Using simplified blood pressure tables to avoid underdiagnosing childhood hypertension

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BACKGROUND: Recent studies have revealed that hypertension remains underdiagnosed in a significant number of children despite their recorded office blood pressure (OBP) exceeding the recommended fourth report OBP thresholds. Simplified OBP thresholds have been proposed to reduce this underdiagnosis of hypertension in children. In clinical practice, OBP screened as elevated according to the fourth report OBP thresholds are referred for ambulatory blood pressure (ABP) monitoring to rule out 'white coat' hypertension.
OBJECTIVES: The present study tested the usefulness of simplified OBP thresholds to screen abnormal OBP for ABP monitoring referral.
METHODS: A total of 155 subjects were retrospectively analyzed with paired OBP and ABP recordings obtained from an outpatient referral clinic. OBP recordings were classified as abnormal according to the simplified and fourth report OBP thresholds. ABP measurements were classified as abnormal according to the ABP reference tables.
RESULTS: Simplified blood pressure (BP) tables correctly identified all OBP classified as abnormal according to fourth report BP thresholds (kappa [κ] 0.72 [95% CI 0.61 to 0.83]) for systolic OBP; κ 0.92 [95% CI 0.86 to 0.99] for diastolic OBP). OBP classified as abnormal by the simplified BP thresholds and by the fourth report BP thresholds performed similarly for correctly identifying abnormal ABP measurements as per ABP references (overlapping 95% CIs of the sensitivity, specificity and predictive values and likelihood ratios).
CONCLUSIONS: Simplified BP tables, proposed to reduce the underdiagnosis of hypertension in children, can serve as a useful screening tool to decide a referral for ABP monitoring. Future prospective studies are needed to establish these findings.

Key Words: *Ambulatory blood pressure monitoring; Blood pressure tables; Diagnosis; Hypertension; Pediatrics*

L'utilisation de tableaux simplifiés de la tension artérielle pour prévenir le sous-diagnostic d'hypertension infantile

HISTORIQUE : De récentes études ont démontré que l'hypertension demeure sous-diagnostiquée chez de nombreux enfants, même si leur tension artérielle prise en cabinet (TAC) dépassait les seuils recommandés pour la quatrième TAC enregistrée. Certains ont proposé des seuils simplifiés de TAC pour réduire ce sous-diagnostic. En pratique clinique, les TAC considérées comme élevées selon les seuils pour la quatrième TAC enregistrée sont dirigées vers une surveillance de la tension artérielle en milieu ambulatoire (TAA), pour écarter le « syndrome de la blouse blanche ».
OBJECTIFS : La présente étude portait sur l'utilité des seuils simplifiés de TAC pour dépister les TAC anormales en vue de les aiguiller vers la surveillance de la TAA.
MÉTHODOLOGIE : Au total, 155 sujets ont fait l'objet d'une analyse rétrospective par rapport à des enregistrements appariés de TAC et de TAA obtenues dans une clinique de consultation ambulatoire. Les enregistrements de TAC étaient classés comme anormaux d'après le seuil simplifié et le seuil de la quatrième TAC enregistrée. Les mesures de TAA étaient classées comme anormales en fonction des tableaux de référence de la TAA.
RÉSULTATS : Les tableaux simplifiés de la tension artérielle (TA) ont permis de dépister toutes les TAC classées comme anormales selon les seuils de quatrième TA enregistrée (kappa [κ] 0,72 [95 % IC 0,61 à 0,83] pour la TAC systolique; κ 0,92 [95 % IC 0,86 à 0,99] pour la TAC diastolique). La TAC classée comme anormale selon les seuils simplifiés de la TA et les seuils de la quatrième TAC enregistrée ont permis de déterminer les mesures anormales de TAA conformément aux références de TAA (chevauchement 95 % IC de la sensibilité, de la spécificité et des valeurs prédictives ainsi que des ratios de probabilité).
CONCLUSIONS : Les tableaux simplifiés de la TA proposés pour réduire le sous-diagnostic d'hypertension chez les enfants peuvent être utiles pour orienter ou non les patients vers une surveillance de la TAA. D'autres études prospectives s'imposent pour confirmer ces observations.

The prevalence of paediatric hypertension has significantly increased as a result of the childhood obesity epidemic (1). To evaluate for hypertension, office blood pressure (OBP) measurements are interpreted using the Task Force OBP reference thresholds (also known as the fourth report blood pressure [BP] tables) (2). One-third of children, however, with OBP-based hypertension have 'white coat' hypertension, which does not require the same treatment (3,4). In addition, OBP measurements are insensitive to masked and night-time hypertension, which can independently influence target organ damage (4,5).

In clinical practice, the diagnosis of 'white coat', masked and night-time hypertension is made by 24 h ambulatory BP monitoring (ABPM) (3-5). This assessment involves specialized instrumentation (for continuous and timed ABP measurements), trained staff and costs that are nonreimbursable in many regions. Those diagnosed with OBP-based hypertension as per fourth report BP thresholds are referred for ABPM assessment (6-8).

While the fourth report BP tables are widely available, two large North American studies found that hypertension remained undiagnosed by care providers in 74% to 87% of children, even though their recorded OBP exceeded fourth report OBP thresholds (9,10). This underdiagnosis of hypertension was largely due to the logistics of applying the fourth reports BP tables in clinical practice. The fourth report BP tables require a patient's height percentile to interpret his or her OBP. Height percentile is not always plotted in many patient care settings. Moreover, 476 OBP

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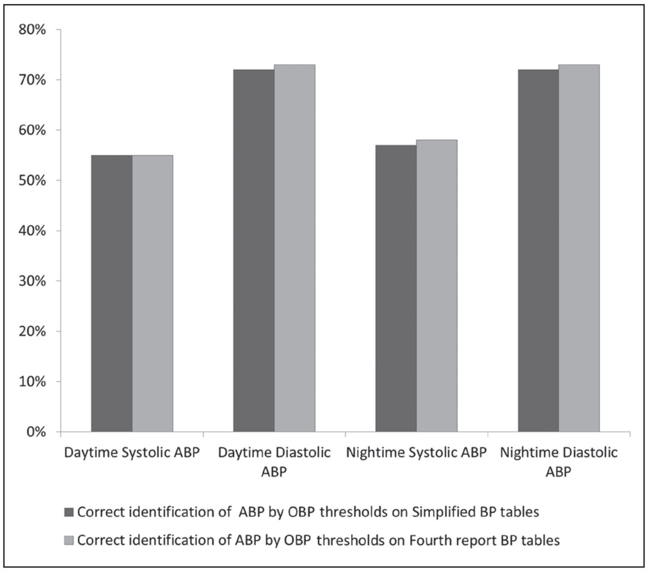

Figure 1) *The diagnostic accuracy of the office blood pressure (OBP) thresholds on simplified and fourth report blood pressure tables in correctly identifying ambulatory blood pressure (ABP) categories (abnormal and normal)–classified according to the ABP reference intervals; P>0.05 for all individual ABP categories*

thresholds (stratified according to an individual's sex, age and height percentile) make the use of these tables complex and challenging for health care professionals who are less familiar with them.

To address this under-recognition of hypertension, Kaelber and Pickett (11) proposed a simplified version of fourth report BP tables (termed simplified BP tables), which condensed fourth report BP tables into 64 OBP thresholds (single systolic and diastolic thresholds – separate for boys and girls in 16 age groups). The single systolic and diastolic OBP thresholds in the simplified BP tables correspond to the lowest (90th OBP and fifth height percentiles) OBP threshold for a given sex and age in the fourth report BP tables. Consequently, these new BP tables have also eliminated the need for an individual's height percentile to classify abnormal OBP (11).

Although simplified BP tables may reduce the under diagnosis of hypertension, the screening utility of these BP tables to make a referral for ABPM assessment has not been systematically assessed. The present study aimed to evaluate the screening utility of these simplified OBP thresholds in identifying appropriate referrals for ABPM assessments as compared with the fourth report OBP thresholds, which is the current tool in clinical practice.

METHODS

Following approval by Western University Research Ethics Board (London, Ontario), children's records were retrospectively collected using a departmental database from those who were referred to the outpatient nephrology and hypertension clinic (Children's Hospital at the London Health Sciences Centre, Western University, London, Ontario), for the evaluation of hypertension between January 2003 and December 2008. Patients between five and 18 years of age were identified, and those with complete OBP and ABP recordings while not taking any antihypertensive medications were selected for analysis.

Body mass index percentiles were calculated based on the most recent Centers for Disease Control and Prevention (Georgia, USA) reference intervals (overweight: 85th to 95th percentiles; obese: >95th percentile) (12). A standard protocol was used to evaluate patients for secondary hypertension (5).

OBP measurement

Clinical protocol mandated that OBP be measured twice using an appropriately sized cuff with the individual rested and seated, as per the recommendations (13). Trained personnel measured OBP using an automated oscillometric device (V 100, Dinamap, USA) and confirmed the elevated OBP using the auscultatory method according to the guidelines (2). For auscultatory OBP measurements, an aneroid sphygmomanometer was used because Canadian legislation has banned the use of conventional mercury sphygmomanometers due to workplace safety concerns. Aneroid sphygmomanometers are accurate when calibrated semi-annually (14) and their use is supported by the Task force (2).

The second oscillometric OBP reading was used for the analysis, as per the guidelines (13). The accuracy of the second oscillatory OBP reading was compared with a corresponding auscultatory measurement in an internal quality validation study. In this analysis, 162 pairs of duplicate OBP measurements obtained from 86 individuals showed a reasonable conformity of these oscillatory and auscultatory measurements, with oscillatory OBP overestimating systolic OBP by +1.5 mmHg and diastolic OBP by +0.8 mmHg on Bland Altman analysis. The conformity between oscillatory measurements (obtained by the same equipment used in the present study) and auscultatory measurements was also confirmed by Salice et al (15).

ABP measurement using ABPM

24 h ABPM was performed using oscillometric Spacelabs 90207 equipment (Spacelabs Inc, USA), which has been validated for use in children (16). A staff member, specifically trained to coordinate the ABPM program, chose an appropriately sized BP cuff (as per the guidelines) (2). The same set of instructions were provided to all ABPM users. ABPM appointments were scheduled either on the same day or on a day near to when the OBP was measured. Monitoring was considered to be successful if at least 80% valid ABPM readings were obtained during day and night.

The APB mean and load were computed for each patient. Percentile and *z*-score were calculated based on the ABP references using Box-Cox transformations with age- and sex-specific estimates of the distribution median, coefficient of variation and degree of skewness (17). ABP load was the proportion of ABP >95th percentile according to the ABPM references (18).

Definitions

- **Abnormal OBP on simplified BP tables:** OBP ≥ OBP thresholds (sex- and age-specific) on the simplified BP tables (corresponds to OBP ≥90th percentile for the 5th height percentile on the fourth report BP tables or ≥120/80 mmHg) (11).
- **Abnormal OBP on fourth report BP tables:** OBP ≥90th OBP percentile (sex- and age-specific) corresponding to the patient's actual height percentile or ≥120/80 mmHg (2).
- **Abnormal ABP on ABPM:** Mean ABP >95th percentile and ABP load ≥25% readings, as per the American Heart Association classification (17-19).

Statistical analysis

The Kolmogorov-Smirnov test was used to assess the normality of continuous numerical data. Categorical variables were compared using the χ^2 test, while continuous variables were compared using the parametric unpaired *t* test or nonparametric Mann-Whitney U test, as appropriate. Calculations were performed using SPSS

TABLE 1
Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of the office blood pressure (OBP) thresholds for appropriately classifying ambulatory blood pressure (ABP) categories (according to ABP reference intervals)

	OBP thresholds on simplified BP tables				OBP thresholds on fourth report BP tables			
	Sensitivity	Specificity	PPV	NPV	Sensitivity	Specificity	PPV	NPV
Daytime systolic ABP								
Entire group	0.95 (0.82–0.99)	0.42 (0.33–0.51)	0.33 (0.24–0.43)	0.96 (0.87–0.99)	0.91 (0.78–0.97)	0.45 (0.36–0.53)	0.34 (0.25–0.44)	0.95 (0.86–0.98)
Age ≥10 years	0.96 (0.80–0.99)	0.43 (0.32–0.52)	0.28 (0.18–0.38)	0.97 (0.85–0.99)	0.92 (0.74–0.99)	0.47 (0.37–0.58)	0.32 (0.22,0.44)	0.96 (0.82–0.99)
Female sex	1.00 (0.78–1.00)	0.42 (0.26–0.56)	0.37 (0.23–0.53)	0.12 (0.84–1.10)	1.00 (0.79–1.00)	0.45 (0.32–0.62)	0.40 (0.25–0.57)	0.10 (0.81–1.10)
Secondary hypertension	0.94 (0.76–0.98)	0.41 (0.24–0.62)	0.57 (0.39–0.74)	0.87 (0.47–0.98)	0.95 (0.77–0.99)	0.45 (0.26–0.65)	0.62 (0.44–0.79)	0.91 (0.55–0.98)
Daytime diastolic ABP								
Entire group	0.56 (0.40–0.73)	0.76 (0.67–0.83)	0.41 (0.28–0.57)	0.85 (0.77–0.91)	0.52 (0.34–0.68)	0.78 (0.70–0.85)	0.42 (0.28–0.58)	0.84 (0.76–0.90)
Age ≥10 years	0.54 (0.34–0.72)	0.78 (0.68–0.86)	0.43 (0.24–0.61)	0.84 (0.75–0.92)	0.50 (0.31–0.69)	0.80 (0.70–0.88)	0.44 (0.26–0.62)	0.83 (0.73–0.90)
Female sex	0.59 (0.33–0.81)	0.82 (0.67–0.92)	0.55 (0.31–0.78)	0.84 (0.69–0.93)	0.53 (0.28–0.77)	0.84 (0.70–0.93)	0.56 (0.30–0.80)	0.82 (0.68–0.92)
Secondary hypertension	0.53 (0.33–0.72)	0.76 (0.55–0.88)	0.70 (0.42–0.90)	0.62 (0.41–0.83)	0.52 (0.32–0.71)	0.77 (0.56–0.90)	0.69 (0.41–0.89)	0.63 (0.42–0.81)
Night-time systolic ABP								
Entire group	0.85 (0.73–0.93)	0.42 (0.32–0.52)	0.44 (0.35–0.54)	0.84 (0.71–0.93)	0.82 (0.67–0.90)	0.45 (0.35–0.55)	0.43 (0.34–0.54)	0.81 (0.68–0.90)
Age ≥10 years	0.83 (0.69–0.92)	0.41 (0.30–0.53)	0.44 (0.33–0.54)	0.73 (0.56–0.88)	0.79 (0.61–0.87)	0.46 (0.37–0.61)	0.49 (0.37–0.61)	0.76 (0.61–0.87)
Female sex	0.84 (0.64–0.95)	0.39 (0.23–0.57)	0.49 (0.33–0.65)	0.78 (0.52–0.93)	0.80 (0.59–0.93)	0.44 (0.28–0.62)	0.50 (0.34–0.66)	0.76 (0.53–0.92)
Secondary hypertension	0.88 (0.70–0.95)	0.37 (0.22–0.60)	0.63 (0.45–0.79)	0.62 (0.25–0.91)	0.84 (0.65–0.93)	0.38 (0.20–0.61)	0.66 (0.47–0.81)	0.64 (0.31–0.89)
Night-time diastolic ABP								
Entire group	0.55 (0.40–0.70)	0.78 (0.69–0.85)	0.52 (0.37–0.66)	0.80 (0.72–0.87)	0.52 (0.36–0.66)	0.81 (0.72–0.88)	0.53 (0.38–0.68)	0.79 (0.71–0.87)
Age ≥10 years	0.51 (0.34–0.68)	0.80 (0.70–0.88)	0.54 (0.37–0.71)	0.78 (0.68–0.87)	0.49 (0.32–0.66)	0.83 (0.73–0.90)	0.56 (0.38–0.74)	0.77 (0.68–0.86
Female sex	0.48 (0.26–0.70)	0.80 (0.64–0.91)	0.55 (0.31–0.78)	0.74 (0.59–0.86)	0.44 (0.22–0.66)	0.82 (0.67–0.93)	0.56 (0.30–0.80)	0.73 (0.58–0.85)
Secondary hypertension	0.54 (0.34–0.73)	0.73 (0.51–0.84)	0.69 (0.41–0.89)	0.64 (0.34–0.75)	0.51 (0.30–0.69)	0.76 (0.54–0.89)	0.68 (0.40–0.88)	0.69 (0.39–0.78)

Data presented as column heading value (95% CI). BP Blood pressure. OBP threshold on simplified BP tables: OBP ≥ OBP thresholds (age- and sex-specific) on simplified BP tables (corresponds to OBP ≥90th percentile for fifth height percentile on the fourth report BP tables or ≥120/80 mmHg) (11). OBP threshold on the fourth report BP tables: OBP ≥90th OBP percentile (age- and sex-specific) corresponding to patient's actual height percentile or ≥120/80 mmHg (2). ABP threshold as per ABP reference intervals (16,17): Mean BP >95th percentile and BP load ≥25% on ABP monitoring as per ABP reference intervals (18)

version 21 (IBM Corporation, USA). Sensitivity, specificity, kappa statistics, positive and negative predictive values and likelihood ratios were calculated and Bland-Altman analysis performed using MedCalc version 12.5 (MedCalc Software, Belgium) for Windows (Microsoft Corporation, USA); P<0.05 was considered to be statistically significant.

RESULTS

Study group characteristics

A total of 155 patients were eligible for the present study. Data regarding OBP, classified according to both simplified and fourth report BP thresholds and ABP, classified according to the ABP reference thresholds, were collected and analyzed. The study group was 39% female, 20% were overweight, 34% were obese and 76% were ≥10 years of age.

Of 155 ABP values, the ABP reference intervals categorized 37 (24%) daytime systolic ABP, 36 (23%) daytime diastolic ABP, 55 (35%) night-time systolic ABP and 47 (30%) night-time diastolic ABP as elevated.

Agreement between the simplified and fourth report BP tables

The simplified BP tables correctly identified all systolic and diastolic OBP values, classified as elevated according to the fourth report BP tables. Among the systolic OBP (n=55) values and diastolic OBP values (n=109) classified as normal according to the fourth report BP tables, the simplified BP tables identified 18 (33%) systolic and four (4%) diastolic OBP values as elevated. Overall agreement between the simplified and fourth report BP tables was good for systolic OBP (κ 0.72 [95% CI 0.61 to 0.83]) and very good for diastolic OBP (κ 0.92 [95% CI 0.86 to 0.99]) (19).

Accuracy of simplified and fourth report BP tables for identifying ABP categories

Daytime ABP: Among 37 abnormal daytime systolic ABP (as per the ABP references), the simplified BP thresholds identified 35 (95%) cases correctly and fourth report BP tables identified 34 (92%) of abnormal ABPM results correctly. Of the normal ABP (as per the ABP references), the simplified BP tables misclassified 68 (58%) and the fourth report BP incorrectly identified 66 (56%–P>0.05) as abnormal. Taken together, the simplified BP tables correctly identified 85 (55%) and the fourth report BP tables 86 (55%) daytime systolic ABP (P>0.05) (Figure 1). Both BP tables had considerable overlap in the 95% CI of their sensitivity, specificity and predictive values (Table 1) and likelihood ratios (Table 2), in the group as a whole and in subgroups based on age, sex and secondary hypertension.

Identifying daytime abnormal and normal diastolic ABP appropriately, the two BP tables had considerable overlap in the 95% CIs of their sensitivity, specificity and predictive values (Table 1) as well as likelihood ratios (Table 2). Overall, correct ABP identification was similar for both BP tables (72% simplified verses 73% fourth report; P>0.05) (Figure 1). The simplified BP tables correctly identified 5% more abnormal daytime diastolic ABP values and incorrectly classified 2% more normal daytime diastolic ABP than the fourth report BP tables (P>0.05).

Night-time ABP: For night-time systolic ABP, the simplified BP tables correctly identified 57% (n=88) and the fourth report BP

TABLE 2

Likelihood ratio (LR) of the office blood pressure (OBP) thresholds for appropriately classifying ambulatory blood pressure (ABP) categories (as per ABP reference intervals)

	OBP thresholds on simplified BP tables		OBP thresholds on fourth report BP tables	
	Positive LR	Negative LR	Positive LR	Negative LR
Daytime systolic ABP				
Entire group	1.63 (1.37–1.92)	0.14 (0.03–0.51)	1.67 (1.38–2.01)	0.18 (0.06–0.54)
Age ≥10 years	1.69 (1.49–2.10)	0.14 (0.02–0.80)	1.73 (1.39–2.19)	0.17 (0.04–0.65)
Female sex	1.81 (1.41–2.22)	0.00 (–)	1.85 (1.43–2.46)	0.00 (–)
Secondary hypertension	1.69 (1.13–2.18)	0.14 (0.02–1.11)	1.73 (1.17–2.58)	0.10 (0.01–0.74)
Daytime diastolic ABP				
Entire group	2.35 (1.54–3.59)	0.58 (0.39–0.84)	2.37 (1.49–3.76)	0.62 (0.44–0.88)
Age ≥10 years	2.43 (1.42–4.27)	0.60 (0.40–0.90)	2.49 (1.44–4.35)	0.62 (0.43–0.92)
Female sex	3.27 (1.44–7.49)	0.53 (0.29–0.91)	3.32 (1.47–7.51)	0.56 (0.33–0.94)
Secondary hypertension	2.32 (0.98–5.54)	0.61 (0.37–1.01)	2.30 (0.96–5.51)	0.63 (0.38–1.04)
Night-time systolic ABP				
Entire group	1.48 (1.21–1.80)	0.41 (0.21–0.73)	1.46 (1.17–1.82)	0.44 (0.25–0.78)
Age ≥10 years	1.41 (1.07–1.86)	0.55 (0.29–1.07)	1.45 (1.12–1.95)	0.51 (0.28–0.97)
Female sex	1.39 (1.01–1.98)	0.41 (0.15–1.10)	1.44 (1.01–2.03)	0.45 (0.19–1.07)
Secondary hypertension	1.31 (0.88–1.88)	0.43 (0.18–1.58)	1.35 (0.91–2.06)	0.41 (0.14–1.19)
Night-time diastolic ABP				
Entire group	2.59 (1.64–4.17)	0.57 (0.41–0.80)	2.64 (1.66–4.23)	0.60 (0.45–0.82)
Age ≥10 years	2.74 (1.52–4.96)	0.61 (0.43–0.86)	2.79 (1.58–5.03)	0.62 (0.45–0.86)
Female sex	2.39 (1.11–5.52)	0.66 (0.42–1.01)	2.44 (1.06–5.64)	0.69 (0.47–1.03)
Secondary hypertension	2.12 (0.88–5.05)	0.62 (0.38–1.04)	2.10 (0.87–5.02)	0.65 (0.40–1.06)

Data presented as likelihood ratio (95% CI). OBP thresholds (on the simplified blood pressure (BP) tables and fourth report BP tables) and ABP categories: See footnote to Table 1

tables correctly identified 58% (n=90) of the abnormal and normal ABP values (P>0.05) (Figure 1). Both BP tables also showed similar accuracy for night-time diastolic ABP (simplified BP tables, 72% versus fourth report BP tables, 73%; P>0.05). Both BP tables had similar sensitivity, specificity and predictive values (Table 1) as well as likelihood ratios (Table 2) for night-time systolic and diastolic ABP. The simplified BP table correctly identified 5% more abnormal night-time systolic ABP and 4% diastolic ABP and incorrectly labeled 3% more normal night-time systolic ABP and 2% diastolic ABP than the fourth report BP tables (P>0.05).

DISCUSSION

The main focus of the present study was to evaluate the utility of simplified OBP thresholds (proposed as a screening tool to decrease the underdiagnosis of hypertension in children) to decide an appropriate referral for ABPM (used as a confirmatory tool to characterize hypertension and rule out 'white coat' hypertension). We found that the OBP screened as abnormal according to the simplified BP tables were similar to the fourth report BP tables, which is the current tool used for deciding a referral for ABPM in clinical practice.

The findings from our study are important in view of the reported under-recognition of hypertension in 74% to 87% of children (9,10), despite the use of fourth report BP tables in these two large studies. The simplified BP tables were proposed as a result of these observations (11) and later studies demonstrated their usefulness in improving the under-recognition of hypertension (21-23). Zuijdwijk et al (21) reported that Kaelber's simplified BP tables can correctly screen all OBP values classified as hypertension and prehypertension according to the fourth report BP tables. With slightly different simplified BP tables (10 OBP thresholds, two measures for five age groups in increments of three years), Mitchell et al (23) reported a sixfold improvement, from 15% to 77%, in recognition of OBP-based hypertension as per the fourth report BP tables. Aatola et al (22) established that simplified BP tables (both Kaelber's and Mitchell's) could be as good as the fourth report BP tables in identifying pediatric patients who are at an increased risk for high arterial stiffness in adulthood and, hence, aid in improving the primary prevention of cardiovascular diseases.

Placing our study within the context of existing literature, we examined a novel feature of the simplified BP tables by evaluating whether they were useful in deciding an appropriate referral for ABPM. The findings from our study suggest that, compared with using the fourth report BP tables, a referral based on the simplified BP tables will improve hypertension recognition without increasing the number of unnecessary ABPM procedures. We used OBP ≥90th percentile in our analysis because it is a screening threshold with good sensitivity (to reduce the underdiagnosis of hypertension), while ABP >95th percentile was consistent with American Heart Association recommendations and it is a confirmatory ABP threshold with good specificity (to reduce unnecessary overdiagnosis of hypertension by ABPM) (19).

It was a noteworthy finding that despite the difference in OBP thresholds in the simplified and fourth report BP tables (because simplified BP tables do not account for an individual's height, unlike fourth report BP tables), the two tables performed similarly in correctly identifying abnormal ABP (classified as per ABP references). Similar performance of the two OBP thresholds to correctly identify abnormal ABP can be explained by an inherent difference between OBP and ABP measurements (16,24): the difference between OBP and ABP ranges from 4.59±16.76 mmHg for systolic BP and 0.39±14.36 mmHg for diastolic BP (25). Also, BP thresholds used to classify OBP and ABP are different. The differences arise from the fact that OBP thresholds for the fourth report BP tables are derived from the auscultatory OBP measurements in American children (2), whereas ABP references are based on oscillatory ABP measurements from European children (17,18). It was previously shown that measurements obtained using auscultatory and oscillatory techniques can differ (26) and, interestingly, even with the same measurement techniques, European children have shown higher BPs than their American counterparts (2,27).

A few methodological considerations must be highlighted. Our study was limited by its retrospective design. We did, however, attempt to improve the validity of our observations in the following ways: consistent use of standard methodology to measure OBP and ABP; use of OBP and ABP classifications that are based on established BP thresholds; homogenous inclusion of a complete set of OBP and ABP recordings of patients who were not taking any antihypertensive medications; establishing our findings in subgroup analysis based on age, sex and secondary hypertension and through the use of different sets of statistical tools; and ruling out any technique-induced measurement bias in our internal validation assessment (see Methods).

The main strength of the present study is that it provides evidence for the validity of a simple new tool that can reduce the underdiagnosis of hypertension in children to decide a referral for ABPM assessment. Underdiagnosis of hypertension has major clinical implications considering the significant rise in childhood hypertension shown in population-based studies (1), the progression of hypertension from childhood to adulthood shown in many landmark studies (28,29) and major increase in hypertension-attributable mortality in adults (30). On the other hand, ABPM assessments optimize the diagnosis of OBP-based hypertension in clinical practice by providing a better correlation with target organ damage, ruling out 'white coat' hypertension and confirming masked and night-time hyptension (3-5). Our analyses suggest that the optimization in patient care by improved recognition of pediatric hypertension by simplified BP tables does not come with an increase in resource utilization through unnecessary ABPM usage.

We conclude that the simplified BP tables, proposed to improve the significant underdiagnosis of hypertension in children, can serve as a useful screening tool to decide a referral for ABPM assessment. Future prospective studies are needed to further establish our findings.

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