ORIGINAL ARTICLE

Prevalence and Screening of Hypertension Among Schoolchildren in Phitsanulok, Lower Northern Thailand

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Objective: To identify the prevalence of hypertension among children living in Phitsanulok, lower northern Thailand, and to compare blood pressure (BP) equal or greater than 120/80 mmHg screening with the American Academy of Pediatrics (AAP) 2017 diagnostic criteria for hypertension.

Materials and Methods: A retrospective cross-sectional study was conducted among primary schoolchildren in Phitsanulok between February 2014 and August 2016. Elevated BP and hypertension were determined using the AAP 2017 diagnostic criteria. Data were analyzed for frequency, mean, and diagnostic test performance comparing BP equal or greater than 120/80 mmHg screening with the reference test.

Results: One thousand four hundred thirty-four children aged 5 to 12 years were recruited, with 52.4% males. The prevalence of elevated BP and hypertension was 7.5% (108 children) and 16.9% (243 children). The diagnostic test performance, comparing BP equal or greater than 120/80 mmHg screening with BP equal or greater than the 95th percentile diagnostic criteria of AAP 2017 (reference test), showed the probability of a positive BP equal or greater than 120/80 mmHg screening and the probability of a negative BP equal or greater than 120/80 mmHg screening were 57.6% and 99.6%, respectively. The likelihood that children with a positive screening test truly had hypertension and that children with a negative screening test truly did not have hypertension were 96.6% and 92.1%, respectively. The accuracy of the screening test was 92.5%. To increase the sensitivity of 81.1% of the hypertension screening test, further analysis identified the optimal cut-off values of systolic BP of equal or greater than 114 mmHg and diastolic BP of equal or greater than 63 mmHg (area under the curve 0.94, 95% CI 0.92 to 0.96 and 0.86, 95% CI 0.83 to 0.89, respectively). BMI was a significant risk factor for hypertension with an odds ratio of 1.19 (95% CI 1.16 to 1.23).

Conclusion: The prevalence of hypertension in children aged 5 to 12 years in lower northern Thailand was high. Utilizing the simplified BP of equal or greater than 120/80 mmHg cut-off could be a valuable screening tool for primary healthcare providers in early detecting pediatric hypertension.

Keywords: Blood pressure; Hypertension; Children; Thailand; Screening

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Elevated blood pressure (BP) among children and adolescents is a significant risk factor for the development of adult hypertension and metabolic syndrome(1). Moreover, this condition can lead to severe complications such as heart disease, renal impairment, and vascular disorders during adulthood(2). In addition, hypertension represents a silent danger, posing a substantial threat to life due to the absence of discernible warning symptoms. Measuring BP is essential to determine if one had high BP. However, BP measurements are often overlooked, especially in children who do not have any underlying medical conditions. Despite the asymptomatic nature of elevated BP in children, early detection is needed and to reduce the risk of target organ damage during childhood and prevent the development of hypertension and related cardiovascular diseases in adulthood(1-4).

Predisposing factors causing elevated BP in children include body mass index (BMI), obesity, abdominal circumference, male gender, positive family history, low birth weight, sleep disorders, maternal smoking during pregnancy, high-sodium diet, absence of a dietary approaches to stop hypertension (DASH)-type diet, and increased sedentary time(3-6). The American Academy of Pediatrics (AAP) 2017 and the Royal College of Pediatricians of Thailand & Pediatric Society of Thailand recommend annual BP measurement at well-child visits beginning at the age of three for children without identified risk factor(1,7). For children with risk factors for hypertension, more

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frequent BP monitoring at each well-child visit is advised[8]. Lifestyle modifications, including dietary changes and increased physical activity, are the cornerstone of therapeutic intervention for all children with elevated BP or hypertension. Children who remain hypertensive despite lifestyle modifications may require medication and further evaluation for potential complications. The goal of hypertension management in children and adolescents is to reduce the risk of target organ damage during childhood and prevent the development of hypertension and related cardiovascular diseases in adulthood[1,3,4,6].

Children's BP varies according to the age, body size, and race[9]. Currently there is limited information on standardized reference BP levels in Thai children[10-12]. Therefore, the present study aimed to identify the prevalence of hypertension among children living in Phitsanulok, a province situated in lower northern Thailand. The results could be utilized as a reference for BP levels among children in this region. Since the AAP 2017 has defined normal BP in children aged 13 years or older and adults as less than 120/less than 80 mmHg, the authors additionally explored the feasibility of using a BP threshold of equal or greater than 120/80 mmHg as a screening tool for hypertension compared to the standardized criteria established in the AAP 2017 Guidelines[1]. This BP level of equal or greater than 120/80 mmHg, has been linked to increased cardiovascular risk according to multiple epidemiologic studies[3,13].

Materials and Methods

A retrospective cross-sectional study was conducted among children attending a mid-sized primary school near Naresuan University, located in Phitsanulok, lower northern Thailand. The present study utilized data collected during an ambulatory service program offered by the Pediatric Department of Naresuan University Hospital between February 2014 and August 2016. This ambulatory service program aimed to enhance the overall health of the surrounding community by providing health promotion services such as screenings, education, and supervision.

Data collection included age, gender, weight, height, BMI, underlying diseases, and BP measurements. Accurate BP measurement was ensured using cuffs with appropriate sizing. Cuff bladder width was approximately 40% of the upper arm circumference, and the bladder length encircled 80% to 100% of the upper arm. In cases where initial BP readings were abnormal, measurements were repeated at least two to three times at different intervals during the visit[1,8]. BP data for all children were reviewed for elevated levels according to the AAP 2017 Guidelines[1]. Following these guidelines, which utilize gender-, age-, and height-specific reference values, systolic BP (SBP) and/or diastolic BP (DBP) were classified as normal at less than the 90th percentile, elevated at the 90th to 95th percentile or 120/80 mmHg to 95th percentile, whichever is lower, and hypertension at equal or greater than the 95th percentile or equal or greater than 130/80 mmHg, whichever is lower for children under 13 years[1]. Children with confirmed elevated BP were referred to the Pediatric clinic of Naresuan University Hospital for further evaluation.

The present study was reviewed and approved by the Naresuan University Institutional Review Board (NU-IRB) with NU-IRB ethics approval certification number 948/59. The NU-IRB Committee granted permission to conduct the study on student's data records from pediatric ambulatory service and waived the requirement of patient consent.

Statistical analysis

Data analysis was performed using Stata Statistical Software, version 17 (StataCorp LLC, College Station, TX, USA). Categorical parameters were presented as frequencies and percentages, while continuous parameters were expressed as mean and standard deviation (SD). To assess the diagnostic test performance of the screening test with a BP of equal or greater than 120/80 mmHg, compared to the reference test of standardized diagnosed hypertension from the AAP 2017 Guidelines as SBP or DBP equal or greater than 95th percentile. The authors calculated sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. Additionally, a receiver operating characteristic curve (ROC) analysis was performed to determine optimal BP cut-off values for screening. A univariable logistic regression analysis was conducted to identify potential risk factors for hypertension, such as gender, age, and BMI. Results are presented as odds ratio (OR) with 95% confidence intervals (CI). A two-sided p-value of less than 0.05 was considered statistically significant.

Results

One thousand four hundred forty-five school children from grades 1 to 6 were initially recruited for the study, with ages ranging from 5 to14 years. Eleven children (0.7%) aged 13 years or above were excluded

Table 1. Characteristic data of participants

Characteristic data	Total (n=1,434)	Female (n=683)	Male (n=751)
Age (years); n (%)			
5 to 8	585 (40.8)	279 (40.9)	306 (40.8)
9 to 12	849 (59.2)	404 (59.2)	445 (59.3)
Body weight (kg); mean±SD	31.6±11.5	31.4±11.4	31.9±11.6
Height (cm); mean±SD	132.3±11.2	132.3±11.6	132.2±10.9
BMI (kg/m²); mean±SD	17.6±4.2	17.4±3.9	17.8±4.5

BMI=body mass index; SD=standard deviation

due to differing diagnostic criteria for hypertension in this age group as equal or greater than 130/80 mmHg, compared to children aged 5 to 12 years with a SBP or DBP equal or greater than the 95th percentile as defined by the AAP 2017 Guidelines[1]. Therefore, the final study population comprised 1,434 children, with 683 (47.6%) females and 751 (52.4%) males. The mean age was 9.0±1.6 years, with no significant difference between females at 8.9±1.6 years and males at 9.0±1.6 years. The average body weight, height, and BMI were 31.6±11.5 kg, 132.3±11.2 cm, and 17.6±4.2 kg/m², respectively, with no statistically significant differences observed between genders (Table 1). Underlying medical conditions were reported in 119 children (8.2%), including allergic diseases, thalassemia, skin rash, and dyspepsia. Notably, no cardiovascular, renal, or other conditions typically associated with elevated BP were identified.

Among the 1,434 children aged 5 to 12 years assessed for elevated BP and hypertension using the aforementioned diagnostic criteria, 1,083 (75.5%) had normal BP, with a similar distribution between females at 75.3% (514) and males at 75.8% (569) (Table 2). The prevalence of elevated BP equal or greater than the 90th to 95th percentile or 120/80 mmHg to 95th percentile, whichever is lower was 7.5% (108), with a slightly higher prevalence in males at 7.9% (59), compared to females at 7.2% (49) (Table 2). The authors' study identified a prevalence of hypertension at BP equal or greater than the 95th percentile or equal or greater than 130/80 mmHg, whichever is lower of 16.9% (243 childern), with a nearly equal distribution between females at 17.6% (120) and males at 16.4% (123) (Table 2). Employing a BP threshold of equal or greater than 120/80 mmHg for hypertension screening in the 1,434 children aged 5 to 12 years The authors identified 145 children (10.2%) presenting with BP readings of equal or greater than 120/80 mmHg, with comparable prevalence in females at 10.2% (70) and males at 10.0% (75) (Table 2).

Univariable logistic regression analysis revealed that BMI was a statically significant risk factor for hypertension in the authors' study population, with an OR of 1.19 (95% CI 1.16 to 1.23) and p<0.001 (Table 3). Neither gender nor age were identified as significant risk factors in the present study.

The authors compared the diagnostic test performance of a screening BP of equal or greater than 120/80 mmHg with the reference standard of BP equal or greater than the 95th percentile for diagnosing hypertension. The probability of the positive screening test (sensitivity) and the probability of the negative screening test (specificity) were 57.6% and 99.6%, respectively. The possibility that children with a positive screening test really had hypertension (PPV) and children with negative screening test really did not have hypertension (NPV) were 96.6% and 92.1%, respectively. The overall diagnostic accuracy of this screening test was 92.5% (Table 4). These results were consistent across genders. However, the sensitivity of using equal or greater than 120/80 mmHg for hypertension screening was dependent on age. Among children aged 5 to 10 years, the sensitivity ranged from 40% to 73%. Conversely, for children aged 10 to 12 years, the sensitivity increased progressively with age, ranging from 73% to 100% (Figure 1). Furthermore, to improve the probability of the positive screening for hypertension, ROC curve analysis identified optimal cut-off values. The area under the curve (AUC) was 0.94 (95% CI 0.92 to 0.96) for SBP cut off equal or greater than 114 mmHg (sensitivity 81.1% and specificity 95.2%). The AUC for DBP cut off equal or greater than 63

Table 2. Blood pressure measurements in children aged 5 to 12 years (n=1,434)

Screening for high blood pressure	Total (n=1,434) n (%)	Female (n=683) n (%)	Male (n=751) n (%)
Normal blood pressure	1083 (75.5)	514 (75.3)	569 (75.8)
Elevated blood pressure	108 (7.5)	49 (7.2)	59 (7.9)
Hypertension (by criteria systolic and/or diastolic blood pressure ≥95 percentile)	243 (16.9)	120 (17.6)	123 (16.4)
Hypertension (by screening criteria systolic ≥120 mmHg and/or diastolic ≥80 mmHg)	145(10.2)	70 (10.2)	75 (10.0)

Table 3. Risk factors for hypertension

	Univariable; odds ratio (95% CI)	p-value
Sex	0.92 (0.70 to 1.21)	0.540
Age	1.06 (0.97 to 1.16)	0.163
BMI	1.19 (1.16 to 1.23)	<0.001

BMI=body mass index; CI=confidence interval

Table 4. Diagnostic performance of ≥120/80 mmHg BP cut-off for hypertension screening compared to ≥95th percentile diagnostic criteria of the 2017 AAP Guideline in children aged 5 to 12 years

Performance measure	Total (n=1,443)	Female (n=683)	Male (n=751)
Sensitivity	57.6%	57.5%	57.7%
Specificity	99.6%	99.8%	99.4%
Positive predictive value (PPV)	96.6%	98.6%	94.7%
Negative predictive value (NPV)	92.1%	91.7%	92.3%
Accuracy	92.5%	92.4%	92.5%

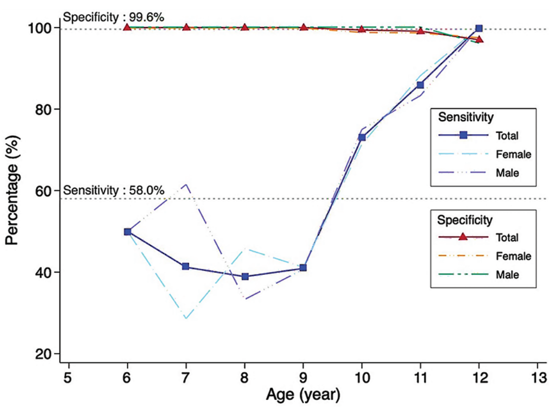

Figure 1. Sensitivity and specificity of hypertension screening with BP levels of ≥120/80 mmHg compared to BP ≥95th percentile diagnostic criteria of the AAP 2017 Guidelines.

mmHg was 0.86 (95% CI 0.83 to 0.89) (sensitivity 80.3%, specificity 71.5%) (Figure 2).

Discussion

Studies globally have reported diverse varying prevalence rates of hypertension in children, ranging from 1% to 23%[14-16]. Similarly, in Thailand, studies have demonstrated a prevalence of hypertension ranging from 3.2% to 26.2%[5,17,18]. The authors' investigation focused on determining the prevalence rate of hypertension among children aged 5 to 12 years residing in Phitsanulok, situated in lower northern Thailand, revealing a rate of 16.9%, falling within the middle to high range. To contextualize the authors' findings, the authors compared them with the previous Thai studies, such as the 2012 Bangkok study involving 693 children aged 8 to 12 years with 3.2% for girls and 4.7% for boys[18], other studies in 536 Bangkok school children aged 8 to 13 years at 10.8%[11], and the 2014 Thai National Health Examination Survey V, which included 3,505 children aged 10 to 19 years at 9.4%[5]. The authors' study indicated a higher prevalence of hypertension compared to these reported studies. However, the authors' findings were remarkably lower than the hypertension rate of 26.2% reported among 3,870 schoolchildren aged 6 to 12 years in central Thailand surveyed in 2015[17]. These discrepancies stem from differences in the age groups studied, methodologies used, and the race/ethnicity of the participants, which may have influenced the results[9,17]. Moreover, factors such as gender, genetic/epigenetic factors, socioeconomic status, and geographical location could also impact hypertension prevalence[15,19]. Consistent with other studies, the authors' study confirms that BMI is a significant risk factor for

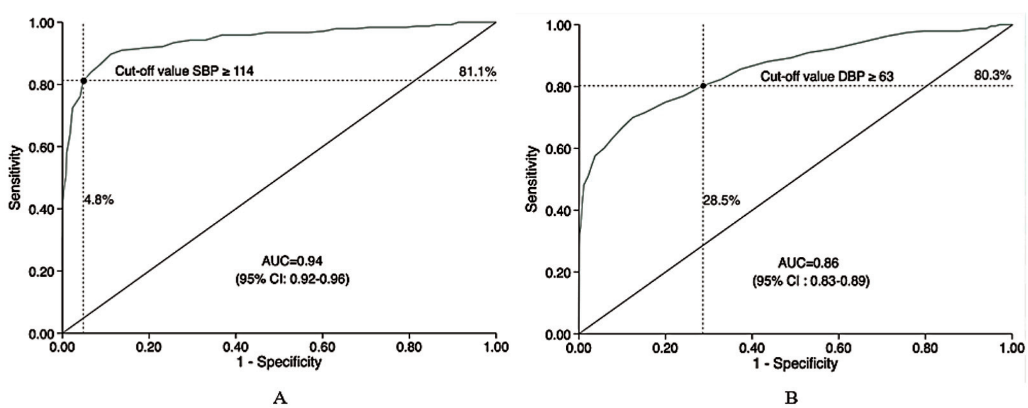

Figure 2. ROC curve showing the optimal cut-off value for hypertension screening, with an AUC of 94% and 86% for the cut-off SBP ≥114mmHg (A) and DBP ≥63mmHg (B), respectively (black dot).

elevated BP[1,3,11,16]. The excess adipose tissue in obese children can lead to increased sympathetic activity and subsequent sodium reabsorption, resulting in increased peripheral vascular resistance[16]. The National Health and Nutrition Examination Survey has demonstrated an association between increased sodium intake and elevated SBP[3,20]. The high prevalence of hypertension observed in the authors' pediatric population in lower northern Thailand suggests a potential confluence of factors, including high sodium intake, increased BMI, genetic/epigenetic factors, and decreased physical activity levels associated with modern lifestyles in urban environments. Further investigations are warranted to explore these potential contributing factors.

The authors' evaluation of a screening BP cut-off of equal or greater than 120/80 mmHg compared to the standardized diagnostic criteria of equal or greater than the 95th percentile showed high specificity but low sensitivity, with an overall test accuracy of 92.5%. This suggests that the BP equal or greater than 120/80 mmHg cut-off may miss hypertensive children, particularly younger children of less than 10 years of age. While 99.6% of children without hypertension in the authors' study had BP readings below 120/80 mmHg, there is currently no definitive BP threshold in childhood that is linked to cardiovascular outcomes in adulthood[1,13]. However, clinical studies have provided evidence of left ventricular hypertrophy and target organ damage such as vascular stiffness and increased carotid intimal thickness in hypertensive children and adolescents with BP equal or greater than 120/80 mmHg and obesity[13,21-23]. These findings imply that a BP of 120/80 mmHg in adolescence may be associated with early cardiovascular target organ damage[13]. The commentary accompanying the SPRINT trial commentary suggests that normal BP for adolescents should be less than 120/80 mmHg, and for children younger than 12 years, less than 110/70 mmHg. Furthermore, these BP thresholds should be emphasized for primary prevention of future target organ damage[3,13]. The optimal cut-off values identified in the authors' study for elevated BP screening was SBP equal or greater than 114 mmHg and DBP equal or greater than 63 mmHg among children aged 5 to 12 years further support these recommended BP levels. Moreover, researchers have developed simplified tools for screening children for high BP[24], which may be beneficial in clinical practice considering the complexity and time-consuming nature of the reference criteria outlined in the AAP 2017 Guidelines. A previous cohort study employed simplified definitions for childhood prehypertension and hypertension, utilizing cut-off points of 110/70 mmHg for SBP/DBP in children aged 6 to 11 years and 120/80 mmHg for SBP/DBP for children aged 12 to 17 years, respectively[24]. Interestingly, this cohort study demonstrated that these simplified BP definitions could predict adult hypertension and subclinical CVD outcomes, including arterial stiffness, subclinical atherosclerosis, and LVH, with similar efficacy to the complex definition outlined in the 2004 Fourth Report[24]. The authors identified cut-off SBP of equal or greater than 114 mmHg and DBP of equal or greater than 63 mmHg for elevated BP screening in children further strengthens the potential utility of such simplified approaches.

The authors' study findings, showing high prevalence rates of hypertension in school children, should alert primary healthcare providers and general pediatricians to implement BP screening surveillance at a national level. Additionally, the present study developed simplified tools for screening children's BP of equal or greater than 120/80 mmHg for hypertension, which may be useful in clinical practice given the complexity and time-consuming nature of the reference criteria outlined in the AAP 2017 Guidelines. Furthermore, the authors' findings suggest that a lower cut-off of 114/63 mmHg may improve the probability of positive screening for detecting hypertension in this age group, especially among younger children.

The present study has limitations associated with its retrospective design. The retrospective approach resulted in an uneven distribution of age ranges and potential selection bias, resulting in smaller sample sizes for some age groups. Consequently, this may have limited the authors' ability to comprehensively explore potential predisposing factors for elevated BP. Future research should aim to randomly select larger pediatric populations from all regions in Thailand to ensure a more accurate representation of hypertension prevalence and confirm the efficacy of this cut-off for elevated BP screening in Thai children.

Conclusion

There was a high prevalence of hypertension among children aged 5 to 12 years in lower northern Thailand. BMI emerged as a statistically significant risk factor for hypertension in this population. This information should raise the awareness of hypertension identification and prevention. The simplified BP cut-off of equal or greater than 120/80 mmHg for hypertension screening in children could be a valuable tool for primary healthcare providers in detecting hypertension.

What is already known on this topic?

Studies globally have reported diverse varying prevalence rates of hypertension in children, ranging from 1% to 23%[14-16]. Similarly, in Thailand, studies have demonstrated a prevalence of hypertension ranging from 3.2% to 26.2%[5,17,18]. Currently there is limited information on standardized reference BP levels in Thai children[10-12]. Moreover, there is no study on the prevalence rate of hypertension in lower northern Thailand and no report on BP cut-off level for hypertension screening in Thailand.

What does this study add?

This study focused on determining the prevalence rate of hypertension among children aged 5 to 12 years residing in Phitsanulok, situated in lower northern Thailand, which revealed a rate of 16.9% falling within the middle to high range. This high prevalence rate should increase awareness among primary healthcare workers to screen BP in children for early detection and early management of high BP.

By using a BP threshold of equal or greater than 120/80 mmHg as a simplified screening tool for hypertension compared to the standardized criteria established in the AAP 2017 Guidelines[1], the sensitivity, specificity, positive and NPV, and overall diagnostic accuracy of this screening test were 57.6%, 99.6%, 96.6%, 92.1%, and 92.5%, respectively. Furthermore, to improve the sensitivity at 81.1% of the hypertension screening test, ROC curve analysis identified the optimal cut-off values of SBP at equal or greater than 114 mmHg and DBP at equal or greater than 63 mmHg. These findings suggest that BP equal or greater than 120/80 mmHg could serve as a simplified initial tool for hypertension screening in children, compare to the complexity and potential confusion associated with interpreting the reference criteria outlined in the AAP 2017 Guidelines. In addition, this simplified BP cut-off should encourage primary healthcare providers to monitor BP in children for early hypertension surveillance in primary care settings.

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Authors' contributions

The present study was conceptualized and designed by KS, and secured funding, collected data, and drafted the manuscript. JW, WJ, and SU contributed to data collection efforts. SU provided analysis, interpretation of the results, reviewed and edited the manuscript, and validated its accuracy.

Conflicts of interest

The authors have no conflict of interest to disclose.

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