International Journal of Contemporary Pediatrics
Saini A et al. Int J Contemp Pediatr. 2022 Jun;9(6):553-559
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: https://dx.doi.org/10.18203/2349-3291.ijcp20221373

Original Research Article

Comparison of thyroid hormonal status and serum albumin level between children with moderate acute malnutrition and severe acute malnutrition

Aashish Saini[1], Hemant Jain[1]*, Mili Doshi[1], Jinesh Saini[2]

[1]Department of Pediatrics, Geetanjali Medical College and Hospital, Udaipur, Rajasthan, India
[2]School of Public Health, All India Institute of Medical Sciences, Jodhpur, Rajasthan, India

Received: 04 April 2022
Accepted: 28 April 2022

***Correspondence:**
Dr. Hemant Jain,
E-mail: hemant.gmch@gmail.com

ABSTRACT

Background: Malnutrition is one of the most common nutritional problems in developing countries of the world and an important cause of childhood mortality and morbidity leading to permanent impairment of physical and mental growth. Objective of current study was comparison of thyroid hormonal status and serum albumin level between children with MAM and SAM.
Methods: The present study was a hospital-based Descriptive comparative study. A total of 96 children aged 6 months to 5 years were enrolled. They were divided into two groups (MAM and SAM) based on WHO staging for malnutrition. A detailed clinical examination was done. Thyroid function test and Serum albumin were done. Statistical analysis was performed.
Results: Children with SAM have low levels of albumin, T3, T4, FT4 as compared to children with MAM. The difference was statistically significant (p value <0.01). The Serum TSH levels were comparable among two groups. Significant positive correlation between mean T3 and T4 levels of children with MAM with serum albumin was observed and significant positive correlation of T3, T4, and FT4 was observed in SAM. Serum TSH level in both categories does not correlate with serum albumin.
Conclusions: Children with MAM and SAM have low albumin levels probably due to decreased intake of proteins and reduced biosynthesis. Serum T3, T4 and FT4 levels are lower in children with MAM and SAM probably due to reduction in circulating plasma proteins.

Keywords: Severe acute malnutrition, Moderate acute malnutrition, Serum T3, Serum T4, Serum FT4, Serum TSH, Serum albumin

INTRODUCTION

The WHO defines malnutrition as the imbalance between the supply of nutrients and energy at the cellular level and the body's need for these nutrients to provide adequate growth, maintenance and specific functions.[1] Malnutrition indicates both undernutrition and overweight but usually this term is used to indicate undernutrition. In children, under-nutrition presents as underweight and stunting, and severely malnourished children show the clinical signs and symptoms of kwashiorkor, marasmus, or marasmic-kwashiorkor.[2]

Malnutrition contributes to approximately one-third of the nearly 8 million under 5 mortality worldwide.[3] In 2019, 21.3% or more than one-fifth of children under the age of 5 worldwide had stunted growth. Between 2000 and 2019, the prevalence of stunting was 21.3% globally, and the number of children affected by stunting was 144 million.[4] In 2019 globally, 47 million under-five children were wasted out of which 14.3 million children were

wasted severely.[4] This translates into a prevalence of 6.9% and 2.1% of stunting and wasting, respectively. India has the greatest population of severely under-nourished children in the world and accounts for over 20% of under-five childhood death every year and 2.1 million children in India do not survive to celebrate their fifth birthday.[5] National family health survey 5 (NFHS-5) reveals that 32.1% of Indian children under 5 years are underweight, 35.5% are stunted and 19.3% are wasted and about 7.7% are severely wasted, and these children have a high mortality rate.[6] According to the global hunger index (2020) India is in 94th position out of 107 countries, this index is determined based on total undernourished population, child stunting, wasting and childhood mortality.

In the early stages of malnutrition, it leads to failure to gain adequate weight, as the condition progresses there is loss of weight followed by loss of subcutaneous tissue and muscle mass. Every organ system is affected by malnutrition, as it worsens organ dysfunction develops and leads to numerous metabolic derangements. Due to decreased hepatic synthesis levels of circulatory proteins are also decreased. With increasing severity, there is an increasing failure in the homeostatic mechanism of the body and the immune system is damaged, which leads to severe infection and death.[7,8] Thyroid hormone is necessary for normal growth and maturation as it plays an important role in the regulation of carbohydrate and lipid metabolism. Thyroid dysfunction leads to mental and physical slowing and dwarfism.[9] Severely malnourished children have reduced serum total protein and albumin.[8,10] Studies indicate that malnutrition leads to deficiency of minerals and vitamins like iodine, vitamin A and iron which further leads to anemia and increased risk of death. Some infections like diarrhoea and parasitic infection cause decreased nutrients available in the diet.[7,8,11]

In previous studies, significant alterations in secretion and metabolism of thyroid hormones have been reported due to malnutrition. These changes result in the decreased activity of the thyroid gland and decrease serum levels of T3, T4, and FT4. The change in thyroid function is contributed by changes in iodine metabolism and decreased levels of circulating proteins. These changes play a significant role in the adaptive process of protein and energy in children with malnutrition and help in the conservation of energy when the energy-producing substances is scarce, and the child is protected from an early death due to a low-calorie state.[12] In current study, we have attempted to study the concentration of serum thyroid hormone levels in children with moderate acute malnutrition and severe acute malnutrition and its correlation with serum albumin levels.

Objectives

Objectives of current study were to compare serum T3, T4, free T4 and TSH levels between children MAM and SAM, to compare serum albumin levels between children with MAM and SAM and to study any correlation between thyroid hormones and serum albumin levels among both groups.

METHODS

Study design

The present study was a hospital-based descriptive comparative study, done at the department of paediatrics, Geetanjali hospital, Udaipur, during the term January 2020 to June 2021.

Inclusion criteria

Inclusion criteria for current study were all children between 6 months to 5 years of age with a diagnosis of MAM and SAM admitted to the department of paediatrics.

Exclusion criteria

Exclusion criteria for current study were children with any known chronic disease and children whose parents did not give consent.

Procedure

Informed written consent was sought from parents of eligible children before the commencement of the study. After explaining about purpose of the study, outcome and explaining that respondents can refuse and withdraw from study at any time. All related information was conveyed in the local language. A total of 96 children aged 6 months to 5 years were included in the present study after obtaining written informed consent from parents/guardians. They were divided into two groups SAM and MAM 48 each. Detailed clinical assessment of nutritional status followed by anthropometric measurements was recorded in a predesigned proforma. The cases were categorized into moderate malnutrition (z-score between -2 SD and -3 SD) and severe malnutrition (z-score below -3 SD) as per WHO classification (weight for height). Taking aseptic precaution, 3 ml of venous blood was collected. The blood sample collected in the test tube was centrifuged at 5000 rpm (rotation per minute) for 5 minutes; serum thus obtained was used to estimate T3, T4, FT4 and TSH, serum albumin in both groups. T3, T4, FT4, and TSH were estimated by the ECLIA method (using Hitachi Cobas 6000-E601). Serum albumin was estimated by spectrophotometric assay on Hitachi Cobas 6000-C501 by bromocresol green dye method (BCG dye). Other relevant investigations were done as needed based on the underlying problem.

Statistical analysis

Statistical analysis was performed using the statistical packages for social sciences (SPSS) version 21 IBM Corporation. Data was entered into MS Excel software.

Statistical analysis of Categorical variables was compared between patients using the Chi square test. Quantitative data was analyzed using the student t test. A p value <0.05 is considered to be significant. Pearson correlation coefficient was calculated to establish correlation between thyroid hormones and serum albumin levels.

RESULTS

Total 96 children (46 children of each category, that is, MAM and SAM) were enrolled in the study. Data was collected for each subject in pre-designed proforma. Age and gender-wise distribution of children with MAM and SAM is shown in (Table 1).

Table 1: Age and gender-wise distribution of children with MAM and SAM.

Age group (years)	MAM frequency (%)		SAM frequency (%)	
	Male (n=24)	Female (n=24)	Male (n=23)	Female (n=25)
≤2	5	11	10	19
≥2 to ≤4	13	9	10	4
>4	6	4	3	2
Mean age (months)±SD	37.20±14.33	30.66±16.20	30.26±15.22	23.56±14.26
Total	48 (100)		48 (100)	
P value	0.039		0.028	

Table 2: Distribution of presenting complaints among children with MAM and SAM.

Presenting complaints	MAM	SAM
	N (%)	N (%)
Fever	33 (66.67)	29 (60.41)
Loose stools	14 (29.16)	18 (37.5)
Vomiting	13 (27.08)	20 (41.66)
Cough	13 (27.08)	13 (27.08)
Failure to gain weight	11 (22.91)	22 (45.83)
Pallor	4 (8.33)	8 (16.66)
Swelling	3 (6.25)	3 (6.25)
Urinary complaints	2 (4.16)	11 (22.91)
Skin lesions	1 (2.08)	4 (8.33)
Breathing difficulty	0	2 (4.16)
Other	1 (2.08)	1 (2.08)

Table 3: Immunization status of children with MAM and SAM.

Immunization status	MAM	SAM	P value
	N (%)	N (%)	
Immunized	37 (77.08)	18 (37.5)	0.0001
Partially immunized	10 (20.83)	23 (47.91)	
Unimmunized	1 (2.08)	7 (14.58)	

Table 4: Comparison of anthropometric parameters among MAM and SAM groups.

Parameters	MAM (n=48)	SAM (n=48)	P value
	Mean±SD	Mean±SD	
Weight (kg)	10.14±2.36	7.53±1.93	<0.001
Length/height (cm)	89.5±12	78.10±9.76	<0.001
MUAC (cm)	12.33±0.65	11.03±0.14	<0.001
Head circumference (cm)	48.06±2.39	47.08±2.67	0.061

Table 5: Comparison of mean serum albumin, T3, T4, FT4 and TSH levels in children with MAM and SAM.

Parameters	MAM (n=48)	SAM (n=48)	P value
	Mean±SD	Mean±SD	
S. albumin (g/dl)	3.44±0.36	3.05±0.47	<0.001
T3 (ng/ml)	1.49±0.41	1.30±0.33	0.013
T4 (µg/dl)	9.69±2.99	7.85±2.73	0.002

Continued.

Parameters	MAM (n=48)	SAM (n=48)	P value
	Mean±SD	Mean±SD	
FT4 (ng/dl)	1.24±0.27	1.07±0.22	0.0001
TSH (uIU/ml)	2.47±1.28	2.66±1.61	0.532

Table 6: Correlation between serum albumin and thyroid hormones (T3, T4, FT4, and TSH) in children with MAM and SAM.

Parameters	MAM		SAM	
	Serum albumin		Serum albumin	
	Pearson corr.	P value	Pearson Corr.	P value
T3	0.4813	0.0005	0.532	<0.005
T4	0.3786	0.0080	0.4391	<0.05
FT4	0.056	0.708	0.5531	<0.005
TSH	-0.021	0.886	-0.012	0.937

In our study maximum number of cases in children with MAM were between the age of 2 years and 4 years whereas in SAM maximum number of children were under the age of 2 years. Male:female ratio among MAM and SAM was 1:1 and 23:25 respectively. The distribution of presenting complaints among children with MAM and SAM is shown in (Table 2).

Fever was the predominant symptom in children of both groups (66.67% in MAM and 60.41% in SAM), followed by loose stools in children with MAM (29.16%) and Failure to gain weight in children with SAM (45.83%). The immunization status of children with MAM and SAM is shown in Table 3. Children with SAM are more likely to be not fully immunized as compared to children with MAM and it was significant statistically with a p value of <0.001.

The comparison of anthropometric parameters among children with MAM and SAM is shown in Table 4. The mean weight, height and MUAC of children with MAM was more as compared to children with SAM.

The difference was statistically significant with a p value <0.001. There was no statistically significant difference was observed in head circumference. The comparison of various biochemical markers in children with MAM and SAM is shown in Table 5. As the table shows mean Serum Albumin, T3, T4, and FT4 levels are significantly lower in children with SAM as compared with the mean levels of children with MAM. There was a statistically significant difference between the two groups. Whereas there was no statistically significant difference was noted in serum TSH levels among the two groups. The correlation between serum albumin and thyroid hormones (T3, T4, FT4, and TSH) in children with MAM and SAM is shown in Table 6. In our study, we observed that the mean serum albumin level in children with MAM shows a positive correlation with T3 and T4 and does not correlate with the mean FT4 and TSH levels. Whereas, among children with SAM we observed that the mean Serum Albumin level in children with SAM shows a positive correlation with T3, T4, and FT4 and does not correlate with the mean TSH level.

DISCUSSION

The current study was done to estimate and compare thyroid hormone and serum albumin in children with MAM and SAM, to find the correlation between serum albumin and thyroid hormones. In our study, 48 children with MAM and 48 children with SAM in age group 6 months to 5 years were enrolled. The majority of children with SAM enrolled in this study were in the age group ≤2 years and between 2 years and 4 years in children with MAM. Similar studies were conducted by Arya et al, Chakraborty et al, Prashanth et al and Ghimre et al where most of the cases (children with SAM) were under the age of 2 years.[13-17] Contradictory results to our study were given by Yadav et al and Lazarus et al where the majority of cases with SAM were above 2 years of age.[17,18] The high prevalence of malnutrition in this age group implied the importance of the need for continued breastfeeding and the appropriate introduction of complementary feeds. In our study number of cases of male and female were equal in MAM whereas female was slightly more in SAM group (M:F=23:25) which was statistically insignificant (p=0.838). Studies done by Yadav et al and Ghimre et al also gave a similar result, where the number of females were more than males. Contradictory results were reported by Sudhir et al and Sandeep et al. The results given by Sudhir et al and Sandeep et al can be explained by presentation of male child more than female child to health care facilities as female children were usually ignored in terms of nutrition and growth.[16-20]

In the present study, more children with MAM and SAM were from rural background. Similar results were reported by Sandeep et al and Yadav et al.[17,20] Contradictory results were reported by Ghimre et al.[16] This difference in rural versus urban background can be explained by proximity and easy asses of rural population to our health facility. The main presenting complaint in our study was fever in children with MAM and SAM

followed by loose stools in children with MAM and failure to gain weight in children with SAM. The majority of the studies conducted reported gastrointestinal symptoms as the main presenting feature which was also one of the major presenting features in our study. The majority of the cases in our study were partially immunized or completely unimmunized (22.92% in MAM and 62.5% in SAM). Arya et al also reported in their study that a large proportion of children were either partially or completely unimmunized.[13]

In our current study mean serum albumin levels were significantly lower in children with SAM as compared to children with MAM with a p value of <0.001. The mean albumin level was 3.44±0.36 gm/dl for children with MAM and 3.05±0.47 gm/dl for children with SAM. Serum albumin was low in both MAM and SAM, the decrease in serum albumin was more with the severity of malnutrition.[18] A study conducted by Lazarus et al also found that the mean value of albumin in children with MAM and children with SAM was 2.8±0.3 g/dl and 2.3±0.2 g/dl, respectively. The results were significant at (p<0.001) and there was correlation between decrease in serum albumin and the grade of malnutrition in children. Similar findings were reported by Dhanjal et al, Valinjkar et al, Surewad et al, Sah et al and Sandeep et al also reported similar findings. The alterations in serum albumin in malnutrition could be explained based on decreased protein intake and reduced biosynthesis.[20-24]

In the present study mean serum T3 level was significantly lower in children with SAM as compared to children with MAM (p=0.013). The mean serum T3 level was 1.49±0.41 ng/ml and 1.30±0.33 ng/ml for children with MAM and SAM respectively. Serum T3 was low in both MAM and SAM, the decrease in serum T3 correlate with the severity of malnutrition. A similar study was conducted by Lazarus et al to determine the effect of malnutrition on thyroid profile.[18] They reported mean values of T3 in children with MAM and SAM were 106.7±13.4 ng/dl and 91.8±3.5 ng/dl respectively and they observed that there was a significant (p<0.001) association between decreased T3 levels and grade of malnutrition. Sah et al, Sudhir et al, Sandeep et al, Gamit et al, and Abrol et al also reported similar findings in their study.[19-26] Low T3 levels in malnourished children is possibly because of low binding proteins, deranged thyroxine monodeiodination in the liver leading to a decrease in peripheral conversion of T4 to T3 and high levels of corticosteroids were often seen in children with malnutrition.

In the present study mean serum T4 level was significantly lower in children with SAM as compared to children with MAM (p=0.002). The mean serum T4 level was 9.69±2.99 ng/ml and 7.85±2.73 ng/ml for children with MAM and SAM respectively. We observed that the decrease in serum T4 correlate with the severity of malnutrition. Lazarus et al did a similar study and reported similar findings. In their study mean values of T4 in children with MAM and SAM were 6.53 µg/dl and 5.62 µg/dl respectively there was a significant (p<0.05) association between decreased T4 and grade of malnutrition.[18] Sah et al, Turkay et al, Abrol et al, Farida Khatun et al, Orbak et al, Kumar et al and Gamit et al, also reported comparable findings.[25-30] In contrast to our study, Das et al reported no difference in mean T4 levels of cases of PEM and controls, they concluded that normal T4 levels in PEM children were secondary to an adaptive process.[31] A fall in thyroid secretion rate, depletion of reserves and failure of the adaptive mechanism are believed to be the factors responsible for low T4 levels in children with MAM and SAM.

In our study, the FT4 level in children with MAM and SAM was within the normal range but there was a significant difference between the mean FT4 levels in children with SAM and MAM. The mean FT4 value of children with MAM (1.24±0.27 ng/dl) was higher as compared to children with SAM (1.07±0.22 ng/dl) with a p value <0.001. we observed that there was a significant correlation between the value of free T4 and the grade of malnutrition. Recent studies done by Valinjkar et al, Surewad et al, Dhanjal et al and Shaheen et al also reported similar findings.[21-23,32] In our study mean TSH level was similar in children with MAM (2.47±1.28 uIU/ml) and SAM (2.66±1.61 uIU/ml) with no significant difference (p=0.532). Studies conducted by Surevad et al, Lazarus et al, Dhanjal et al and Valinjkar et al also reported similar findings, no significant difference between mean TSH value of TSH in different grades of malnutrition.[18,22,23]

In contrast to our study, the study carried out by Orbak et al found that mean TSH levels in children with PEM were higher as compared to controls. A similar study done by Kumar et al observed a positive increase in TSH level with the increase in severity of PEM (p=0.015).[29,30] Normal TSH levels in children with acute malnutrition were probably due to the fact that T4 underwent intracellular monodeiodination to induce T3 at the pituitary level which resulted in negative feedback to TSH secretion, central unresponsiveness to low levels of T3 were due to low capacity of intracellular receptor.[20] In short-term and low-grade malnutrition, marked changes are limited to the thyroid hormone transport system and the proper feedback response that allowed the maintenance of euthyroid status. But in chronic and severe forms of malnutrition, stores were depleted resulting in decreased thyroid output and thyroid adaptation may fail.[30] In our study, we observed a significant positive correlation between mean T3 and T4 levels of children with MAM with serum albumin. Whereas in children with SAM a significant positive correlation of T3, T4 and FT4 was observed. Serum TSH level in both the categories, MAM and SAM, did not correlate with serum albumin. A study conducted by Sandeep et al also reported a significant correlation of T3 and T4 levels with serum albumin in children with PEM. Dhanjal et al also reported a significant correlation

between thyroid hormones (T3, T4 and TSH) with serum albumin.[20,21] A study conducted by Das et al also reported correlation between T3 and serum albumin.[31]

CONCLUSION

Malnutrition can lead to mental and physical slowing due to alteration in the albumin and thyroid hormonal status of the child. Thyroid status of a child is often ignored during management of malnutrition. Given the strong correlation of thyroid imbalance with severity of malnutrition, it is suggested that serum levels of albumin and thyroid hormones should be performed in all cases of children with severe acute malnutrition and proper measures should be taken accordingly. Thus, it is an important step toward strengthening management of such malnourished children.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Health W, Tech O, Ser R. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. Available at: Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. Accessed on 24 October 2021.
2. Saurabh K, Shilpi R, Narayan JP. Co-Morbidities and micronutrients deficiencies in children with severe acute malnutrition. Int J Contemp Pediatr. 2017;4(4):1225-27.
3. Levels and trends in child mortality Report 2012. Available at: https://data.unicef.org/. Accessed on 24 October 2021.
4. Levels and trends in child malnutrition: Key Findings of the 2020 Edition of the Joint Child Malnutrition Estimates. Available at: https://www.who.int/publications/i/item/9789240003576. Accessed on 24 October 2021.
5. The state of the world's children 2008. Child survival in Geneva. Available at: https://www.unicef.org/reports/state-worlds-children-2008. Accessed on 24 October 2021.
6. National Family Health Survey (NFHS-5), 2019-2020. Available at: http://rchiips.org/nfhs/. Accessed on 24 October 2021.
7. Shaw KN, Gorelick M, McGowan KL, Yakscoe NM, Schwartz JS. Prevalence of urinary tract infection in febrile young children in the emergency department. Pediatr. 1998;102(2):16.
8. Roberts JA. Factors predisposing to urinary tract infections in children. Pediatr Nephrol. 1996;10(4):517-22.
9. Srivastava RN, Bagga A. Pediatric Nephrology. 5th ed. New Delhi; Jaypee: 2011.
10. Bagga A, Tripathi P, Jatana V, Hari P, Kapil A, Srivastava RN, et al. Bacteriuria and urinary tract infections in malnourished children. Pediatr Nephrol. 2003;18(4):366-70.
11. Hoberman A, Chao HP, Keller DM, Hickey R, Davis HW, Ellis D. Prevalence of urinary tract infection in febrile infants. J Pediatr. 1993;123(1):17.
12. Iyer SS, Chatraw JH, Tan WG, Wherry EJ, Becker TC, Ahmed R, et al. Protein-energy malnutrition impairs homeostatic proliferation of memory CD8 T cells. J Immunol. 2012;188(1):77-84.
13. Arya AK, Lal P, Kumar P. Co-morbidities in children with severe acute malnutrition – a tertiary care centre experience. Int J Contemp Med Res. 2017;4(5):1086-8.
14. Chakraborty S, Chaturvedi BK. A study of protein energy malnutrition (PEM) in children (0 to 6 years) in a rural population of Jhansi district (U.P.). Indian J Commu Med. 2006;31:291.
15. Prashanth MR, Savitha MR, Prashantha B. Risk factors for severe acute malnutrition in under-five children attending nutritional rehabilitation centre of tertiary teaching hospital in Karnataka: a case control study. Int J Contemp Pediatr. 2017;4:1721-6.
16. Ghimire U, Aryal BK, Gupta AK. Severe acute malnutrition and its associated factors among children under-five years: a facility-based cross-sectional study. BMC Pediatr. 2020;20:249.
17. Yadav SS, Yadav ST, Mishra P, Mittal A, Kumar R, Singh J. An Epidemiological Study of Malnutrition Among Under Five Children of Rural and Urban Haryana. J Clin Diagn Res. 2016;10(2):LC7-10.
18. Lazarus M, Kashyap AK, Borkar R, Ajmariya M. Study of thyroid profile in malnourished children (6 months-5 years) admitted in the nutritional rehabilitation centre and paediatric ward NSCB Medical College Jabalpur, India. Int J Contemp Pediatr. 2018;5(3):1072.
19. Mehta S. Thyroid hormone status in children with severe acute malnutrition. EJPMR. 2017;4(4):592-4.
20. Sandeep M, Krishnamurthy B. Thyroid hormone status in children with protein energy malnutrition. Int J Contemp Pediatr. 2016;3(1):193-9.
21. Dhanjal GS, Singh M. Thyroid hormone status in children with protein energy malnutrition a hospital-based case control study. Int J Contemp Pediatr. 2017;4(2):2-6.
22. Valinjkar SK, Sutay NR, Prachi V. Thyroid status and serum protein levels in severe and moderate acute malnourished children. JMSCR. 2016;4(1):5059-67.
23. Surewad GV, Ambatipudi K, Rao AVS, Rao KN. Interrelation of Free Thyroid Hormone levels and Serum proteins in Malnourished Children at Rural Tertiary Care Hospital in Andhra Pradesh. J Adv Med Dent Scie Res. 2020;8(11):64-8.
24. Sah SP, Arora M, Kumar S, Batra J, Mustafa I, Yadav L. Effect of PEM on thyroid status, serum

total protein and A/G ratio in pre-school going children. Int J Res Med Sci. 2017;5(10):4486.
25. Gamit AM, Khubchandani AS, Gamit MR, Parmar U, Adarsh A. A study of serum total protein, serum albumin and thyroid hormones in protein energy malnutrition in children. Int J Med Sci Public Health. 2016;6(2):409-12.
26. Abrol P, Verma A, Hooda HS. Thyroid hormone status in protein energy malnutrition in Indian children. Indian J Clin Biochem. 2001;16(2):221-3.
27. Turkay S, Kus S, Gokalp A, Baskin E, Onal A. Effects of protein energy malnutrition on circulating thyroid hormones. Indian Pediatr. 1995;32(2):193-7.
28. Farida Khatun UH, Khan MR, Ara F, Ahmed K, Choudhury SA. Study of thyroid functions in protein energy malnutrition. Bangladesh Med Res Counc Bull. 1982;8(2):68-71.
29. Orbak Z, Akin Y, Varoglu E, Tan H. Serum thyroid hormone and thyroid gland weight measurements in protein-energy malnutrition. J Pediatr Endocrinol Metab. 1998;11(6):719-24.
30. Kumar S, Nadkarni J, Dwivedi R. Thyroid hormone status in malnourished children. Indian Pediatr. 2009;46(3):263-4.
31. Das BK, Panda BK, Dhingra R, Mishra OP, Agarwal JK. Thyroid hormone studies in protein-energy malnutrition. J Trop Pediatr. 1999;45(6):375-6.
32. Shaheen B, Haji IM, Suma MN. Serum FT3, FT4, TSH and proteins in children with protein-energy malnutrition. Int J Pharm Bio Sci. 2013;4(3):834-9.

Cite this article as: Saini A, Jain H, Doshi M, Saini J. Comparison of thyroid hormonal status and serum albumin level between children with moderate acute malnutrition and severe acute malnutrition. Int J Contemp Pediatr 2022;9:553-9.