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Which Blood Pressure Measures Correlate with Nocturia Severity in Adolescents?

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Abstract

Nocturia, defined as waking to void during sleep hours, is common in adolescents, causing sleep disruption and daytime fatigue. While numerous studies have found nocturia associated with systolic blood pressure (BP) hypertension in adults, diastolic (D) BP has greater relative importance in youth. Little is known about the hemodynamic profile of the hypertension–nocturia link in adolescents. Accordingly, we evaluated relationships between nocturia severity and brachial artery systolic and DBPs in each arm, as well as central aortic pressures using applanation tonometry. We studied 100 adolescents, 10–18 years, from pediatric clinics. Nocturnal urinary indices were obtained from voiding diaries. Results: In total, 45% reported nocturia. Nocturia severity was correlated with left and right arm brachial SBP, higher of two arms, and central SBP (r = 0.27, p = 0.007). Brachial SBP was also correlated with nocturnal urine volume (NUV) (r = 0.31, p = 0.001) and production rate (NUP) (r = 0.32, p = 0.001). DBP showed no significant correlations. After adjusting for BMI and sex, brachial SBP remained independently associated with nocturia severity. The median first uninterrupted sleep period was 171 min (25–75%ile; 94, 300). In adolescents, SBP is associated with nocturia severity, NUV, and NUP. Nocturia typically occurs during the first half of nighttime, suggesting an impact on deep sleep.

Keywords: nocturia; hypertension; blood pressure; adolescents; central aortic pressure

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1. Introduction

Nocturia, defined as waking to void during sleep hours, is common in the general population, causing disrupted sleep architecture and daytime fatigue [1,2]. Although once viewed mainly as a urological symptom in adults, nocturia has been increasingly recognized to accompany a variety of systemic disorders mediated by circadian rhythm disturbances that regulate hormone secretion, renal function, and blood pressure (BP) [1,2]. Among the most widely studied, nocturia severity is strongly related to hypertension

(HTN) as multiple studies have confirmed adults with higher systolic (S) blood pressures (BPs) to have more frequent nocturia [3,4].

While often overlooked by clinicians, nocturia is also common is adolescents as approximately one fourth of teenagers have reported waking to void and experiencing fragmented sleep, daytime somnolence, impaired cognitive performance, and emotional stress [5–12]. In a previous report from this cohort, we described the prevalence of nocturia and its association with elevated BP defined using pediatric age-dependent thresholds [13]. The present secondary analysis extends those findings by examining continuous peripheral and estimated central BP measures, inter-arm differences, and diary-derived measures of nocturnal urine volume (NUV), nocturnal urine production (NUP), nocturnal maximum voided volume (nMVV), and first uninterrupted sleep period (FUSP). While systolic BP is the best predictor of future cardiovascular events across the lifespan, diastolic BP is also important in young adults and children [14–16]. Moreover, even mildly increased diastolic BP persists into adulthood is predictive of hypertension, metabolic syndrome and higher cardiovascular risk later in life, especially in the presence of poor sleep [15,17]. However, we did not cross-compare specific peripheral BP components, leaving a critical gap in our understanding of whether systolic or diastolic measures drive this association in youth. Furthermore, peripheral brachial artery BP measurements often do not reflect the true hemodynamic load experienced by the central organs because of BP amplification-SBP increasing from the central aorta to the periphery due to vascular branching and tapering and peripheral arterial wave reflections [18]. Central aortic pressure which can be non-invasively determined via pulse wave analysis provides a more accurate reflection of central pathophysiology [18]. Central aortic pressure is relevant to youth because BP amplification, normal phenomenon is notably exaggerated in adolescents due to compliant arterial walls and higher cardiac output [19,20]. To date, the relationship between nocturia severity and central aortic pressure parameters has not been evaluated in an adolescent cohort. Finally, clinical assessments must account for inter-arm BP differences because BP frequently differs between the left and right arms [21]. Notably, the left subclavian artery branches directly from the aortic arch and gives rise to the brachial artery, making left-arm hemodynamics anatomically closer to the descending aorta and the renal arteries, which are felt to modulate fluid balance and nocturnal urine production. Therefore, this study aims to comprehensively evaluate the relationship between nocturia frequency and distinct hemodynamic profiles in adolescents, comparing peripheral systolic and diastolic measures, investigating central aortic pressures, and accounting for inter-arm BP differences to elucidate the early cardiovascular correlates of nocturia in youth.

2. Results

Patient characteristics are shown in Table 1. Among 109 subjects recruited, 100 completed the follow-up voiding diary and were included for analysis. The mean age of the subjects was 14 $\pm$ 2 years and 52% were female 14% were severely obese. Of the participants who completed the diaries, forty five percent noted nocturia (range: 1–4 voids) on the voiding diary, while 55% did not report any nightly voids.

Table 1. Study Participant Characteristics.

Variable	Patients (N = 100)
Age (years)	14 (IQR; 12,16)
Gender (% Female)	52
Race (%)	

Table 1. *Cont.*

Variable	Patients (N = 100)
African American	94
Hispanic	5
Other	1
Obesity (%)	14
History of Smoking (%)	0
Diabetes (%)	1
History of previously diagnosed hypertension (%)	18
Ever taken meds for BP (%)	4
Obstructive sleep apnea (%)	3
Diuretic use (%)	0
Nocturia (voiding diary) (%)	45
Nocturia (self-report) (%)	37
Systolic BP (mm Hg) (right arm)	114.0 (105, 121)
Diastolic BP (mm Hg) (right arm)	67.1 (60, 72)
Systolic BP (mm Hg) (left arm)	112.6 (104, 120)
Diastolic BP (mm Hg) (left arm)	67.7 (61, 74)
Systolic BP (mm Hg) (central)	99.9 (92, 107)
Diastolic BP (mm Hg) (central)	70.2 (63, 77)
Ejection Duration (%)	35.8 (33, 39)
Nocturnal Voiding Episodes (%)	
Zero	55
One	33
Two or more	12
Hours Asleep	9.54 (8.0, 10.5)
Nocturnal Urine Volume (mL)	375 (200, 500)
Nocturnal Urine Production rate (mL/hr)	40.3 (22.7, 52.2)
Nocturnal Maximal Voided Volume (mL)	268 (200, 300)

Nocturia severity was significantly correlated with the following BP measurements: right arm SBP (r = 0.32, p = 0.001), left arm SBP (r = 0.30, p = 0.003), higher of the two arms (r = 0.33, p = 0.001) and central SBP (r = 0.27, p = 0.007), while DBP showed no significant correlations. Correlations between nocturia severity and right and left arm PPs and MAPs were also significant but less robust (Table 2).

Table 2. Blood Pressure Measurements association with nocturia severity.

Parameter	Spearman's Correlation Coefficient vs. ANV	Significance (p-Value, Two-Tailed)
Systolic Blood Pressure (SBP)		
Right Arm SBP	0.321	0.001
Left Arm SBP	0.295	0.003

Table 2. *Cont.*

Parameter	Spearman's Correlation Coefficient vs. ANV	Significance (*p*-Value, Two-Tailed)
Highest SBP of both arms	0.331	0.001
Central SBP	0.267	0.007
Diastolic Blood Pressure (DBP)		
Left Arm DBP	0.118	0.241
Right Arm DBP	0.083	0.41
DBP of Highest SBP of both arms	0.065	0.522
Central DBP	0.057	0.576
Pulse Pressure (PP)		
Right Arm PP	0.212	0.034
Left Arm PP	0.128	0.204
PP (Highest SBP—DBP of Highest SBP)	0.168	0.096
Mean Arterial Pressure (MAP)		
Left Arm MAP	0.228	0.023
Right Arm MAP	0.177	0.079
Highest SBP MAP	0.172	0.086

On partial correlation analysis, correlations between SBP and nocturia remained significant after adjusting for BMI and sex, with the higher SBP (higher of the 2 arms) showing the strongest correlation (r = 0.28, p = 0.005). Other BP measures, including PP and MAP, were not significant after adjustment (Table 3).

Table 3. Blood Pressure Measurements' association with nocturia severity after adjusting for BMI and sex.

Parameter	Spearman's Correlation Coefficient vs. ANV	Significance (*p*-Value, Two-Tailed)
Right Arm SBP	0.262	0.008
Left Arm SBP	0.219	0.028
Highest SBP of both arms	0.276	0.005
Central SBP	0.181	0.070
Right Arm PP	0.165	0.100
Left Arm MAP	0.145	0.151

In the sensitivity analysis restricted to the 94 participants aged 10–17 years, age-, sex-, and height-standardized highest-arm SBP remained significantly associated with nocturia severity (r = 0.33, p = 0.001). Standardized SBP was also significantly correlated with NUV (r = 0.27, p = 0.008) and NUP (r = 0.25, p = 0.014) but not with nMVV (r = 0.07, p = 0.513) or sleep duration (r = −0.02, p = 0.883). After additional adjustment for age, height, BMI, and sex, the association between standardized SBP and nocturia severity remained significant (partial r = 0.22, p = 0.035). The association with NUV also remained significant (partial r = 0.22, p = 0.036), whereas the association with NUP was attenuated and did not reach conventional statistical significance (partial r = 0.21, p = 0.050). Standardized SBP remained unrelated to nMVV (partial r = 0.11, p = 0.310) (Table 4).

Table 4. Association of age-, sex-, and height-standardized systolic blood pressure with nocturia and nocturnal urinary indices in participants aged 10–17 years (n = 94).

Outcome	Spearman Correlation with Highest-Arm SBP z-Score, r	*p*-Value	Partial Correlation Adjusted for Age, Height, BMI, and Sex, r	*p*-Value
Actual number of voids (ANV)	0.329	0.001	0.223	0.035
Nocturnal urine volume (NUV)	0.272	0.008	0.222	0.036
Nocturnal urine production (NUP)	0.254	0.014	0.207	0.050
Nocturnal maximum voided volume (nMVV)	0.068	0.513	0.108	0.310
Sleep duration	−0.015	0.883	-	-

Higher arm SBP was also significantly correlated with NUV (r = 0.31, $p = 0.001$) and with NUP (r = 0.32, $p = 0.001$). Central SBP was also correlated with NUV (r = 0.24, $p = 0.016$) and NUP (r = 0.25, $p = 0.01$). Conversely, nMVV was unrelated to any of the BP measures (Table 5).

Table 5. Correlation of systolic blood pressure (SBP) measures with Nocturnal Urine Volume (NUV), Nocturnal Urine Production (NUP), and nocturnal maximum voided volume (nMVV).

SBP Measure	Comparison	Spearman's Correlation Coefficient	*p*-Value
Highest SBP	NUV	0.31	0.001
	NUP	0.32	0.001
	nMVV	0.11	0.250
Central SBP	NUV	0.24	0.016
	NUP	0.25	0.010
	nMVV	0.05	0.576

On Poisson regression analysis, SBP was a significant predictor ($p < 0.01$), with each 1-point increase in SBP associated with 0.04 more nocturia episodes (95% CI: 0.018 to 0.067), while gender was not significant ($p = 0.24$).

Median FUSP was 171 min (25–75%ile; 94, 300 min). Among participants with nocturia (45.0%), however, FUSP did not differ by blood pressure category (3.06 [1.53–4.58] vs. 2.50 [1.25–5.00] vs. 2.93 [2.21–4.63] hours, respectively; H(2) = 0.273, $p = 0.873$) (Table 6). There was no significant relation between FUSP and BP status.

Table 6. First Uninterrupted Sleep Period (FUSP) by Blood Pressure Category in Patients with Nocturia (N = 45).

Blood Pressure Category	n	FUSP, Median (IQR), Hours
Normal	16	3.06 (1.53–4.58)
Elevated BP	9	2.50 (1.25–5.00
Stage 1 + 2 HTN	20	2.93 (2.21–4.63)

3. Discussion

The major study finding was that multiple SBP measures showed a statistically significant, positive association with nocturia severity in adolescents. Specifically, SBP measured in the right arm, left arm, the higher of the two arms, and central SBP all correlated moderately with ANV with *p* values ranging from 0.27 to 0.33. In contrast, DBP measures from

the same locations were not significantly associated with nocturia severity. Pulse pressure and MAP variables showed weaker and less consistent relationships: right arm PP and left arm MAP were modestly correlated with number of voids while other PP and MAP indices did not reach statistical significance. Overall, these findings suggest that in adolescents, nocturia severity is more closely related to systolic and pulsatile components of BP than to diastolic or MAP. Therefore, we have characterized the hemodynamic profile of adolescents experiencing nocturia. These findings extend our prior report from the same cohort, which demonstrated an association between nocturia and elevated BP, by examining continuous peripheral and central BP measures as well as their relationships with nocturia severity and diary-derived urinary indices.

These findings pose several implications. The strongest association of nocturia severity was observed for the highest SBP between arms, suggesting that the maximum peripheral SBP may better reflect the vascular load associated with nocturnal urinary symptoms than either arm alone. Although right arm PP and left arm MAP were also significantly associated with nocturia severity, these associations were weaker and less consistent than those observed for SBP and should therefore be interpreted cautiously. The modest strength of the correlations (low 0.3 range) is consistent with nocturia being a multifactorial condition influenced by sleep, behavioral, hormonal, urological, and cardiovascular factors, with BP explaining only a portion of the variability in nocturia severity. The present study findings are consistent with prior studies in adults showing an association between nocturia and hypertension, particularly systolic BP elevation, as well as cardiovascular abnormalities including left ventricular hypertrophy, left atrial enlargement, and arterial remodeling [3,4]. Interestingly, we did not find a significant correlation between DBP and nocturia severity, despite DBP being an important predictor of CV risk in younger adults [22]. Thus, the present study did not confirm an association between DBP and nocturia severity in adolescents. Rather, the observed predominance of systolic associations more closely resembles findings reported in adult studies of nocturia and hypertension. One possible explanation is that adolescents have greater vascular compliance and lower arterial stiffness, reducing the impact of DBP on renal blood flow and nocturnal urine production. Factors such as antidiuretic hormone secretion, fluid intake, and sodium balance may also play a more significant role in nocturnal diuresis than DBP alone. As adolescents undergo significant growth-related cardiovascular changes, including increased cardiac output, peripheral SBP may exert a stronger influence on nocturia severity due to its effects on glomerular capillary pressure and renal perfusion [23]. While nocturia in adolescents is attributed to urological conditions such as pelvic floor weakness and small bladder capacity, our findings suggest it may also serve as an early marker of cardiovascular dysfunction [24].

Importantly, we also found that peripheral SBP was associated with increased NUV, NUP, but not nMVV. These findings demonstrate an association between SBP and urine production during the recorded nocturnal period; however, because daytime and 24 h urine volumes were not collected, they cannot distinguish disproportionately increased nocturnal urine production from generally increased 24 h urine output. Similarly, the absence of an association with nMVV does not exclude reduced functional bladder capacity, because maximum voided volume over a full 24 h period was not assessed. Nocturia was related to both brachial artery and central aortic BP. Adolescents typically exhibit brachial arterial elasticity contributing to greater SBP amplification from central to peripheral arteries, leading to higher brachial SBP relative to cSBP1 [25,26]. While some studies have noted that elevated SBP with normal cSBP, other studies have found isolated systolic hypertension predictive of adverse cardiovascular outcomes in children [18,27].

Furthermore, we also assessed PP, a measure of vascular stiffness, and MAP, which represents the average pressure in the arteries during the cardiac cycle [22]. There was

inconsistency in associations between PP and nocturia severity. Some potential explanations are that PP is influenced by arterial stiffness, in adults but not youth. because of greater PP amplification. Similarly, MAP showed a modest correlation with nocturia frequency, but these associations were weaker than those observed with SBP. This may be because MAP is a composite measure incorporating both SBP and DBP, which could obscure the specific role of pulsatile pressure and cardiac output in nocturnal urine production. Given the number of BP measures examined, these secondary PP and MAP findings should be interpreted cautiously and considered exploratory.

Several potential mechanisms may link elevated SBP with increased nocturnal urine production. In adults, inadequate nocturnal BP dipping may promote pressure natriuresis, resulting in greater nighttime sodium and water excretion. Alterations in vasopressin and natriuretic peptide secretion have also been proposed, while nocturnal awakenings may increase sympathetic nervous system activity and influence BP. However, nocturnal BP patterns, urinary sodium excretion, vasopressin, atrial natriuretic peptide, and objective sleep-stage measurements were not obtained in the present study; therefore, these mechanisms remain speculative in this cohort.

Notably, the median FUSP occurred early after sleep and was unrelated to BP status. FUSP represents the interval between sleep onset and the first awakening to void. We found median FUSP values in adolescents to be similar to those previously reported in adults [28]. However, FUSP is not a direct measure of slow-wave sleep or sleep architecture, and sleep stages were not measured in the present study. Therefore, the relationship between nocturia, FUSP, and specific sleep stages requires further study. Among participants with nocturia, FUSP was unrelated to BP status. Although multiple studies have evaluated FUSP in adults, we are aware of only one prior study that evaluated FUSP in children and focused on those with enuresis [29]. For participants without a nocturnal void, the time to first void is not directly observed; therefore, analyses of FUSP across the entire cohort would be more appropriately evaluated using a time-to-event approach accounting for right censoring.

4. Limitations

This study poses the limitations of a cross-sectional study, which does not allow for causality. While elevated SBP may contribute to nocturia, nocturia could influence BP through sleep disruption and sympathetic activation, or both may be impacted by other factors. We performed additional analyses on our prospectively recruited cohort that previously reported robust associations between BP status and nocturia. The sample size of 100 adolescents, of whom 45 had nocturia, while sufficient for initial insights, may not be large enough to draw robust, generalizable conclusions. Furthermore, the age range of 10–18 years encompasses substantial developmental differences in age, height, body size, urine production, bladder capacity, and sleep duration. Although analyses were adjusted for BMI and sex, residual confounding by age and body size may remain. The correlations were statistically significant, but mild to moderate in magnitude, highlighting the multifactorial nature of nocturia beyond blood pressure. Also, potential confounders such as undiagnosed sleep disorders such as insomnia and fluid intake were not assessed. Other potentially relevant factors, including caffeine or sugar-sweetened beverage consumption, sodium intake, and undiagnosed obstructive sleep apnea, were also not systematically assessed. We did not assess nocturnal BP patterns, such as non-dipping status, which has been implicated in nocturia pathophysiology in adults [30]. Future studies incorporating ambulatory BP monitoring could provide a more comprehensive understanding of nocturnal hemodynamic changes in adolescents with nocturia.

The use of a nocturnal-only voiding diary also limited assessment of total 24 h urine production and fluid balance. Without daytime and 24 h urine volume measurements, nocturnal polyuria indices could not be calculated, global polyuria could not be excluded, and day-to-night redistribution or circadian variation in urine production could not be assessed. Likewise, nMVV represents only the maximum voided volume during the nocturnal recording period and cannot be considered equivalent to 24 h functional bladder capacity.

Additionally, BP measures were taken at the time of a clinical visit, which may overestimate BP levels compared to home or ambulatory monitoring. Most of the subjects were of African descent, which may limit the applicability of our findings to the broader adolescent populations. The exclusion of participants with limited English proficiency may also have introduced selection bias and further limited generalizability in a diverse urban population. More diverse and larger cohorts would strengthen the external validity of our results. Furthermore, patients were recruited from mostly general pediatric clinics, but also pediatric cardiology and renal clinics, potentially increasing the likelihood of hypertension-related nocturia and limiting the generalizability to otherwise healthy adolescents. Finally, while we adjusted for BMI and sex, we did not evaluate the long-term implications of nocturia on adolescent hypertension or cardiovascular risk. Future studies should explore whether nocturia in adolescence longitudinally serves as an early marker for sustained hypertension and adverse cardiovascular outcomes.

5. Methods

The present study involves a secondary analysis of prospectively collected voiding diary data from adolescents seen at a large academic medical center. The cohort and recruitment procedures have been described previously [13]; the current analysis focuses on continuous peripheral and estimated central BP measures and additional diary-derived urinary indices. Briefly, patients 10–18 years of age were prospectively recruited in the general pediatrics, pediatric nephrology, and pediatric cardiology clinics at the University Hospital at Downstate (Brooklyn, NY, USA) between July 2022–May 2023. The primary objective of this study aimed to characterize nocturia and BP elevation in this population. Patient accrual was performed to achieve a 1:2 ratio of hypertensive to normotensive subjects, but subjects were recruited independent of nocturia status. Patients with limited English proficiency, compulsive water drinking, congenital heart disease, arrhythmias, end-stage renal disease, prior renal transplant, diabetes insipidus, known urological conditions including bladder and/or bowel dysfunction, and a history or current presence of bedwetting were excluded from the study. This study was approved by the SUNY Downstate Health Sciences University Institutional Review Board and conformed to the ethical guidelines of the 1975 Declaration of Helsinki and informed consent was obtained from all participants and their parent(s).

Nocturia frequency was assessed using nighttime voiding diaries [31]. To enhance adherence, voiding diary data were collected in a nocturnal-only format [31]. Nocturnal voided volumes were documented during the primary sleep period, spanning from bedtime to waking, and included the first-morning void in alignment with International Children's Continence Society (ICCS) guidelines [32]. Bedtime and waking time recorded in the diary were used to determine the duration of the primary sleep period. Sleep stages were not measured. Participants were provided with calibrated measuring containers and standardized diary templates, along with both verbal and written instructions to ensure accurate record-keeping. They were advised to refrain from drinking fluids two hours prior to and during the primary sleep period. Guardians were encouraged to assist younger participants in completing the diaries. Follow-up telephone calls were conducted to collect the diary data, which were reviewed upon submission to address inconsistencies, such as

missing entries or implausible values (e.g., zeros or excessively high volumes). Participants were contacted for clarification as necessary, and incomplete or unreliable diaries were excluded from the analysis. Because diary collection was limited to the nocturnal period, daytime and 24 h urine output and 24 h maximum voided volume were not available.

BP measurements were obtained using a validated automated cuff monitor (DataScope Accutorr Plus™, Paramus, NJ, USA) at the brachial artery of both arms. The arms were supported to ensure optimal positioning and minimal movement after 5 min of sitting rest time. BP elevation was defined according to age-specific thresholds in the American Academy of Pediatrics Clinical Practice Guidelines, with patients grouped into "BP Elevation" (elevated BP, stage 1, and stage 2 hypertension) [33]. Central aortic blood pressure (CBP) was estimated using the SphygmoCor® system, a noninvasive tonometry device (SphygmoCor, Atcor Medical, Sydney, Australia). The tonometer probe was placed over the radial artery, and a validated mathematical transfer function was applied to derive central SBP. The radial waveform was calibrated using the brachial BP measurement from the arm with the higher systolic BP obtained during the study visit. Thus, central SBP represents an estimated rather than directly measured pressure. Nocturia was defined as waking to urinate $\geq$1 time per night.

Statistics

Spearman's rank correlation coefficient was used to evaluate the relationships between blood pressure indices, including peripheral systolic blood pressure (SBP) from each arm, highest SBP of both arms, peripheral diastolic blood pressure (DBP), pulse pressure (PP), mean arterial pressure (MAP), as well as central SBP (cSBP). Of note, central aortic and brachial artery diastolic pressures are typically within 1–2 mmHg [18]. Nocturia severity was assessed by actual number of voids (ANV) and the following urinary indices were determined from the voiding diaries including, nocturnal urine volume (NUV), which is the sum of the volumes of all nighttime voids and the first morning void, nocturnal urine production (NUP) calculated as total volume divided per hours of sleep and nocturnal maximum voided volume (nMVV), a measure of bladder capacity. Because only nocturnal voids were recorded, nMVV reflects nocturnal rather than 24 h functional bladder capacity. The first uninterrupted sleep period (FUSP) was calculated as the interval between the sleep onset time and the first nocturnal void [26]. FUSP was summarized among participants who experienced nocturia; participants without a nocturnal void were not assigned the full sleep period as an observed FUSP. These analyses aimed to explore the strength of associations between various BP indices and nocturia severity. Spearman's rank correlation coefficient was selected because the data were non-parametric. Partial correlation analysis and Poisson regression modeling were used to identify factors independently associated with nocturia severity including the specific BP measure that was strongest on univariate analysis, BMI and gender as independent variables.

To account for age-, sex-, and height-related variation in BP, an additional sensitivity analysis was performed using pediatric SBP z-scores. Height z-scores were calculated using age- and sex-specific pediatric growth references, and highest-arm SBP was standardized for age, sex, and height using pediatric BP reference equations. This analysis was limited to participants aged 10–17 years (n = 94); six participants aged 18 years were excluded because the pediatric BP z-score equations were not extrapolated beyond their reference age range. Associations between standardized SBP and ANV, NUV, NUP, and nMVV were evaluated using Spearman correlation. Additional partial correlation analyses were performed adjusting for age, height, BMI, and sex.

Because multiple related BP and urinary measures were examined, analyses involving PP, MAP, central SBP, and secondary urinary indices were considered exploratory and interpreted cautiously.

Statistical significance was considered at $p < 0.05$.

6. Conclusions

In conclusion, this study identified peripheral SBP as the strongest predictor of nocturia severity in adolescents, while other BP indices, including cBP, PP, and MAP, and DBP, show weaker or nonsignificant associations. The modest magnitude of these associations highlights the multifactorial nature of nocturia. These findings suggest that nocturia in adolescents may be linked to early changes in systemic circulation rather than localized vascular resistance. Given the well-established connection between nocturia and cardiovascular risk in adults, our results raise the possibility that nocturia severity could serve as an early clinical marker for hypertension and cardiovascular dysfunction in adolescents. In adolescents with nocturia, the first uninterrupted sleep period (FUSP) occurs early (2–3 h), suggesting a potential compromise of deep sleep. However, because sleep stages were not directly measured, the implications of this timing for slow-wave sleep or sleep architecture cannot be determined. Therefore, the hemodynamic profile and temporal course of the first void are similar to those previously reported in adults.

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