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Malnutrition status and impact of daily activities and dietary habits on stunting: A study of 4,871 preschool children in Inner-City Hanoi

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Abstract. This study aimed to investigate malnutrition and the impact of daily activities and dietary habits on stunting in preschool children to identify effective prevention strategies. The study consisted of two phases: a cross-sectional analysis of 4,871 children from nine preschools in Hoang Mai District and a case-control study of 207 stunted children and 2,984 normal-height children, using the WHO criteria for nutritional status classification. The results indicated that the prevalence of underweight, stunting, and wasting was 3.6, 7, and 2.4%, respectively. Underweight and stunting were more common among girls (4.4 vs. 3.0% and 8 vs. 6%, respectively), while wasting was slightly higher in boys (2.5 vs. 2.2%). Significant associations with stunting included less than one hour of moderate and vigorous physical activity (Odds Ratio (OR) = 1.71) and meal times exceeding 40 minutes (OR = 1.73). Preferring to eat lean meat reduced the risk of stunting (OR = 0.72, 95% confidence interval is 0.54–0.98). Factors such as nighttime sleep duration, bedtime, active physical activities at school, sedentary behaviours, and preferences for fats, sweets, eggs, vegetables, and milk consumption before sleep were not significantly associated with stunting. The study suggests that monitoring eating times, encouraging more moderate and vigorous physical activity, and increasing lean meat consumption can help reduce the risk of stunting in children.

Keywords: daily routine, dietary habit, preschool children, malnutrition status, stunting

1 Introduction

Malnutrition refers to deficiencies in nutrient intake, an imbalance of essential nutrients, or impaired nutrient utilisation, which has a negative impact on normal bodily functions, activities, and growth. Among children, malnutrition can present as stunting (too short for age), wasting (too thin for height), and underweight (too thin for age) [1]. According to a World Health Organisation (WHO) report in 2019, there were 144 million stunted children under the age of 5 and 47 million wasted children [2]. Malnutrition is a major concern because of its high rates among children and is the leading cause of morbidity and mortality among children under 5 years old [3]. Malnourished children are at a higher risk of poor physical, cognitive, and intellectual development when they mature, which can reduce the quality of the labour force and hinder the national economic development [4].

Stunting is a form of malnutrition caused by various factors, including genetic and environmental influences, such as infectious diseases, environmental pollution, poverty, and poor appetite [5]. Currently, there is significant interest in how children's physical activity and dietary patterns affect stunting [6, 7]. Understanding these factors can lead to recommendations and interventions aimed at changing lifestyle habits and reducing the risk of early stunting among children [8].

Hoang Mai is an urban district in Hanoi, known for being the fourth-largest district in terms of area and population. Despite its economic development, the district still has a high rate of stunting among children. Therefore, this study aimed to determine the prevalence of malnutrition and examine the impact of daily activity habits and dietary characteristics on stunting among preschool children in Hoang Mai District.

2 Research methods

2.1 Study design and participants

The study is divided into two phases: Phase 1 is a cross-sectional study, and Phase 2 is a case-control study. The cross-sectional study was performed on 4,871 children from nine preschools in Hoang Mai District. Children's weight and height were measured to determine their nutritional status in October and November 2018, which was part of the scientific project under the Ministry of Education and Training under code No. B2018-SPH-50. Children of normal height and stunted children were included in the case-control study to determine the association of daily activities and eating habits with children's stunting.

Children with acute diseases, chronic diseases (asthma, chronic kidney disease, congenital heart disease, etc.), tuberculosis, HIV infection, kyphosis, and scoliosis were excluded from the study.

2.2 Collection of anthropometric data

To prevent measurement error, we measured children's weight and height in the morning, in an air-conditioned room. Children wore light clothing and were weighed and measured according to standard procedures of the National Institute of Nutrition. Weight was measured with an electronic scale with an accuracy of 100 grams. Standing height was measured with a stadiometer with an accuracy of 0.1 cm.

2.3 Classification of nutritional status

To classify children's nutritional status, we used Z-scores; a Z-score represents the number of standard deviations a child's anthropometric measurement deviates from the reference population median. For children under 60 months of age, we used the 2006 WHO standards to determine weight-for-age Z-score (WAZ), Z-score height-for-age Z-score (HAZ), BMI-for-age Z-score (BAZ), and weight-for-height Z-score (WHZ). For children aged 60 months to 9 years, we used the 2007 WHO criteria to assess WAZ, HAZ, and BAZ.

These analyses were automatically calculated by means of the WHO Anthro software (for children under 60 months) version 3.2.2 and the AnthroPlus® software (for children over 60 months) version 1.0.4 (Geneva, Switzerland). The threshold for classifying children's nutritional status is presented in Table 1.

Table 1. Z-score cut-off to classify nutritional status in preschool children (under 9 years old)

Index	Z-score cut-off value	Nutritional status
WAZ	<–3	Severe underweight
	–3 to <–2	Moderate underweight
	–2 to 2	Normal
	>2 to 3	Overweight
	>3	Obesity

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Index	Z-score cut-off value	Nutritional status
HAZ	<– 3	Severe stunting
	–3 to <–2	Moderate stunting
	>–2	Normal
BAZ	<– 3	Severe wasting
	–3 to <–2	Moderate wasting
	–2 to 2	Normal
	>2 to 3	Overweight
	>3	Obesity

2.4 Collection of information on daily routines and dietary habits

Children's daily activities and eating behaviours were assessed via a structured parent-completed questionnaire. Meal time was defined as the average duration of a meal and categorised into <20, 20–40, and >40 minutes. Moderate-to-vigorous physical activity was defined as active play or exercise, categorised as >1 hour/day or ≤1 hour/day. Additional information was night sleep duration, usual bedtime, participation in school-based physical activities (yes/no), time spent on sedentary activities at home, preferred food types (e.g., lean meat, sweets, fats, eggs, vegetables), and habitual milk consumption before sleep.

2.5 Data analysis

Statistical tests were conducted by using SPSS version 16.0 (SPSS, Chicago, USA). Quantitative variables were tested for normality. If normally distributed, they were expressed as mean ± standard deviation; otherwise, they were presented as median (25–75th percentile). The student's t-test was employed to compare the distribution of two normally distributed groups, and the Mann-Whitney U test was employed to compare the distribution of two nonnormally distributed groups. Differences in proportions were analysed by using the Chi-square test. The influence of risk factors on stunting was analysed by means of univariate and multivariate logistic regression. A two-tailed *p*-value of less than 0.05 was considered statistically significant.

3 Results

3.1 Malnutrition status of Hoang Mai preschool children

The cross-sectional study was conducted to determine the malnutrition status of 4,871 preschool children in Hoang Mai District, Hanoi. The percentages of the three types of malnutrition among the children in the total study population, divided by gender, are presented in Table 2.

Table 2. Malnutrition status of preschool children in Hoang Mai District, Hanoi

Malnutritional status	Total *n* (%) (*n* = 4,871)	Male *n* (%) (*n* = 2,500)	Female *n* (%) (*n* = 2,371)	*p*
Classification by WAZ index				
Severe underweight	23 (0.5%)	9 (0.4%)	14 (0.6%)	**<0.0001**
Moderate underweight	153 (3.1%)	64 (2.6%)	89 (3.8%)	
Classification by HAZ index				

Malnutritional status	Total *n* (%) (*n* = 4,871)	Male *n* (%) (*n* = 2,500)	Female *n* (%) (*n* = 2,371)	*p*
Severe stunting	52 (1.1%)	20 (0.8%)	32 (1.3%)	**0.010**
Moderate stunting	289 (5.9%)	129 (5.2%)	160 (6.7%)	
Classification by BAZ index				
Severe wasting	19 (0.4%)	13 (0.5%)	6 (0.3%)	**<0.0001**
Moderate wasting	95 (2.0%)	49 (2.0%)	46 (1.9%)	

p-Values were obtained from the Chi-square test. *p*-Values less than 0.05 are presented in bold. Some *p*-values are very low (e.g., <0.0001).

Stunted children had the highest percentage, while wasted children had the lowest percentage, accounting for 7 and 2.4%, respectively. There was a difference in the sex ratio between boys and girls across the underweight, stunted, and wasted groups. Among them, the rates of underweight and stunting in girls were higher than those in boys (4.4 vs. 3.0%, and 8 vs. 6%, respectively). However, the proportion of wasted boys was 1.14 times as high as that of girls (2.5% compared with 2.2%).

3.2 Association between physical activity routine, dietary characteristics, and stunting in Hoang Mai District's preschool children

Characteristics of case-control study subjects

Characteristics of sex ratio, age group ratio, age, weight, height, BMI, WAZ, HAZ, BAZ, and WHZ of children in the case group (stunted children) and control group (normal height children) are presented in Table 3.

Table 3. Anthropometric characteristics of normal height and stunted groups

Characteristics		Normal group (*n* = 2,984)	Stunted group (*n* = 207)	*p*
Sex (*n*,%)[a]	Male	1601 (94.4%)	95 (5.6%)	**0.031**
	Female	1383 (92.5%)	112 (7.5%)	
Age group (month) (*n*,%)[a]	24–35.9	157 (84.4%)	29 (15.6%)	**0.0001**
	36–47.9	643 (88.6%)	83 (11.4%)	
	48–59.9	1340 (94.8%)	74 (5.2%)	
	60–71.9	844 (97.6%)	21 (2.4%)	
Age (months)[b]		51.4 (43.2–57.2)	47.7 (42–51.8)	**< 0.0001**
Weight (Kg)[b]		16.1 (14.4–18.6)	12.9 (11.8–14.2)	**< 0.0001**
Height (kg)[b]		103 (98–108)	92 (88.0 –95.0)	**< 0.0001**
BMI (Kg/m^2)[b]		15.4 (14.5–16.8)	15.5 (14.5–16.7)	0.637
WAZ[b]		–0.16 (–0.83–0.64)	–1.61 (–2.15–(–1.01))	**< 0.0001**
HAZ[b]		–0.39 (–1.03–0.31)	–2.45 (–2.78–(–2.17))	**< 0.0001**
BAZ[b]		0.08 (–0.67–0.99)	0.12 (–0.61–(0.91))	0.452
WHZ[b]		0.05 (–0.7–0.96)	–0.15 (–0.83–(0.71))	**0.020**

[a] Qualitative variables are expressed as *n*, % of the total study population; *p*-values were obtained from the Chi-square test; [b] Quantitative (continuous) variables are expressed as median (25th–75th percentile); *p*-values were obtained from the Mann-Whitney U test; *p*-Values less than 0.05 are presented in bold.

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The proportion of stunted children was highest in the youngest age group and decreased with age (12.8% in the 24–35.9 month group, 9.5% in the 48–59.9 months group, and 5.9% in the 60–71.9 months group). Children in the stunted group had significantly lower weight, height, WHZ, and HAZ compared with those in the normal group ($p < 0.05$). There was no difference in BMI and BAZ values between the case group and control group ($p > 0.05$).

Association between physical activity routine and stunting in Hoang Mai District's preschool children

The association of some daily routine characteristics with stunting among preschool children in Hoang Mai District, Hanoi, is presented in Table 4. It indicates a significant association between moderate and vigorous physical activity (e.g., playing football, running, bicycling, aerobic dancing), and stunting. Children who engage in these activities for less than one hour a day have a 1.71-fold increased risk of stunting ($p = 0.007$), compared with those who practice for more than one hour. No significant association was found between night sleep duration, time of starting night sleep, whether or not children take part in active physical activities at school, and time spent on sedentary activities at home, and stunting.

Association between eating habits and stunting in Hoang Mai District's preschool children

Table 5 presents the relationship between meal time, the type of favorite food, whether children drink milk before sleeping, and stunting among preschool children.

The data reveal no relationship between drinking milk before sleeping and stunting. Children who like eating sweets, fats, eggs, and vegetables also do not show any association with stunting. However, children who prefer lean meat reduce their stunting risk by 1.38-fold ($p = 0.033$). Before adjusting for sex and age, meal times longer than 40 minutes increase the risk of stunting by 1.63-fold ($p = 0.09$) and after adjusting, this risk is 1.73-fold ($p = 0.04$).

Table 4. Logistic regression analysis of physical activity daily routines associated with stunting

Variable		OR (95%CI)	*p*	OR* (95%CI)	*p**
Night sleeping hours	≥9 hours	1		1	
	8–9 hours	0.88 (0.65–1.19)	0.407	0.94 (0.70–1.28)	0.706
	<8 hours	0.60 (0.28–1.32)	0.204	0.78 (0.35–1.71)	0.531
Time goes to sleep at night	Before 9 PM	1		1	
	From 9 PM to 11 PM	1.26 (0.79–2.01)	0.329	1.25 (0.78–2.00)	0.356
	After 11 PM	1.32 (0.48–3.62)	0.591	1.60 (0.58–4.45)	0.367
Active physical activity at school	Yes	1		1	
	No	0.73 (0.42–1.24)	0.239	0.68 (0.40–1.18)	0.169
Sedentary activity time at home	>60 min/day	1		1	
	30–60 min/day	1.37 (0.79–2.38)	0.269	1.37 (0.79–2.38)	0.269
	<30 min/day	1.08 (0.61–1.92)	0.791	1.08 (0.61–1.92)	0.791
Moderate and vigorous physical activity time	>1 hour/day	1		1	
	≤1 hour/day	1.69 (1.16–2.47)	**0.006**	1.71 (1.16–2.51)	**0.007**

Note: OR, *p*-values were obtained from univariate logistic regression analysis; OR*, *p**-values were obtained from multivariate logistic regression analysis adjusted for age and sex. *p*-Values less than 0.05 are presented in bold.

Table 5. Logistic regression analysis of eating habits associated with stunting

Variable		OR (95%CI)	*p*	OR* (95%CI)	*p**
Meal time (minutes)	20–40	1		1	
	<20	0.53 (0.27–1.06)	0.073	0.60 (0.30–1.19)	0.143
	>40	1.63 (1.13–2.34)	**0.009**	1.73 (1.20–2.51)	**0.004**
Sweet-food favourite	No	1		1	
	Yes	1.30 (0.83–2.06)	0.254	1.26 (0.79–1.99)	0.330
Fat-food favourite	No	1		1	
	Yes	0.78 (0.57–1.07)	0.661	0.82 (0.60–1.14)	0.236
Lean-meat favorite	No	1		1	
	Yes	0.72 (0.54–0.98)	**0.033**	0.82 (0.60–1.11)	0.189
Eggs favourite	No	1		1	
	Yes	0.98 (0.62–1.53)	0.925	1.04 (0.66–1.65)	0.854
Vegetables favourite	No	1		1	
	Yes	1.17 (0.81–1.68)	0.399	1.13 (0.79–1.64)	0.504
Drinking milk before sleeping	No	1		1	
	Yes	0.62 (0.37–1.02)	0.062	0.69 (0.41–1.16)	0.159

Note: *p*-Values were obtained from univariate logistic regression analysis; *p**-Values were obtained from multivariate logistic regression analysis adjusted for age and sex. p-Values less than 0.05 are presented in bold.

4 Discussion

Our survey shows that the rate of malnourished children (underweight, stunting, and wasting) in Hoang Mai District was lower than the general rate among preschool children in Northern Vietnam—where the prevalence of malnutrition among Kinh children was 14.7% [9]—and lower than the global prevalence of stunting among children under five in 2027, which was 22.2% [10]. This can be explained by the fact that Hoang Mai is an inner-city district of Hanoi, where economic and social conditions are developed. Consequently, knowledge of child-rearing, nutritional conditions, and medical care for children here is good, which reduces the risk of malnutrition.

The direction of sex differences in malnutrition prevalence varies across countries, areas, and households [11, 12]. In Hoang Mai District, the rate of underweight and stunting in girls was higher than in boys, while the opposite trend was observed in wasting (Table 2). A systematic review and meta-analysis by Thurstans et al. [11] listed several reasons explaining sex differences in undernutrition, such as differences in biological characteristics and varying care trends due to social and family factors.

In our study, the rate of stunted children decreased with age (Table 3), aligning with Pham Thi Thu et al., who found higher stunting in the 36–47 month age group compared with the 48–59 month group (17.6% vs. 10.0%) [13]. Conversely, a study in Nghe An's coastal plain showed that stunting peaked in the 36–47 month age group (41.7%) [14]. The decreasing rate of stunting with increasing age can be explained by the fact that younger children have underdeveloped immune

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systems, making them more susceptible to illnesses, which is the major cause of stunting.

Because of the observed sex and age differences in stunting prevalence, we performed both univariate and age- and sex-adjusted logistic regression analyses. Our major finding was that moderate and vigorous physical activity for more than one hour a day helps prevent stunting (Table 4). This is supported by studies in South Africa and Mexico, which found that normal children engaged in more moderate and vigorous physical activity than stunted children [15, 16]. A vast amount of research has shown that activities are significantly associated with bone development, increasing bone mineral content and density, as physical activity stimulates osteoblasts to form bone and enhance bone strength [17, 18]. Additionally, increased physical activity boosts appetite, leading to higher food intake and thus preventing stunting [19].

Sedentary activities, such as sitting, watching TV, or playing video games, lead to minimal physical movement. In our study, the time spent on sedentary activities at home was insignificantly different between normal and stunted children. Similarly, studies in Uganda and South Africa found no association between sedentary behaviour and BMI among children [20, 21]. Moreover, our study found no significant difference in stunting whether children participated in physical activities at school. This might be because children in our study had similar schedules, resulting in comparable durations of sedentary activity and physical activity at school.

Regarding other daily routine factors, we found no relationship between night sleeping hours or bedtime and stunting. In contrast, a study in China found that stunted children had shorter sleep [22]. Another study showed a link between shorter sleep duration with body height but not stunting [23]. Growth hormone, crucial for skeletal development, is secreted during deep sleep [24]. Thus, shorter sleep duration and later bedtimes reduce growth hormone secretion, and thus increasing stunting risk. However, children in our study attended public kindergartens with similar schedules, hence having uniform sleep duration.

In the logistic regression analysis of eating habits (Table 5), we found that longer meal times significantly increased the risk of stunting. Sparse direct evidence exists on meal duration and stunting. Children with eating disorders or selective eating habits often take longer to eat and are at higher risk of being thin [25]. Longer meal times reduce food intake because of the decrease of ghrelin hormone (“hunger hormone” released by the stomach when empty) [26], thus increasing the risk of stunting.

Among the five food patterns studied, only a preference for lean meat was associated with a reduced risk of stunting, nearly 1.38-fold compared with children who did not prefer lean meat. This finding aligns with Korean research that found lower meat intake among short-statured children [27]. Meat is rich in proteins, minerals, and antioxidants, supporting growth and reducing stunting risk [28]. However, our study found no significant relationship between preferences for sweets, fats, eggs, and vegetables, and stunting. Contrasting results were reported by Flores et al., who indicated increased stunting risk with higher fruit and vegetable intake [29]. These discrepancies may stem from varying population characteristics and nutritional practices.

Milk is commonly believed to support height development among children, largely because of insulin-like growth factor-1 (IGF-1), which enhances bone growth and amino acid uptake [30]. Evidence indicates that milk consumption can boost IGF-1 levels and potentially reduce stunting risk [31]. For instance, a study in India found that daily milk consumption lowers stunting risk (OR = 0.93, 95% CI = 0.90–0.96) [32]. However, findings vary across populations. A study in Mexico found no link between milk consumption and nutritional status [29]. Our study, conducted in an area with daily milk access, also found no significant relationship between drinking milk before sleep and stunting.

The results of our study underscore the critical role of physical activity and dietary habits in preventing stunting. However, the study's cross-sectional design limits the ability to draw causal conclusions. Self-reported data may introduce bias, and findings may not be generalisable beyond Hoang Mai District. Additionally, the children's uniform school schedules may have affected the observed relationships between physical activity and stunting. Moreover, the findings may not be fully generalisable to other regions, as specific socio-economic and cultural characteristics of Hoang Mai District may have influenced the outcomes. Despite these limitations, the study's strengths include its large sample size and comprehensive analysis using internationally recognised WHO criteria.

5 Conclusion

Our study found that the prevalence of underweight, stunting, and wasting among Hoang Mai District's preschool children was 3.6, 7, and 2.4%, respectively. Underweight and stunting were more common in girls, whereas wasting was slightly more frequent in boys. Stunting was significantly associated with engaging in less than one hour of moderate and vigorous physical activity (OR = 1.71) and having meal durations longer than 40 minutes (OR = 1.73). Conversely, preferring to eat lean meat was found to be a protective factor against stunting (OR = 0.72). The study highlighted the importance of promoting regular physical activity and encouraging shorter mealtimes among young children. Supporting lean meat consumption may also contribute to reducing the risk of stunting.

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Conflicts of Interest

All authors declare that there were no conflicts of interest regarding publishing this paper.

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References

1. WHO. Malnutrition [Internet]. Geneva: WHO; 2024 [cited 2025]. Available from: https://www.who.int/news-room/fact-sheets/detail/malnutrition
2. UNICEF, WHO, World Bank Group Joint Child Malnutrition Estimates. Levels and trends in child malnutrition: key findings of the 2020 edition. Geneva: World Health Organization; 2020.
3. Martorell R, Ho TJ. Malnutrition, Morbidity, and Mortality. Population and Development Review. 1984;10:49-68.
4. Nugent R, Levin C, Hale J, Hutchinson B. Economic effects of the double burden of malnutrition. The Lancet. 2020;395(10218):156-64.
5. Black RE, Heidkamp R. Causes of Stunting and Preventive Dietary Interventions in Pregnancy and Early Childhood. In: Colombo J, Koletzko B, Lampl M, editors. Recent Research in Nutrition and Growth: 89th Nestlé Nutrition Institute Workshop, Dubai, March 2017. 89: S.Karger AG; 2018. p. 0.

pISSN 1859-1388
eISSN 2615-9678

6. Qureshi S, Iqbal M, Rafiq A, Ahmed H, Malik T, Kalam MN, et al. Dietary habits and physical activity patterns in relation to nutritional status among school-aged children in Pakistan: A cross-sectional study. AIMS public health. 2023;10(3):553-67.
7. Ieiri MCA, Kosaka S, Tomitsuka E, Umezaki M. Factors Affecting Undernutrition among School Children in Cebu, Philippines. Ecology of food and nutrition. 2021;60(2):182-97.
8. Permatasari TAE, Chadirin Y, Ernirita, Elvira F, Putri BA. The association of sociodemographic, nutrition, and sanitation on stunting in children under five in rural area of West Java Province in Indonesia. Journal of public health research. 2023;12(3):22799036231197169.
9. Le TT, Le TTD, Do NK, Nadezhda VS, Andrej MG, Nguyen TTT, et al. Ethnic Variations in Nutritional Status among Preschool Children in Northern Vietnam: A Cross-Sectional Study. International journal of environmental research and public health. 2019;16(21):4060
10. Unicef. 2018 Global Nutrition Report reveals malnutrition is unacceptably high and affects every country in the world, but there is also an unprecedented opportunity to end it. Geneva: Unicef; 2018. [cited 15th July 2024]. Available from: https://www.unicef.org/press-releases/2018-global-nutrition-report-reveals-malnutrition-unacceptably-high-and-affects
11. Thurstans S, Opondo C, Seal A, Wells J, Khara T, Dolan C, et al. Boys are more likely to be undernourished than girls: a systematic review and meta-analysis of sex differences in undernutrition. BMJ global health. 2020;5(12):e004030.
12. Thompson AL. Greater male vulnerability to stunting? Evaluating sex differences in growth, pathways and biocultural mechanisms. Annals of human biology. 2021;48(6):466-73.
13. Thu PT, Mai TT, Thai VV. malnutrition status and some factors related to stunting in children aged 36- 59 months at two communes, Tien Du district, Bac Ninh province. Vietnam Journal of Nutrition and Food. 2017;13(1):65-72.
14. Ngoan NT, Đao VT, Oanh NH, Phuong TTH. Knowledge and attitudes regarding complementary feeding of mothers with children under 24 months old attending outpatient services at Tra Vinh pediatric hospital in 2023. Vietnam Medical Journal. 2024;539(1):169-173.
15. Draper CE, Tomaz SA, Jones RA, Hinkley T, Twine R, Kahn K, et al. Cross-sectional associations of physical activity and gross motor proficiency with adiposity in South African children of pre-school age. Public Health Nutrition. 2018;22(4):614-23.
16. Said-Mohamed R, Bernard JY, Ndzana A-C, Pasquet P. Is overweight in stunted preschool children in Cameroon related to reductions in fat oxidation, resting energy expenditure and physical activity?. PLoS One. 2012;7(6):e39007.
17. Heidemann M, Mølgaard C, Husby S, Schou AJ, Klakk H, Møller NC, et al. The intensity of physical activity influences bone mineral accrual in childhood: the childhood health, activity and motor performance school (the CHAMPS) study, Denmark. BMC Pediatrics. 2013;13(1):32.
18. Li X, Han L, Nookaew I, Mannen E, Silva MJ, Almeida M, et al. Stimulation of Piezo1 by mechanical signals promotes bone anabolism. eLife. 2019;8:e49631.
19. Kumar V, Abbas AK, Aster JC. Robbins Basic Pathology: Robbins Basic Pathology E-Book. Elsevier Health Sciences; 2017.
20. Christoph MJ, Grigsby-Toussaint DS, Baingana R, Ntambi JM. Physical Activity, Sleep, and BMI Percentile in Rural and Urban Ugandan Youth. Annals of global health. 2017;83(2):311-9.
21. Tomaz SA, Prioreschi A, Watson ED, McVeigh JA, Rae DE, Jones RA, et al. Body Mass Index, Physical Activity, Sedentary Behavior, Sleep, and Gross Motor Skill Proficiency in Preschool Children From a Low- to Middle-Income Urban Setting. Journal of Physical Activity and Health. 2019;16(7):525-32.
22. Zhang YQ, Wu HH, Zong XN, Li H. Survey on the influential factors of stunting among children under seven years of age in nine cities of China. Chinese journal of pediatrics. 2021;59(9):743-51.
23. Zhou Y, Aris IM, Tan SS, Cai S, Tint MT, Krishnaswamy G, et al. Sleep duration and growth outcomes across the first two years of life in the GUSTO study. Sleep Medicine. 2015;16(10):1281-6.
24. Van Cauter E, Latta F, Nedeltcheva A, Spiegel K, Leproult R, Vandenbril C, et al. Reciprocal interactions between the GH axis and sleep. Growth Hormone & IGF Research. 2004;14:10-7.
25. Taylor CM, Emmett PM. Picky eating in children: causes and consequences. The Proceedings of the Nutrition Society. 2019;78(2):161-9.

26. Williams DL, Cummings DE. Regulation of Ghrelin in Physiologic and Pathophysiologic States1. The Journal of Nutrition. 2005;135(5):1320-5.

27. Lee EM, Park MJ, Ahn HS, Lee SM. Differences in Dietary Intakes between Normal and Short Stature Korean Children Visiting a Growth Clinic. Clinical nutrition research. 2012;1(1):23-9.

28. Wolnicka K, Taraszewska AM, Jaczewska-Schuetz J, Jarosz M. Factors within the family environment such as parents' dietary habits and fruit and vegetable availability have the greatest influence on fruit and vegetable consumption by Polish children. Public Health Nutrition. 2015;18(15):2705-11.

29. Flores ME, Rivera-Pasquel M, Macías N, Sánchez-Zamorano LM, Rodríguez-Ramírez S, Contreras-Manzano A, et al. Dietary patterns in Mexican preschool children are associated with stunting and overweight. Revista de saude publica. 2021;55:53.

30. Wiley AS. Cow milk consumption, insulin-like growth factor-I, and human biology: a life history approach. American Journal of Human Biology. 2012;24(2):130-8.

31. Qin L-Q, He K, Xu J-Y. Milk consumption and circulating insulin-like growth factor-I level: a systematic literature review. International Journal of Food Sciences and Nutrition. 2009;60(sup7):330-40.

32. Vanderhout SM, Corsi DJ. Milk consumption and childhood anthropometric failure in India: Analysis of a national survey. Maternal & child nutrition. 2021;17(2):e13090.