

Relationship between protein deficiency accompanied by low body mass index with the head shape and face type of 6-7 years old children

Idelia Gunawan¹, Niekla Survia Andiesta², Meirina Gartika^{1*}, Risti Saptarini Primarti¹

¹Department of Pediatric Dentistry, Faculty of Dentistry Universitas Padjadjaran, Indonesia

²Children and Community Oral Health Division, School of Dentistry International Medical University, Malaysia

ABSTRACT

Introduction: Environmental factors such as socio-economic and nutrients factor can affect the dimensions and proportions of the body. Nutritional intake has a long-term effect on physical growth and can be assessed through body mass index up to age. Children with a nutritional disorder are characterised with low body mass index. This study was aimed to analyse the relationship of protein deficiency and low body mass index on the head shape and facial type of 6-7 years old children. **Methods:** The research type was descriptive correlative, and the research was conducted towards 16 subjects with low body mass index. Protein deficiency was assessed from food intake for 3 x 24 hours through food recall method and interview. The measurement of the cephalic and facial index was carried out to find out the head shape and face type, and then to correlate with protein deficiency and body mass index. Data was analysed using the chi-square test with the significance (p-value)<0.05. **Results:** There was a significant correlation between protein deficiency and low body mass index with the head shape (p-value=0.007), and the facial type of 6-7 years old children (p-value=0.027). There was a significant correlation between head shape with facial type in protein-deficient children with low body mass index (p-value=0). **Conclusion:** Protein deficiency accompanied by low body mass index influences the head shape and facial type of children.

Keywords: Head shape, face type, low body mass index, protein deficiency.

p-ISSN: 1979-0201; e-ISSN: 2549-6212; Available from: <http://jurnal.unpad.ac.id/pjd/article/view/21165>

DOI: [10.24198/pjd.vol32no1.21165](https://doi.org/10.24198/pjd.vol32no1.21165)

Submission: Mar 26, 2019; Accepted: Mar 27, 2020; Published online: Mar 31, 2020

INTRODUCTION

Undernourishment is one of the common problems found in Indonesia. Basic Health Research (Riset Kesehatan Dasar; RISKESDAS) recorded that the prevalence of underweight

school-age children is still high because it only experiences a slight decrease from 12.1% to 11.2% from 2007 to 2013. In 2010, there were 35.7% Indonesian children with stunting. Other study in Indonesia in 2013 found 18.2% children aged 5-12 years experienced stunted growth.¹⁻³

*Corresponding author: Meirina Gartika, Department of Pediatric Dentistry, Faculty of Dentistry Universitas Padjadjaran, Indonesia. Jalan Sekeloa Selatan I, Bandung, West Java, Indonesia, 40132. Phone: +62811204863; Email: meirina.gartika@fkg.unpad.ac.id

Changes in body dimension and proportion during growth is affected by several factors, including genetics, hormone, environment and behavior. Environmental factors such as socio-economic and nutrition often became the causal factor of disturbances in growth and development as compared to other factors.^{1,4-6} Nutritional intake has a long-term effect on physical growth and can be assessed from body mass index to age. Children with nutritional disorder is characterized with low body mass index.

Several studies proved that the nutrition which affects physical growth the most is protein, all due to it being the basic component of cells and has a crucial role in relation with the change of body composition as well as tissue regeneration.^{7,8} Thakur et al⁵ correlated low body mass index due to protein deficiency to cranium growth of children aged 5 years and showed that 75% of boys and girls had mesocephalic and dolichocephalic with smaller head circumference.

The shape of the head and type of face can be determined through some cephalic and facial index using a simple tool. Studies in orthodontics found that there was no correlation between head shape and facial type. However, other studies concluded that there was a correlation between doliocephalic and leptoprosopic face type to facial profile of school-age children leading to retrognathism.^{9,10} This study was aimed to analyse the relationship of protein deficiency and low body mass index on the head shape and facial type of 6-7 years old children.

METHODS

This study was conducted using correlational design, and also a part of previous study that involved 300 subjects aged 6-7 years old from several elementary school in Bandung, chosen by Health Office according to low socio-economic status and was suspected of undernourishment based on data has collected, and was conducted multidisciplinary with community health center, doctors and specialist in Dentistry from Universitas Padjadjaran. Previous research was conducted through grouping body mass index, resulting in 42 children who were categorized to have low body mass index.

The subjects were determined using purposive sampling method, and in result, there were 16 children who fulfilled the inclusion criteria, which included children who were willing to be the object of research, children who were diagnosed with protein deficiency, and children with orofacial defects/mental retardation or have a history of surgery in the craniofacial area. Measurement of height and weight of children who have a low body mass index based on age was performed.

Children with low body mass index were assessed for protein nutritional status by 3x24 hour food recall methods and interviews with parents/guardians. The results of the assessment of protein nutritional status were attuned to the 2013 Nutritional Adequacy Rate and protein energy adequacy of the Ministry of Health 1999. Furthermore, measurement of head length and head width were performed while the head shape was determined based on calculation of cephalic index. Measurement of face length and width were also carried out, then the type of the face was determined based on facial index. Ethical clearance of this study was approved by Research Ethics Committee Universitas Padjadjaran No.68/UN6.KEP/EC/2018. The chi-square followed by contingency coefficient test were used to determine the percentage of relationship between variables.

RESULTS

The results of the study presented in incorporated subject characteristics, which was determined based on protein deficiency, cephalic and facial index such as in Table 1. Subject characteristics in Table 1 showed that out of 16 subjects, 14 of them had severe protein deficiency and two children had moderate protein deficiency with average protein intake value of 55.24% per day or equivalent to 28.3 gram.

Table 2 showed a significant correlation between protein deficiency and head shape. In severe protein deficiency, two subjects had doliocephalic, 11 subjects had mesocephalic, and one child had brachycephalic.

The correlation between protein deficiency followed by low body mass index with facial type

represented by facial index measurement can be seen in Table 3. Table 3 showed the results of correlation analysis between protein deficiency and facial type. In severe protein deficiency, it was shown that three children had euryprosopic, nine children had mesoprosopic, and two children had leptoprosopic.

The correlation between head shape and facial shape of children with protein deficiency followed by low body mass index can be seen in Table 4. Table 4 showed the correlation

between head shape and facial shape in children with protein deficiency followed by low body mass index. The results of correlation analysis showed that two children with doliocephalic head had leptoprosopic face, two children with mesocephalic head had euryprosopic and nine children mesoprosopic, and one child with brachycephalic head had hypereuryprosopic face and two children with euryprosopic face. Statistical test results showed p value = 0.000 (< 0.0005). Therefore, it can be concluded that

Table 1. Subject characteristic based on protein deficiency, head shape, and facial type

Variable	N	\bar{X}
Protein deficiency	16	55.24
Mild deficiency	-	
Moderate deficiency	2	
Severe deficiency	14	
Head shape (Cephalic index)	16	78.28
Dolicocephalic	2	
Mesocephalic	11	
Brachycephalic	3	
Hiperbrachycephalic	-	
Facial type (Facial index)	16	86.06
Hypereuryprosopic	1	
Euryprosopic	4	
Mesoprosopic	9	
Leptoprosopic	2	
Hyperleptoprosopic	-	

Table 2. Correlation between protein deficiency and head shape

Protein deficiency	Head shape				Contingency coefficient	P-value
	Dolico cephalic	Meso cephalic	Brachy cephalic	Hiperbrachy cephalic		
Mild	0	0	0	0	61.8%	0.007 ¹⁾
Moderate	0	0	2	0		
Severe	2	11	1	0		
Total	2	11	3	0		

Notes: p-value was determined from the chi-square test

¹⁾ = significant

Table 3. Correlation between protein deficiency and facial type

Protein deficiency	Facial type					Contingency coefficient	P-value
	Hypereury prosopic	Eury prosopic	Meso prosopic	Lepto prosopic	Hyperlepto prosopic		
Mild	0	0	0	0	0	60.3%	0.027*
Moderate	1	1	0	0	0		
Severe	0	3	9	2	0		
Total	1	4	9	2	0		

Notes: p-value was determined from the chi-square test

¹⁾ = significant

Table 4. Correlation between head shape and facial shape in 6-7 years children with protein deficiency accompanied by low body mass index

Head shape	Facial type					Contingency coefficient	P-value
	Hypereury prosopic	Eury prosopic	Meso prosopic	Lepto prosopic	Hyperlepto prosopic		
Dolico cephalic	0	0	0	2	0	78.2%	0.00*
Meso cephalic	0	2	9	0	0		
Brachy cephalic	1	2	0	0	0		
Hypebrachi cephalic	0	0	0	0	0		
Total	1	4	9	2	0		

Notes: p-value was determined from the chi-square test

*) = significant

head shape had significant correlation with facial type, with correlation power of 78.2%. This means that mesocephalic head shape correlated with mesoprosopic facial type.

DISCUSSION

Protein intake that should be consumed by 6-7 years children according to Nutrient Adequacy Ratio in 2013 was 36-49 gram or 90-119% per day.¹¹⁻¹³ The results of this study showed that all subjects aged 6-7 years followed by low body mass index experienced protein deficiency. Other study in 6-24 months children with low body mass index showed protein deficiency. Jati and Nindya's study in twins aged 36-60 months with high body mass index showed excess protein. Low body mass index is linked with the role of protein as development and body regulation substances required for bone and muscle growth.¹⁴

Protein in the body will be digested and broken down to lysine and arginine, which then will be used for the growth of tissue and muscle, especially in children with low body weight.¹⁵ Studies in children aged 24-59 months found that children who rarely consume milk tend to be shorter in height. Milk contains casein protein which affects calcium absorption and phosphor retention in the intestine. Disturbed calcium absorption can cause low matrix mineralization of new bone deposit and osteoblast dysfunction, while prolonged phosphor deficiency will cause the release of calcium from bone.^{15,16} Other study toward a rat with protein deficiency showed that

it also had suffered from hypocalcemia caused by disturbed intestine absorption due to lack of albumin protein, which inevitably lead to the impediment of the calcium to be distributed.¹⁷

Characteristic of subject based on head shape and facial type in Table 1 showed average cephalic index value of 78.28, which means that the subjects were dominated with mesocephalic head, and average facial index value of 86.06, which means that the subjects were dominated with mesoprosopic face. Gautam's study about five-year old children showed that 75% of boys and girls had mesoprosopic and dolichocephalic head shapes with smaller head circumferences.⁵ Rauten's research in the South West Region of Romania stated that the most common facial shape was mesoprosopic type (57.14%), and the most common head shape was mesocephalic type (57.14%) in control group. Similarly, the measurement done to the test group revealed mesocephalic type (52.63%) and the mesoprosopic type (56.57%).¹⁸ Head and brain growth passed the peak of growth for about 70-80% before the age of 5 to 6, began to grow slowly after, and then having accelerated growth of once reaching puberty.¹⁸

Correlation between moderate protein deficiency and head shape showed that two subjects had brachycephalic head (Table 2). The results of statistical test showed p-value = 0.007, which can be concluded that protein deficiency followed by low body mass index had significant correlation with head shape, with correlation value of 61.8%. This indicates that the correlation of protein deficiency followed by low body

mass index to head shape was dominated with mesocephalic. The results of this study were in accordance with Miller and German⁹ to rat model given low protein diet showed shorter and wider cranium shape compared to control group. Tiwari et al showed that children with low protein intake had inhibited growth of brain and smaller cranium size.¹⁴ The results of this study showed a correlation between protein deficiencies to head growth which then affects head shape. The hindrance occurred due to the inadequacy of protein's supposed role as cell developing material, especially during the first five years postnatal.^{14,20} Thakur and Ghautam showed that 5-18 years children with low body mass index caused by protein deficiency had mesocephalic and doliocephalic, with total of 42.6% girls and 33% boys with mesocephalic head, and 43% boys and 26.6% girls had doliocephalic head.⁵ The results of this study showed that most samples had mesocephalic head.

Facial type according to moderate deficiency category showed one child had hypereuryprosopic and one child euryprosopic. The results of statistical test showed p-value = 0.027. It can be concluded that protein deficiency followed by low body mass index had significant correlation with facial type, with correlation power of 60.3%, which means that the correlation of protein deficiency followed by body mass index was dominated by mesoprosopic face. Similar results were reported in a study in rat model using cephalometric radiograph and showed protein deficiency during growing phase can inhibit the development of mandibular condyle process, thus affects changes in face shape.¹⁷ Other study assessed that the correlation between protein deficiency to inhibition of growth of jaw length in rats showed significant effect to facial growth pattern.²¹ Jaw length was correlated with head length growth through synchondrosis, which is located at the base of cranium and connected the jaw and cranium.^{22,23}

According to Franco et al through Hunter Enlow theory stated that facial morphology was determined by cranium base which acts as a mold because it is stable and unchanged. Meanwhile, cranium morphology is affected by brain development. Tiwari et al. stated that brain development can be affected by protein intake,

thus causing smaller cranium size. Facial growth occurs due to maxilla attached to cranium base by several sutures, thus the growth of cranium base directly affects nasomaxillary growth.^{10,20}

Dolichocephalic head had longer brain shape in the anteroposterior direction and narrower in transversal direction, resulting in longer and flatter skull base and wider skull base angle. The shape of dolichocephalic and mesocephalic head supported the development of facial morphology toward lengthier and showed leptoprosopic and brachycephalic head shape supported euryprosopic facial type.^{9,10,24} The result of this study was dominated by mesocephalic head with mesoprosopic facial type.

CONCLUSION

Protein deficiency accompanied by low body mass index influences the head shape and facial type of children. The head shape and facial type of 6-7 years children are dominated with mesocephalic head shape and mesoprosopic facial type.

REFERENCES

1. Hannah RA, Effendi SH. Prevalence of moderate malnutrition in school-age children and its association with hypertension and microalbuminuria. *Am J Clin Med Res.* 2017;5(1):6-9. DOI: [10.12691/ajcmr-5-1-2](https://doi.org/10.12691/ajcmr-5-1-2)
2. National Institute of Health Research and Development (NIHRD). Indonesia Basic Health Research (RISKESDAS) 2012-2013. Jakarta: Ministry of Health of the Republic of Indonesia; 2013.
3. National Institute of Health Research and Development (NIHRD). Indonesia Basic Health Research (RISKESDAS) 2007-2008. Jakarta: Ministry of Health Republic of Indonesia; 2008.
4. Syahrul S, Kimura R, Tsuda A, Susanto T, Saito R, Ahmad F. Prevalence of underweight and overweight among school-aged children and its association with children's sociodemographic and lifestyle in Indonesia. *Int J Nurs Sci.* 2016; 3:169-77. DOI: [10.1016/j.ijnss.2016.04.004](https://doi.org/10.1016/j.ijnss.2016.04.004)
5. Thakur R, Gautam RK. Cephalic growth pattern and nutritional status after 5 years of age: a cross sectional study among girls and boys of

- a Central Indian City-Sagar. *Ind J Phys Anthropol Hum Genet.* 2015;34(1):39-46.
6. Lee G, Ham OK. Factors affecting underweight and obesity among elementary school children in South Korea. *Asian Nurs Res (Korean Soc Nurs Sci).* 2015;9(4):298-304. DOI: [10.1016/j.anr.2015.07.004](https://doi.org/10.1016/j.anr.2015.07.004)
 7. Thomaz EB, Valença AM. Relationship between childhood underweight and dental crowding in deciduous teething. *J Pediatr (Rio J).* 2009;85(2):110-6. DOI: [10.2223/JPED.1876](https://doi.org/10.2223/JPED.1876)
 8. Pimpin L, Jebb S, Johnson L, Wardle J, Ambrosini GL. Dietary protein intake is associated with body mass index and weight up to 5 years of age in a prospective cohort of twins. *Am J Clin Nutr.* 2016;103:389-97. DOI: [10.3945/ajcn.115.118612](https://doi.org/10.3945/ajcn.115.118612)
 9. Torres-Restrepo AM, Quintero-Monsalve AM, Giraldo-Mira JF, Rueda ZV, Vélez-Trujillo N, Botero-Mariaca P. Agreement between cranial and facial classification through clinical observation and anthropometric measurement among Envigado school children. *BMC Oral Health.* 2014;14:1-8. DOI: [10.1186/1472-6831-14-50](https://doi.org/10.1186/1472-6831-14-50)
 10. Franco FCM, de Araujo TM, Vogel CJ, Quintao CCA. Brachycephalic, dolichocephalic and mesocephalic: Is it appropriate to describe the face using skull patterns? *Dent Press J Orthod.* 2013;18(3):159-63. DOI: [10.1590/S2176-94512013000300025](https://doi.org/10.1590/S2176-94512013000300025)
 11. Mutaqqin Z. *Dietitian in your pocket.* Yogyakarta: Deepublish; 2015: p. 14
 12. Ministry of Health of the Republic of Indonesia. Keputusan Kementerian Kesehatan mengenai Standar Antropometri Penilaian Status Gizi Anak in: Gizi DB, ed. Jakarta: Ministry of Health of the Republic of Indonesia. 2010: pp. 4-5, 18-20, 36-40.
 13. Ministry of Health of the Republic of Indonesia. *Angka Kecukupan Gizi yang Dianjurkan Bagi Bangsa Indonesia.* Jakarta. 2013.
 14. Jati DK, Nindya TS. Asupan energi dan protein berhubungan dengan gizi kurang pada anak usia 6-24 bulan. *Amerta Nutr J.* 2017;1(2):124-32. DOI: [10.20473/amnt.v1i2.2017.124-132](https://doi.org/10.20473/amnt.v1i2.2017.124-132)
 15. Uauy R, Kurpad A, Tano-Debrah K, Otoo GE, Aaron GA, Toride Y, et al. Role of protein and amino acids in infant and young child nutrition: protein and amino acid needs and relationship with child growth. *J Nutr Sci Vitaminol (Tokyo).* 2015;61:191-4. DOI: [10.3177/jnsv.61.S192](https://doi.org/10.3177/jnsv.61.S192)
 16. Sari EM, Juffrie M, Nurani N, Sitaresmi MN. Asupan protein, kalsium dan fosfor pada anak stunting dan tidak stunting usia 24-59 bulan. *J Gizi Klin Ind.* 2016;12(4):152-9. DOI: [10.22146/ijcn.23111](https://doi.org/10.22146/ijcn.23111)
 17. Martin AE, del R Pani M, Holgado NR, López Miranda LI, Meheris HE, Garat JA. Facial development disorders due to inhibition to endochondral ossification of mandibular condyle process caused by malnutrition. *Angle Orthod.* 2014;84(3):473-8. DOI: [10.2319/042013-307.1](https://doi.org/10.2319/042013-307.1)
 18. Rauten AM, Maglaviceanu C, Popescu MR, Martu I, Popescu D, Surlin P, et al. Correlations between craniofacial morphology and dento-maxillary anomalies in a population of children in the south west region of Romania. *Curr Health Sci J.* 2014;40(3):200-4. DOI: [10.12865/CHSJ.40.03.08](https://doi.org/10.12865/CHSJ.40.03.08)
 19. Pimpin L, Jebb S, Johnson L, Wardle J, Ambrosini GL. Dietary protein intake is associated with body mass index and weight up to 5 years of age in a prospective cohort of twins. *Am J Clin Nutr.* 2016;103:389-97. DOI: [10.3945/ajcn.115.118612](https://doi.org/10.3945/ajcn.115.118612)
 20. Tiwari K, Goyal S, Malvia S, Sanadhya A, Suman RL, Jain R. Impact of malnutrition on head size and development quotient. *Int J Res Med Sci.* 2017;5(7):3003-6. DOI: [10.18203/2320-6012.ijrms20172977](https://doi.org/10.18203/2320-6012.ijrms20172977)
 21. Mehta V, Bagga MK, Bhatti BK. How diet affects on orthodontic treatment. *Int J of Res Rev.* 2018;5(5):46-51.
 22. Chin A, Perry S, Liao C, Yang Y. The relationship between the cranial base and jaw base in a Chinese population. *Head Face Med.* 2014;10(31):1-8.
 23. Cendekiawan T, Wong RWK, Rabie ABM. Relationships between cranial base synchondroses and craniofacial development: A review. *Open Anat J.* 2010;2:67-75. DOI: [10.2174/1877609401002010067](https://doi.org/10.2174/1877609401002010067)
 24. Singh N, Tripathi T, Rai P, Gupta P. Nutrition and orthodontic-interdependence and interrelationship. *Res Rev J Dent Sci.* 2017;5(3):18-22.