Scientific Foundation SPIROSKI, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences. 2022 Jan 03; 10(T8):91-96.
https://doi.org/10.3889/oamjms.2022.9492
eISSN: 1857-9655
Category: *T8 –"APHNI: Health Improvement Strategies Post Pandemic Covid-19"*
Section: *Pediatrics*

Rapid Growth in Malnutrition Children Associated with Higher Systolic Blood Pressure in Adolescent

Firlia Ayu Arini*, Endang Achadi, Besral Besral

Department of Public Health Study Program, Universitas Indonesia, Depok, West Java, Indonesia

Edited by: Ksenija Bogoeva-Kostovska
Citation: Arini FA, Achadi E, Besral B. Rapid Growth in Malnutrition Children Associated with Higher Systolic Blood Pressure in Adolescent. Open Access Maced J Med Sci. 2022 Jan 03; 10(T8):91-96. https://doi.org/10.3889/oamjms.2022.9492
Keywords: Rapid growth; Malnutrition; Blood pressure; Cohort study
***Correspondence:** Firlia Ayu Arini, Department of Public Health Science, Faculty of Public Health, University of Indonesia, Jakarta, Indonesia. E-mail: firlia.nuryanto@gmail.com
Received: 13-Oct-2021
Revised: 21-Nov-2021
Accepted: 02-Dec-2021

Funding: This research did not receive any financial support
Competing Interests: The authors have declared that no competing interests exist

Abstract

BACKGROUND: Several studies found that children experiencing rapid growth earlier in life might increase the risk of chronic disease. Cardiovascular disease and hypertension are common risk factors and have been the leading cause of death worldwide. However, studies investigating the effects of rapid growth in early life on blood pressure later in life are limited.

AIM*:* This study aimed to analyze the association between rapid growth after the first 1000 days of life and blood pressure at 17−19 years old.

METHODS*:* We analyzed 17-year follow-up cohort using secondary data from the Indonesian Family Life Survey from the second (1997), third (2000), and fifth wave (2014). The survey was conducted in 13 provinces in Indonesia. No more than 672 children under 2 years old were included in the study. Rapid growth was defined as an alteration in length or height-per-age and weight-per-age z-score, based on WHO Child Growth Standard, on 1997 and 2000 time frame which was greater than 0.67, experienced by children with malnutrition (low birth weight, stunted, underweight, and wasting). Blood pressure was measured three times by an oscillometric method in 2014. In addition, we used a one-way ANOVA (analysis of variance) test to assess the association of rapid growth on systolic blood pressure.

RESULTS*:* Malnutrition children at 0-2-year-old that grow rapidly in length or height, had higher systolic blood pressure than normal children (p = 0.029). In contrast, there was no difference observed in systolic blood pressure in children with malnutrition and children who did not experience rapid growth in weight.

CONCLUSIONS*:* Children who had a history of malnutrition earlier in life (0−23 months) and had rapid growth in length or height after the first 1000 days of life had higher systolic blood pressure than normal children and children with malnutrition who did not grow rapidly.

Introduction

The first 1000 days of life are a golden period for growth and development that determines health quality in the subsequent life cycle. Growth failure or malnutrition, mostly caused by nutrition deficiencies during pregnancy or the post-natal period, enables the adaptive response of infants to optimizing survival rate. As a result, they limit growth and development and run into epigenetic changes that alter fat–glucose metabolism by having fewer nephron cells on their kidney. On the other hand, children with malnutrition during the first 2 years of life can grow rapidly as the compensation of restricted conditions and to catch-up growth [1], [2].

Rapid growth is defined as gaining weight and length/height standard deviation exceeding the normal limit after an event of malnutrition. Malnutrition, which commonly occurs during the first 1000 days of life, includes low birth weight, stunting, and underweight. Early rapid growth in the post-natal period increases the risk of having a disease in adulthood. This condition occurs because children with rapid growth prioritize energy allocation from their nutrition intake to catch-up growth, whereas the development of metabolic organs and kidneys become suboptimal. As a result, rapid growth has detrimental effects on long-term health, including the risk of having higher blood pressure later in life. In addition, rapid growth alters metabolism and hormonal change; a bigger body size after a period of rapid growth needs optimal organ capacity. However, in children with malnutrition, the organs' functions are suboptimal. As an outcome, they have a higher risk of excess body fat, insulin resistance, and high blood pressure [3], [4], [5].

According to the World Health Organization (WHO) data in 2015, high blood pressure – also commonly known as hypertension – is the major risk factor of cardiovascular disease and kidney disease. About 1.13 billion people were diagnosed with hypertension, where its complications caused 55% of the mortality rate. Commonly, hypertension is more prevalent in the elderly, but nowadays, hypertension has become more prevalent in the younger age group. Surprisingly, this condition might occur since adolescence. In developing countries, where malnutrition is common, the prevalence of hypertension has increased, including in Indonesia. Based on the Basic Health Survey (RISKESDAS) report, the prevalence of hypertension in adults age 18 years old and older was 25.8% in 2013, and it reached 34.1% in 2018 [6].

Hypertension in adolescence leads to hypertension in adults, which increases the risk of morbidity and mortality. Epidemiological evidence suggests that growth and development in early life affect the development of hypertension later in life [7], [8]. The earlier studies in developed countries have shown that hypertension was more prevalent in children with low birth weight and stunting in early life. In contrast, studies in developing countries have shown that low birth weight and stunting did not strongly correlate to blood pressure. Recent studies from Asian countries show that rapid growth in weight, body mass index, and height/length in early life significantly correlated to the blood pressure elevation [9], [10], [11].

A longitudinal study that analyses rapid growth and its association to later health outcomes is still limited in Indonesia. A distinct mechanism about how rapid growth is associated with blood pressure in the Indonesian population is still unknown. Therefore, this study analyzed the association of rapid growth after the first 1000 days of life to adolescents; blood pressure. The result of this study is expected to provide more information about rapid growth and its impact on blood pressure later in life and to improve early hypertension prevention programs.

Methods

This study used secondary data from Indonesia Family Life Survey (IFLS), which provides longitudinal data from families and their individual members. There are five survey waves in which the data report has been published. We used data from the second wave in 1997, the third wave in 2000 and the fifth wave in 2014. This study was an observational study with a retrospective cohort design. Data were collected from sampled families in 13 provinces of Indonesia (4 provinces in Sumatra, 5 Provinces in Java, the other 4 provinces represent Bali, Nusa Tenggara Barat, South Kalimantan, and Sulawesi).

IFLS used stratified random sampling based on residence area to determine the study sample. The population in this study was households with children under 2 year olds or aged 0−23 months in 1997. The inclusion criteria were singleton biological children in households that had complete anthropometric and blood pressure measurements. Children who were premature or born with small for gestational age (SGA) condition, and children with the extreme value of standard deviation score in anthropometric indicators, were excluded from the sample. From a total of 1215 households with children under 2 available in 1997, only 672 children were included in this study. The questionnaires of IFLS consist of individual, household, and community books followed by anthropometric and health measurements. Data were collected by direct interview for adults and used proxy interviews for children and infants. We merged data from several questionnaire books. Institutional Review Board at Universitas Indonesia approved the study protocol number: Ket_464/UN2.F10.D11/PPM.00.02/2021.

We followed the children aged 0−23 months at a baseline in 1997 until 17 to 19 years old in 2014. Children's data included in this study were birth dates, survey dates, age, sex, birth weight, length or height, weight, and blood pressure in wave 5. In addition, we used parents' education level for parents' data, and for household and community data, we included the household income, total asset, and housing area. As a result, the recontact rate of IFLS in every wave was more than 90%.

We defined children's age based on birth date and survey date. Birth weight was categorized as normal birth weight (>3 kg) and low birth weight (<3 kg). Children with birth weights lower than 3 kg had an increased risk of higher blood pressure in adults [5]. The trained nurse measured anthropometric and health measurements; the same methods were used in every survey wave. Length/height was measured using Shorr measuring boards, and children's weight was measured using Seca Floor Model Scales. Blood pressure was measured three times in the same visit using Omron Digital Self Initiating Meter (Oscillometric method), and we used average from those measurements.

Anthropometric data were converted into age-gender specific z-score using WHO Anthro software, based on WHO Child Growth Standard. Children's length/height measurements were converted into height/length-for-age z-score (HAZ) and weight measurements into weight-for-age z-score (WAZ). Children weight-for-height/length were converted into weight-for-height z-score (WHZ). Stunting was defined as the HAZ score below −2SD, underweight as the WAZ score <−2SD and wasting as the WHZ score <−2SD. Rapid growth was defined as an increase or change of HAZ and WAZ from 1997 (children aged 0−23 months) to 2000 (children aged 3−5 years), more than 0.67 units equal to one unit major centile band in SD Score. This definition has been used in some studies of rapid growth in weight, body mass index (BMI), and length or height with samples in Low middle-income countries or Asian populations [1], [12], [13]. We grouped children at baseline into normal and children with malnutrition (low birth weight, stunting, or underweight). Furthermore, we divided children into three groups based on rapid growth in HAZ and WAZ, categorized as a normal group, children with malnutrition but not growth rapidly (non-rapid growth), and children with malnutrition and growth rapidly (rapid growth).

Mother and father's education level was grouped into three categories: Did not attend school and attended primary school, middle school, and higher school. Next, we calculated household income and total assets. Then, we divided them into five quintiles, from the poorest to the richest – finally, housing areas were categorized as urban and rural areas.

We summarized characteristics of samples using univariate analyses, continuous variables described by mean with standard deviation or median and range after normality test, and categorical variables described by frequency and percentages of the total sample. In addition, we performed a one-way analysis of variance to compare blood pressure among rapid growth groups based on HAZ and WAZ. The test was significant if the p < 0,05. All analyses were conducted using STATA software.

Results

Descriptive statistics of samples characteristic and demographic data are presented in Table 1. This study's samples were dominantly female; the sex ratio was nearly balanced for both sex groups. For most children aged 12−23 months, the least age group was 6 to 11 years old. The prevalence of low birth weight was 21.13% using a low birth weight cutoff point below 3 kg. Stunting was the most prevalent malnutrition experienced by 40% of samples. On the other hand, the prevalence of underweight was 20%, whereas the wasting rate was only 11.9%. Thus, more than half of the samples had a history of malnutrition: Low birth weight, stunting, underweight, or wasting. Of children with malnutrition in early life, 25.63% experienced rapid growth according to HAZ, and 20.3% had rapid growth based on WAZ.

Most of the parent's education level was no education or did not attend school or primary school, the percentage was 58,18% of mothers and 44,94% of fathers. Most samples had household income in Quintile 3 (22.7%) and total household assets mostly in Quantile 3 and 5 (20.09%). The mean value of numeric variables is described in Table 2. It was shown that the mean value of birth weight was 3.19 kg ± 0.52 kg, which was categorized as normal birth weight. However, it was found that the minimum birth weight value was 1 kg – categorized as very low and the maximum birth weight reached 6 kg – which is considered very high considering the gestational age was 37−40 weeks. Based on HAZ, WAZ, and WHZ measurements in 1997, the mean value at baseline was categorized as normal. The least mean value observed among those growth indicators was HAZ, while WHZ had the widest range. The mean value of systolic and diastolic blood pressure was 118.34 mmHg and 72.57 mmHg, respectively. The highest systolic and diastolic blood pressure values were 171.00 mmHg and 103.67 mmHg, respectively, which were above normal blood pressure limits. The normal blood pressure value for adolescents was a maximum of < 120 mmHg for systolic blood pressure and < 80 mmHg for diastolic blood pressure.

Table 1: Characteristic and demographic of respondents (n = 672)

Characteristics	n	%
Sex		
Female	354	52.68
Male	318	47.32
Age group		
0−5 month	181	28.86
6−11 month	153	22.77
12−23 month	338	50.3
Birth weight		
Normal	530	78.87
Low birth weight	142	21.13
Height for age Z score at baseline		
Normal	409	60.86
Stunting	263	39.14
Weight for age Z score at baseline		
Normal	537	79.91
Underweight	145	20.09
Weight for height Z score at baseline		
Normal	592	88.1
Wasting	80	11.9
Malnutrition		
Normal	285	42.4
Malnutrition	387	57.59
Rapid growth in HAZ		
Normal	285	42.4
Non-rapid growth	214	31.9
Rapid growth	172	25.63
Rapid Growth on WAZ		
Normal	285	42.4
Non-rapid growth	250	37.3
Rapid growth	136	20.3
Mother education		
Middle school	111	16.5
Higher school	170	25.3
Father education		
No education/primary	302	44.94
Middle school	98	14.58
Higher school	272	40.47
Household income		
Quantile 1	136	20.24
Quantile 2	136	20.24
Quantile 3	151	22.27
Quantile 4	118	17.56
Quantile 5	131	19.49
Total Asset		
Quantile 1	134	19.94
Quantile 2	134	19.94
Quantile 3	135	20.09
Quantile 4	134	19.94
Quantile 5	135	20.09
Housing area		
Urban	387	64.84
Rural	285	35.17

Table 2: Mean of birth weight, HAZ, WAZ, WHZ at baseline and blood pressure in 2014 at age 17−19

Parameter	Mean ± SD	Min	Max
Birth weight (kilogram)	3.19 ± 0.52	1	6.03
HAZ (score)	−1.42 ± 1.91	−6	5.93
WAZ (score)	−0.95 ± 1.37	−5.76	4.87
WHZ (score)	−0.2 ± 1.73	−5.16	10.57
Systolic blood pressure (SBP) (mmHg)	118.34 ± 12.38	90	171
Diastolic blood pressure (DBP) (mmHg)	72.57 ± 8.61	40.67	103.67

The comparison of blood pressure means value between the group is described in Table 3. The result of HAZ among rapid growth groups – rapid linear growth – shows that the lowest mean value was observed in the non-rapid group for systolic blood pressure (SBP) and in the normal group for diastolic

Table 3: Association of rapid growth with blood pressure in adolescent

Rapid growth group	SBP Mean ± SD	Min	Max	DBP Mean ± SD	Min	Max
Rapid growth HAZ						
Normal	117.9 ± 12.7	90	171	72 ± 8.8	40.67	103.3
Non-rapid growth	117.3 ± 11.8	93.7	159	72.3 ± 8.2	44.67	99
Rapid growth	120.5 ± 12.2	96.7	157	73.9 ± 8.8	54.3	103.7
p value	0.029 *			0.064		
Rapid growth WAZ						
Normal	117.9 ± 12.7	90	171	72 ± 8.8	40.67	103.3
Non-rapid growth	119.1 ± 12.5	95	159	73.3 ± 8.3	51.3	103.7
Rapid growth	118.5 ± 11.5	93.7	153	72.5 ± 8.8	44.67	94.7
p value	0.464			0.258		

SBP: Systolic blood pressure, DBP: Diastolic blood pressure, *p < 0.05.

blood pressure (DBP). The highest mean value for SBP was in children with malnutrition who experienced rapid growth (120.5 mmHg). In line with SBP, the highest DBP based on HAZ was in the rapid growth group (73.9 mmHg). Between the rapid linear growth group, the normal group had the widest range of SBP and DBP. There was a significant difference between SBP mean values among the rapid linear growth group with p-value=0.029. Otherwise, there was no significant difference in DBP mean value among the rapid growth group based on HAZ. In contrast, the result observed in the rapid growth group based on WAZ, the highest mean of SBP and DBP was in the non-rapid growth group, who had a history of malnutrition in early life but did not have rapid weight growth after 2-year-old. The mean value of SBP and DBP was higher in the rapid growth group than in the normal group, but the non-rapid growth group experienced the highest in both measurements. There was no significant difference between SBP and DBP among the rapid growth group based on WAZ. The p-values of the comparison test in SBP and HBP among the rapid growth group based on WAZ were 0.464 and 0.258, respectively.

Discussion

In recent years, the role of early life growth in determining the quality of health later in life has been extensively studied. Rapid growth during early life may have detrimental effects on health. The association between a child's rapid growth and blood pressure as the major risk factor of heart disease was investigated [9], [12]. We conducted an observational study using longitudinal data from 672 children aged 0−23 months in 1997 as a baseline and followed until they were 17 to 19 years old in 2014. We analyzed the rapid growth in children with malnutrition associated with blood pressure in adolescents. This study found that rapid growth in length/height in children with malnutrition during the first 1000 days of life was associated with higher systolic blood pressure. There was a significant difference between SBP in children with malnutrition who experienced rapid growth compared to normal children. The mean value of SBP in children with malnutrition who experienced rapid growth was >120 mmHg, which was above the normal limit of SBP for adolescents aged 17−19 years old. Based on the American Academy of Pediatrics definition, SBP starts from 120 mmHg, categorized as elevated blood pressure [14]. The mean value of DBP in the rapid growth group based on HAZ was 73.9, which is also the highest among groups. However, it is below 80 mmHg, so that, on average, the mean DBP value is still considered normal blood pressure. There was a difference in DBP mean value between the rapid growth group based on HAZ, even though it was insignificant.

A study from Heys (2013) analyzed data from children in Hong Kong of 1997 birth cohort and followed until 11 years old, which found that linear growth in childhood was associated with adolescent systolic and diastolic blood pressure. In line with the study from Heys, another result from the same cohort study, which followed until the samples 17.5 years old, showed that greater length-for-age z-score (LAZ) obtained from 3 to 8 years and 8 to 14 years was positively associated with higher SBP. However, these two studies did not separate children based on their experience of malnutrition in early life. In addition, they collected birth weight data and anthropometric measurements at 3 months. According to a study from Heys, it was found that birth weight and growth in infancy were not strongly associated with adolescent blood pressure. Howeve, current body size and growth in childhood were more correlated to blood pressure. Similarly, the following cohort analyzed by Cheng showed that birth weight had no association with z-score SBP and DBP [9], [11].

This study divided the group of rapid growth into three, which separate children with malnutrition during 1000 first days of life at baseline. The children with malnutrition consist of those who experienced low birth weight, stunting, underweight and wasting. A hypothesis related to the fetal origin of the disease stated that prenatal exposures – indicated by birth weight – were associated with higher blood pressure. Studies in the Western population found an inverse association between birth weight and blood pressure. If studies from the Hong Kong birth cohort did not support the hypothesis, a cohort study from Amsterdam found that lower birth weight was associated with higher blood pressure at 5 years old. This study also suggested that faster weight gain and linear growth after 1 month of age positively correlated with systolic and diastolic blood pressure. The group with lower blood pressure from this study had a longer duration of breastfeeding and had complementary feeding introduction after 6 months of age [11], [15].

Children with prenatal and early post-natal undernutrition are predisposed to the increased risk of coronary heart disease caused by the development of atherogenic metabolic change. Hypertension is one of the risk factors of coronary heart disease. In addition, hypertension is commonly found in adults who experience stunting in early life. In India, a study from Deka found that 28% of stunted children had elevated blood pressure, particularly DBP ($p < 0.05$). Similarly, an earlier study from Febba in Brazil found that stunting was associated with angiotensin-converting enzyme activity, which correlated to higher blood pressure. In contrast, a study conducted in Indonesia shows no significant association between stunting in childhood and adolescent blood pressure, both systolic and diastolic [2], [10], [16], [17].

Several studies have reported that accelerated weight gain in early childhood is related to a higher risk of elevated blood pressure. The weight accelerated growth during childhood predicts elevated blood pressure. The weight gain during childhood was correlated with obesity risk. A study from Nan in China found that rapid growth in body mass index had a higher odd ratio of SBP and DBP with OR 2.38 and 2.42, respectively. Another study from Ong had found that children with fetal growth deceleration followed with rapid postnatal weight gain from 0 to 2 years, was associated with elevated blood pressure. In line with those studies, the study by Asiki in Uganda suggested that children who recovered from wasting had higher blood pressure than the normal group. Children in this group had the highest blood pressure trajectories from 3 to 7 years old compared to other groups [1], [12], [18]. The result of this study was contrary to studies from Ong and Nan. There was no significant difference between rapid growth groups based on WAZ in SBP and DBP. Malnutrition children who did not experience rapid growth in weight, had the highest mean of SBP and DBP. The effect of early pre- and post-natal exposure to malnutrition had significantly affected blood pressure. The limitation of this study was blood pressure measurements that used in this study were collected using digital measuring tools or oscillometer at one visit, not being confirmed or diagnosed as hypertension. We did not exclude the children who might have hypertension caused by immune metabolic disease because no data or supplements mention this condition.

Growth is the process of increasing in size that reflects the child's health and living condition. Poor child growth is associated with poorer cognition and health quality later in life. Hence, the promotion or recovery from poor growth has been a priority to improve cognitive function and children's health. However, many studies have revealed that rapid growth during early life has several adverse effects on long-term health. Rapid growth could increase the risk of chronic disease, including hypertension. This study showed rapid growth in children with malnutrition is the risk factor of higher systolic blood pressure [4], [9]. From the result of this study, it has been shown that rapid growth might increase the risk of elevated systolic blood pressure. On the other hand, if the prevalence of malnutrition was reduced, it might have a protective effect on the development of hypertension in adolescents and adults. Therefore, the growth of children who had malnutrition in early life should be monitored regularly. Furthermore, an intervention program for children and their families should be developed to reduce the risk of hypertension in later life.

Conclusion

Rapid growth in length/height after 1000 days of life in children with malnutrition was associated with higher systolic blood pressure in adolescents. There was a significant difference between SBP in the rapid growth group and the normal group. In contrast, there was no significant difference between SBP in children with malnutrition who did not grow rapidly and the normal group. Diastolic blood pressure of children with malnutrition who experienced rapid growth in length/height was higher than other groups but not significantly different. On the other hand, there was no significant difference between SBP and DBP among the rapid growth group based on WAZ.

Acknowledgment

We would like to thank RAND for making Indonesian Family Life Survey data available for researchers and the Ministry of Education Culture and Technology Research, Indonesia, for scholarship research funding.

References

1. Ong YY, Sadananthan SA, Aris IM, Tint MT, Yuan WL, Huang JY, *et al*. Mismatch between poor fetal growth and rapid postnatal weight gain in the first 2 years of life is associated with higher blood pressure and insulin resistance without increased adiposity in childhood: The GUSTO cohort study. Int J Epidemiol. 2020;49(5):1591-603. https://doi.org/10.1093/ije/dyaa143
PMid:32851407
2. Prendergast AJ, Humphrey JH. The stunting syndrome in developing countries. Paediatr Int Child Health. 2014;34(4):250-65. https://doi.org/10.1179/2046905514Y.0000000158
PMid:25310000
3. Achadi EL, Achadi A, Aninditha T. Stunting Prevention: The Important Role of 1000 First Days of Life. Depok: Jawa Barat; 2020. p. 155.
4. Singhal A. Long-Term Adverse Effects of Early Growth Acceleration or Catch-Up Growth. Ann Nutr Metab. 2017;70(3):236-40. https://doi.org/10.1159/000464302
PMid:28301849

5. Temple NJ, Wilson T, Jacobs DR. Nutritional Health: Strategies for Disease Prevention. 3rd ed. United States: Humana Press; 2012.
6. Shaumi NRF, Achmad EK. Kajian literatur: Risk faktor of adolescent hypertension in Indonesia. Res Dev Media. 2019;29(2):115-22.
7. Eriksson JG. Epidemiology, genes and the environment : Lessons learned from the Helsinki Birth Cohort Study. J Intern Med. 2007;261(5):418-25. https://doi.org/10.1111/j.1365-2796.2007.01798.x

   PMid:17444881
8. Luyckx VA, Bertram JF, Brenner BM, Fall C, Hoy WE, Ozanne SE, *et al*. Effect of fetal and child health on kidney development and long-term risk of hypertension and kidney disease. Lancet. 2013;382(9888):273-83. http://doi.org/10.1016/S0140-6736(13)60311-6

   PMid:23727166
9. Cheng TS, Leung GM, Hui LL, Leung JY, Kwok MK, Yeung SL, *et al*. Associations of growth from birth to puberty with blood pressure and lipid profile at ~17.5 years: Evidence from Hong Kong's "Children of 1997" birth cohort. Hypertens Res. 2019;42(3):419-27. http://doi.org/10.1038/s41440-018-0170-x

   PMid:30559401
10. Deka A, Barman D, Ray PS. Assessment of blood pressure and lipid profile in 1-5 years stunted children attending a tertiary care hospital. Indian J Child Health. 2020;7(3):101-4.
11. Heys M, Lin SL, Lam TH, Leung GM, Schooling CM. Lifetime growth and blood pressure in adolescence: Hong Kong's "Children of 1997" birth cohort. Pediatrics. 2013;131(1):e62-72. http://doi.org/10.1542/peds.2012-0574

    PMid:23230068
12. Li N, Zhang S, Leng JH, Li WQ, Wang LS, Li W, *et al*. Effects of rapid growth in early childhood on metabolic and cardiovascular diseases among preschool-aged children. Asia Pac J Clin Nutr. 2020;29(3):558-65. http://doi.org/10.6133/apjcn.202009_29(3).0015

    PMid:32990616
13. Desmond C, Casale D. Catch-up growth in stunted children: Definitions and predictors. PLoS One. 2017;12(12):1-12. http://doi.org/10.1371/journal.pone.0189135

    PMid:29236728
14. Flynn JT, Falkner BE. New clinical practice guideline for the management of high blood pressure in children and adolescents. Hypertension. 2017;70(4):683-6. http://doi.org/10.1161/HYPERTENSIONAHA.117.10050

    PMid:28827475
15. De Beer M, Vrijkotte TG, Fall CH, Van Eijsden M, Osmond C, Gemke RJ. Associations of infant feeding and timing of weight gain and linear growth during early life with childhood blood pressure: Findings from a prospective population based cohort study. PLoS One. 2016;11(11):1-16. http://doi.org/10.1371/journal.pone.0166281

    PMid:27832113
16. Febba A, Sesso R, Barreto GP, Liboni CS, Franco MC, Casarini DE. Stunting growth: Association of the blood pressure levels and ACE activity in early childhood. Pediatr Nephrol. 2009;24(2):379-86. http://doi.org/10.1007/s00467-008-0980-1

    PMid:18791745
17. Rachmi CN, Agho KE, Li M, Baur LA. Are stunted young Indonesian children more likely to be overweight, thin, or have high blood pressure in adolescence? Int J Public Health. 2017;62(1):153-62. http://doi.org/10.1007/s00038-016-0905-x

    PMid:27704160
18. Asiki G, Newton R, Marions L, Kamali A, Smedman L. The effect of childhood stunting and wasting on adolescent cardiovascular diseases risk and educational achievement in rural Uganda: A retrospective cohort study. Glob Health Action. 2019;12(1):1626184. https://doi.org/10.1080/16549716.2019.1626184

    PMid:31232215