

PEM/Normal	ModeReflex_Left			Total
	1	2	3	
Protein Energy Malnourished Subjects				
Observed number of PEM children with corresponding Ankle reflex grades	1	16	13	30
Expected number of PEM children with corresponding Ankle reflex grades	0.5	10.0	19.5	30.0
Normal Healthy Subjects				
Observed number of healthy children with corresponding Ankle reflex grades	0	4	26	30
Expected number of healthy children with corresponding Ankle reflex grades	0.5	10.0	19.5	30.0
Total				
Observed number of children with corresponding Ankle reflex grades	1	20	39	60
Expected number of children with corresponding Ankle reflex grades	1.0	20.0	39.0	60.0

Significance - 0.002

The mechanism behind this observation could be that hypokalemia causes hyperpolarization and non-responsiveness [15] of the membrane hence affecting nerve conduction.

The result could be thus because PEM is accompanied by decreased muscle bulk, due to muscle wasting, leading to changes in the muscle fibers as well as hypokalemia observed in PEM patients causing an observable change in the reflex grades obtained.

Table 2: Difference in right ankle reflex grades between cases and control

PEM/Normal	ModeReflex_Right			Total
	1	2	3	
Protein Energy Malnourished Subjects				
Observed number of PEM children with corresponding Ankle reflex grades	1	16	13	30
Expected number of PEM children with corresponding Ankle reflex grades	0.5	10.0	19.5	30.0
Normal Healthy Subjects				
Observed number of healthy children with corresponding Ankle reflex grades	0	4	26	30
Expected number of healthy children with corresponding Ankle reflex grades	0.5	10.0	19.5	30.0
Total				
Observed number of children with corresponding Ankle reflex grades	1	20	39	60
Expected number of children with corresponding Ankle reflex grades	1.0	20.0	39.0	60.0

Significance - 0.002

### Clinical Implications

PEM is associated with neurological deficits. Eliciting the deep tendon reflexes and drawing a relation with PEM children can be used as an initial diagnosis for neurological deficits associated with PEM.

MUAC and WHZ scores are used for diagnosing PEM while lowered deep tendon reflex (ankle reflex) will help associating subsequent neurological deficits caused due to malnourishment.

For observation of neurological deficits, a prospective study must be conducted in the subjects with hyporeflexia. Strengths of our study are that it draws a definite relation between ankle reflex grades and malnutrition and this information could add on to the known clinical features of PEM. The limitations of the current study include the lack of data on Serum Vitamin B12 levels which is often lowered in malnourished children and information on thyroid profile was not obtained.

## CONCLUSION

The study was conducted in 30 cases of malnourished children aged between 1 and 5 years and 30 controls who were healthy children of the same age group. It was derived that PEM is accompanied by hyporeflexia. This could be a result of muscle wasting and changes in serum electrolytes, often observed in malnourished children. Electromyographic studies and nerve conduction velocity measurements would provide an objective correlation of the same conclusion.

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