Urinary Sodium: Gender-related Differences and Relation to Blood Pressure in Adolescents

Rimas Jankūnas,[1]
Vladas Volbekas,[1]
Donatas Stakišaitis,[2]
Žaneta Drižienė [2]

[1] *Department of Basic and Clinical Pharmacology of Kaunas Medical University, Kaunas, Lithuania*
[2] *Centre of Pediatrics, Vilnius University Medical Faculty, Vilnius, Lithuania*

To find gender-related differences in blood pressure (BP) and urinary Na^+ excretion as well as a relation between them, we monitored diurnal, overnight, and 24-h urinary Na^+ as well as BP hourly in **22** adolescent males and **22** adolescent females. To show a possible influence of sexual hormones on Na^+ excretion and BP, we monitored 15 adolescent females during different phases of their menstrual cycle. Besides, groups (total groups) of female (n=37) and male (n=30) were investigated for Na^+, K^+, Cl^- excretion. For Na^+, Cl^-, and K^+ analysis, we applied the method of ion-selective electrodes, using an EML-105 electrolyte analyser. Arterial BP was monitored with an automatic AUTO-CUFF outpatient BP monitor.

The overnight systolic and pulse BP was significantly higher in males than in females. The diurnal pulse BP was significantly higher in males than in females at the beginning of the follicular phase. The diurnal systolic, diastolic, and mean BP was significantly higher than nocturnal in all the groups studied. The overnight urinary Na^+ level in females at the beginning of their follicular phase was significantly lower than during ovulation. In the total group of females, diurnal urinary Na^+ excretion negatively correlated with diastolic BP, but such a correlation was absent in males. Overnight, on the contrary, the correlation between urinary Na^+ excretion and BP was absent in females, but it was positive (for systolic BP) in males. The diurnal and overnight urinary Na^+ excretion exhibited a negative correlation with BP in females during the luteal phase. At the time of ovulation no such relationship was found.

BP, urinary Na^+ excretion, and relation between them in adolescents are gender- and circadian cycle-related. Sexual hormones may play a role both in the regulation of BP and urinary Na^+ excretion.

Key words: urinary sodium, blood pressure, adolescents, gender-related differences

INTRODUCTION

Studies confirmed a gender-related difference in the prevalence of hypertension during the last century. Men manifest a stronger predisposition for hypertension than women do (1, 2).

Experimental and clinical data indicate Na^+ metabolism, Na^+ transport across cell membranes, and intracellular Na^+ to be related both to gender and blood pressure. Different male and female blood pressure response to dietary NaCl (salt sensitivity) has been also demonstrated (3). An increase in mean blood pressure of 5 mm Hg or more resulting from a high NaCl supplement was found in 31% of boys and in 18% of girls (3). The response to antihypertensive treatment is also gender-related (2, 4). Sexual dimorphism of blood pressure in spontaneously hypertensive rats is androgen-dependent (1). Genes on Y chromosome may contribute to gender-related variations in blood pressure (4, 5).

This article deals with differences in Na^+ excretion of adolescent males and females as well as gender-related differences in the association of Na^+ excretion with arterial blood pressure.

Correspondence to: D. Stakišaitis, M. D., Ph. D., Habil. D., Centre of Pediatrics, Vilnius University Medical Faculty, Santariškių 4, LT-2029 Vilnius, Lithuania. Tel.: (370-2) 772 779. E-mail: donatasstakisaitis@vvkt.lt

MATERIALS AND METHODS

We monitored the diurnal, overnight, and 24-h urinary Na^+, Cl^-, and K^+ in adolescents 14–17 years old (males n = 30, females n = 37).

In 22 adolescent males and 22 adolescent females, we also monitored BP hourly for 24 h. Mean BP = (systolic BP + 2 × diastolic BP)/3, pulse BP = systolic BP – diastolic BP. The females were monitored irrespectively of the phase of their menstrual cycle.

To show a possible influence of sexual hormones on Na^+ excretion and BP, we monitored 15 adolescent females during different phases of their menstrual cycle. Monitored days included day 5 (follicular phase, serum estrogens and progesterone are close to minimal), day 13 (ovulation, serum estrogens are maximal), and day 20 (luteal phase, serum progesterone is close to maximal).

Overnight urine was collected during first urination after awakening in the morning and during awakenings at night if necessary. Diurnal urine was collected all the day, including last urination before bed. Persons under study were asked to bed at 10–11 p.m. and to rise at 7–8 a.m.

For Na^+, Cl^-, and K^+ analysis, we applied the method of ion-selective electrodes, using an EML-105 electrolyte analyser (*Radiometer*, Denmark). Arterial BP was monitored with an automatic AUTO-CUFF outpatient BP monitor (ABP-1001, Biotrac, USA). We used average diurnal and overnight BP for calculations.

We investigated the relation of Na^+ excretion with Cl^- and K^+ excretion as well as with BP, using a correlation analysis. To show the statistical significance of the difference between 2 means, we used Student's t test.

Diurnal diuresis was 0.61 ± 0.3 l in adolescent males (n = 30) and 0.53 ± 0.27 l in the general group of adolescent females (n = 37). Overnight diuresis was 0.34 ± 0.17 l and 0.29 ± ± 0.15 l, respectively. 24-h-diuresis was 0.95 ± 0.37 l and 0.82 ± 0.34 l, respectively. When measured during different phases of menstrual cycle in adolescent females, diuresis was 0.51 ± 0.24 l (follicular phase), 0.6 ± 0.35 l (ovulation phase), and 0.58 ± ± 0.31 l (luteal phase). Overnight diuresis was 0.33 ± 0.17 l, 0.25 ± 0.13, and 0.27 ± 0.14, respectively. 24-h-diuresis was 0.84 ± ± 0.29 l, 0.85 ± 0.4 l, and 0.85 ± 0.4 l, respectively.

RESULTS

Urinary excretion of Na^+

Table 1 presents data on the diurnal, overnight, and 24-h urine Na^+ level, total Na^+, Na^+/K^+ ratio, and Na^+/creatinine ratio. The overnight urinary Na^+ level in females during follicular phase was significantly lower than during ovulation phase ($p < 0.05$). Other gender- and menstrual cycle-related differences in the diurnal, overnight, and 24-h urinary Na^+ level as well as in total urinary Na^+ were insignificant. In all the groups studied, the overnight and diurnal urinary Na^+ level was comparable, but the total diurnal urinary Na^+ significantly exceeded the overnight one ($p < 0.05$).

The overnight urinary Na^+/K^+ and Na^+/creatinine ratio in females during phase follicular was significantly lower than during phase ovulation ($p < < 0.05$). There was no significant difference in the Na^+/K^+ and Na^+/creatinine ratio between the other groups studied. The overnight urinary Na^+/K^+ ratio significantly exceeded the diurnal one in the general group of females as well as in females during ovulation phase ($p < 0.05$). Other groups showed a similar tendency, but no significant circadian difference was found. The diurnal Na^+/creatinine ratio was found to be significantly higher than the overnight one in the general groups of males and females ($p < 0.05$).

Table 1. **Diurnal, overnight, and 24-h urinary level of sodium and total sodium**

		Urinary Na^+ level (mmol/l)	Total urinary Na^+ (mmol)
Adolescent males	Diurnal	137 ± 61	77 ± 39
(n = 30)	Overnight	114 ± 52	36 ± 22
	24-h	130 ± 52	113 ± 47
Adolescent females,	Diurnal	131 ± 51	67 ± 37
irrespective on menstrual	Overnight	120 ± 66	35 ± 30
phase (n = 37)	24-h	126 ± 52	102 ± 57
Adolescent females,	Diurnal	103 ± 36	47 ± 17
follicular phase	Overnight	82 ± 49	24 ± 13
(n = 15)	24-h	90 ± 37	71 ± 26
Adolescent females,	Diurnal	112 ± 50	59 ± 30
ovulation phase	Overnight	127 ± 30	32 ± 17
(n = 15)	24-h	115 ± 42	91 ± 43
Adolescent females,	Diurnal	106 ± 62	57 ± 35
luteal phase	Overnight	112 ± 71	28 ± 16
(n = 15)	24-h	107 ± 60	84 ± 47

Blood pressure

Table 2 presents data on the diurnal and overnight BP. The overnight systolic and pulse BP was significantly higher in males than in females. This difference was noted between the gender groups and persisted during all menstrual phases in females. Diurnal pulse BP was significantly higher in males than in females during follicular phase of their menstrual cycle. Diurnal systolic, diastolic, and mean BP was significantly higher than nocturnal one in all study groups. The other gender- and menstrual phase-related differences in BP were insignificant. Circadian changes in pulse BP were insignificant, either.

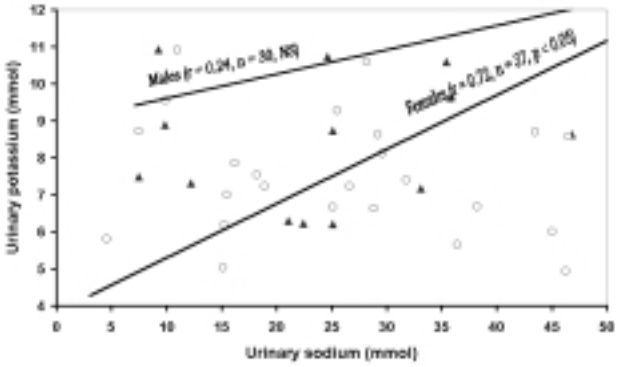

Fig. 1. Overnight correlation between urinary sodium and potassium excretion (▲ – males, O – females

Table 2. **Diurnal and overnight blood pressure**

Groups		Blood pressure (mm Hg)			
		Systolic	Diastolic	Mean	Pulse
Adolescent males (n = 22)	Diurnal	114 ± 9	77 ± 5	89 ± 6	37 ± 7
	Overnight	105 ± 9	65 ± 6	77 ± 6	40 ± 8
Adolescent females, irrespectively on menstrual phase (n = 22)	Diurnal	110 ± 9	76 ± 8	87 ± 8	34 ± 6
	Overnight	100 ± 6	66 ± 5	77 ± 5	34 ± 4
Adolescent females, follicular phase (n = 15)	Diurnal	108 ± 9	77 ± 6	87 ± 6	32 ± 7
	Overnight	98 ± 7	64 ± 4	75 ± 4	33 ± 6
Adolescent females, ovulation phase (n = 15)	Diurnal	109 ± 7	75 ± 5	86 ± 5	34 ± 7
	Overnight	99 ± 6	64 ± 5	75 ± 5	34 ± 5
Adolescent females, luteal phase (n = 15)	Diurnal	109 ± 8	74 ± 6	85 ± 7	34 ± 5
	Overnight	97 ± 6	65 ± 5	76 ± 6	32 ± 5

Correlation of total urinary sodium with total urinary Cl^- and K^+

Urinary Na^+ exhibited a strong correlation with urinary Cl^- (diurnal $r = 0.91$, $p < 0.05$ in males and $r = 0.95$, $p < 0.05$ in females; overnight $r = 0.91$, $p < 0.05$ in males and $r = 0.98$, $p < 0.05$ in females). The gender-related difference in the correlation between urinary Na^+ and Cl^- was insignificant. Urinary Na^+ usually also correlated with urinary K^+, but this relation was significantly weaker than with Cl^- (diurnal $r = 0.74$, $p < 0.05$ in males and $r = 0.77$, $p < 0.05$ in females, overnight $r = 0.72$, $p < 0.05$ in females). No correlation between urinary Na^+ and K^+ was found in males overnight ($r = 0.24$, NS). The gender-related difference in the overnight correlation between urinary Na^+ and K^+ was significant (Fig. 1).

Relation between Na^+ excretion and BP

In adolescent females, diurnal urinary Na^+ excretion negatively ($r = –0.43$, $p < 0.05$) correlated with diastolic BP (with systolic BP $r = –0.29$, NS; with mean BP $r = –0.40$, NS). In adolescent males such a correlation was absent (with systolic BP $r = –0.19$, NS; with diastolic BP $r = 0.13$, NS; with mean BP $r = –0.01$, NS). Overnight, on the contrary, no correlation between urinary Na^+ excretion and BP in adolescent females was found (with systolic BP $r = –0.02$, NS; with diastolic BP $r = –0.12$, NS; with mean BP $r = –0.08$, NS), meanwhile the correlation between urinary Na^+ excretion and systolic BP was positive ($r = 0.51$, $p < 0.05$) in adolescent males (with diastolic BP $r = 0.18$, NS; with mean BP $r = 0.37$, NS). Figure 2 shows a relation between overnight urinary Na^+ excretion and systolic BP in both sexes.

To evaluate the role of sexual hormones in Na^+ excretion and BP regulation, we also monitored 15 adolescent females during different phases of their menstrual cycle. Diurnal urinary Na^+ excretion exhibited a negative correlation with BP during luteal phase in adolescent females (with systolic BP $r = –0.69$, $p < 0.05$; with diastolic BP $r = –0.75$, $p < 0.05$; with mean BP $r = –0.76$, $p < 0.05$). This correlation persisted during phase A (with systolic

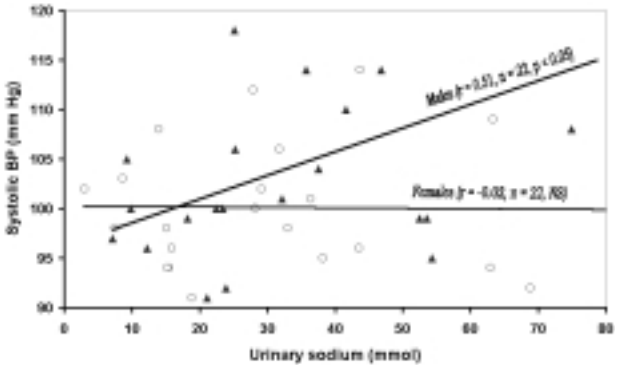

Fig. 2. Overnight urinary sodium excretion and systolic BP (▲ – males, O – females)

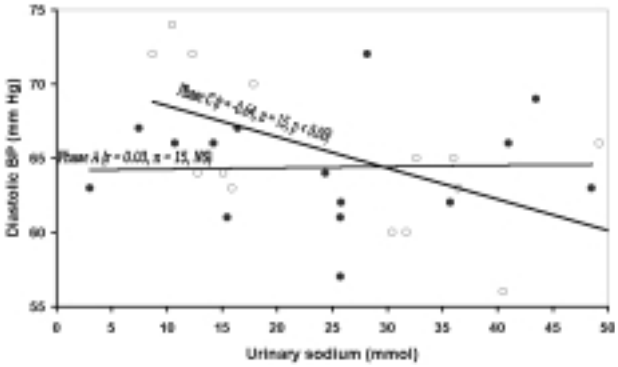

Fig. 3. Overnight correlation between urinary sodium and diastolic blood pressure in females (● – follicular phase, O – luteal phase)

BP r = –0.51, p < 0.05; with diastolic BP r = –= 0.36, NS; with mean BP r = –0.46, p < 0.05), but it was not found in phase B (with systolic BP r = –0.20, NS; with diastolic BP r = –0.35, NS; with mean BP r = –0.33, NS). Overnight urinary Na^+ excretion correlated with BP during luteal phase of the menstrual cycle (with systolic BP r = = –0.14, NS; with diastolic BP r = –0.64, p < 0.05; with mean BP r = –0.52, p < 0.05). The overnight correlation between urinary Na^+ excretion and BP during phases A and B was insignificant (phase A: with systolic BP r = –0.38, NS; with diastolic BP r = 0.03, NS; with mean BP r = –0.20, NS; phase B: with systolic BP r = –0.15, NS; with diastolic BP r = –0.35, NS; with mean BP r = –0.31, NS). The menstrual cycle-related difference in the overnight correlation between diastolic BP and urinary Na^+ excretion during follicular and luteal phases was significant (Fig. 3).

Relation of urinary excretion of Na^+ and BP with height, body weight, and body mass index

Height and body weight significantly correlated with BP only in males. The correlation of BP with body weight and body mass index exhibited gender-related differences. No significant correlation of total urinary Na^+ with height, body weight, and body mass index was found (Table 3).

Table 3. **Correlation of total urinary sodium and BP with height, body weight, and body mass index**

Related parameters		Adolescent males (n = 22)			Adolescent females (n = 22)		
		Height	Body weight	Body mass index	Height	Body weight	Body mass index
Sodium excretion	Diurnal	–0.27	–0.25	–0.13	–0.32	0.02	0.18
Sodium excretion	Overnight	0.09	–0.06	–0.18	–0.33	–0.19	–0.06
Sodium excretion	24-h	–0.19	–0.26	–0.24	–0.37	–0.10	0.06
Systolic BP	Diurnal	0.58*	*0.60**▼	*0.39*▼	0.13	*–0.26*▼	*–0.38*▼
Systolic BP	Overnight	0.38	0.40	0.32	0.18	–0.03	–0.14
Diastolic BP	Diurnal	0.40	0.39	0.28	–0.04	–0.16	–0.17
Diastolic BP	Overnight	0.46*	0.49*	0.34	0.04	0.04	0.02
Mean BP	Diurnal	0.55*	*0.55**▼	0.37	0.02	*–0.21*▼	–0.26
Mean BP	Overnight	0.49*	0.52*	0.38	0.10	0.01	–0.05
Pulse BP	Diurnal	0.37	*0.41*▼	*0.25*▼	0.26	*–0.22*▼	*–0.39*▼
Pulse BP	Overnight	0.12	0.13	0.14	0.24	–0.09	–0.23

* Significant (p < 0.05) correlation, ▼ Significant (p < 0.05) gender-related difference in correlation.

DISCUSSION

Gender-related differences in the mechanisms of hypertension are only partially understood. Earlier we

have presented the literature data on gender-related differences in the mechanisms of Na^+ transport across the cell membrane (6). Their causes are not yet known, however, gender-related differences in extracellular environment and hormonal status might be implicated.

Clinical and experimental observations suggest a possible difference in the female and male response to dietary NaCl (salt sensitivity) (3, 6). Healthy male students showed a significantly higher urinary Na^+ excretion than female ones (7). NaCl excretion in women and girls was lower than in men and boys by approximately 20–25% (8). Recently we have shown gender-related differences in Cl^- excretion in adolescents' urine (8).

Too little is known about gender-related physiological differences and a specific gender-related pathophysiology of blood pressure regulation. The present paper is intended as a contribution to the cognition of the physiology of Na^+ excretion in urine in relationship with blood pressure.

Our data showed that the overnight urinary Na^+ level in adolescent females during the follicular phase of their menstrual cycle was significantly lower than during the luteal phase. Compared with males, the overnight urinary Na^+/K^+ ratio exceeded the diurnal one in the general group of females as well as in females during the follicular phase of their menstrual cycle. Other investigators found the 24-hour-to-overnight Na^+ excretion ratio to be significantly lower in women than in men (9).

The lowest estrogen and progesterone levels in blood serum characterize the beginning of the follicular phase. Thus, estrogen and progesterone levels can influence Na^+ handling in the body. Basal plasma osmolarity was higher in men group and in women group in their early follicular phase than in women in the midluteal menstrual phase (10). The cotransport activity was lower in women during the follicular phase than in men (11). The $Na^+/K^+/2Cl^-$ cotransport was found to reach the lowest rates in ovulatory women and the highest ones in men (23). In contrast, other authors showed that the $Na^+/K^+/2Cl^-$ cotransport was not changed during the menstrual cycle (12).

Earlier we have shown that total diurnal and 24-h urinary Cl^- excretion in adolescent males was significantly higher than in girls during follicular phase (6). In the same pattern, no gender-related differences in Na^+ excretion, were found, either.

The differences observed in urinary Na^+ and Cl^- excretion can be related also to the activity of the Na^+ transport mechanism, whose differences are also known. It is possible that $Na^+/K^+/2Cl^-$ cotransporter is responsible for these differences. This relationship could be supported by the fact that Cl^- excretion is higher than Na^+ in all the groups studied.

The mean value of $Na^+/K^+/2Cl^-$ cotransport in red blood cells was higher in men than in women by 26–46% (13). The Na^+/H^+ exchange in mouse renal brush-border membranes exhibited marked gender-related differences, the Na^+/H^+ exchange activity in males having been higher than in females (13).

In both male and female urinary Na^+ exhibited a strong correlation with urinary Cl^-. Na^+ correlated with urinary K^+, but significantly weaker than with Cl^-, and there were gender differences: contrary to females, no correlation between urinary Na^+ and K^+ was found in males overnight urine. The gender-related difference in the overnight correlation between urinary Na^+ and K^+ was significant.

The observed differences in Na^+ concentration can influence the gender-related blood pressure differences. The overnight systolic and pulse BP was significantly higher in males than in females. This difference was noted between the general groups and persisted during all menstrual phases in females. Diurnal systolic, diastolic, and mean BP was significantly higher than nocturnal one in all groups. Diurnal pulse BP was significantly higher in males than in females during the follicular phase of their menstrual cycle.

Other showed that men had a higher systolic blood pressure than women in follicular and luteal phases (10). The blood pressure response to salt is comparable during the luteal and the follicular phases of the normal menstrual cycle and is characterized by a salt-resistant pattern of young women (14).

Na^+ excretion is closely related to Na^+ ion transport via $Na^+/K^+/2Cl^-$ cotransport (15), Na-Cl symport and indirectly via Na^+/H^+ exchanger, which linked to Cl^-/HCO_3^- exchanger (16, 17, 18). $Na^+/K^+/2Cl^-$ cotransport, Na^+/H^+ exchange and Cl^-/HCO_3^- exchange activities are directly related to an increase in arterial blood pressure (15, 16 , 17, 19, 20).

In total group of adolescent females, diurnal urinary Na^+ excretion negatively correlated with diastolic BP. In adolescent males such correlation was absent. On the contrary, no correlation between overnight urinary Na^+ excretion and BP was found in adolescent females, but it was positive in adolescent males.

Diurnal and overnight urinary Na^+ excretion exhibited a negative correlation with arterial BP (systolic, diastolic and mean) during the luteal phase of menstrual cycle in adolescent females. Such correlation was not found in the ovulation phase. In the follicular phase, arterial overnight BP (systolic, mean) was found to be in a significant negative correlation only with Na^+ of overnight urine.

Other investigators showed a significant inverse relationship between daily Na^+ excretion and systolic blood pressure, as well as between daily Na^+ excretion and diastolic blood pressure in premeno-

pausal women. Such a relationship disappeared after the menopause (21). The menopause status could confound the association between Na^+ excretion and blood pressure, and menstruation can have a protective action against the pressor effect of Na^+. The association between urinary Na^+ excretion and blood pressure tended to be more pronounced in older persons and postmenopausal women than in young menstruating women and young men (22, 23).

Gender-related BP regulation depending on NaCl dietary intake is known. A high dietary NaCl intake did not significantly increase the daytime or nighttime MAP in SHR and WKY female rats, but did increase the daytime and nighttime MAP in male SHR rats. The dietary NaCl supplementation has been associated with reduction in the daytime blood pressure in female WKY rats (24).

It is well known that Na^+ excretion is highly dependent on arterial blood pressure and kidney perfusion. Also, known are gender-related differences in kidney haemodynamics. The female kidney tends to be smaller, have a lower glomerular filtration rate (25). Sex-related differences in the pressure diuresis/natriuresis relationship in rabbits showed that urine flow, Na^+ excretion, and the fractional excretion of Na^+ increased with increasing renal artery pressure, and were greater in male than in female rabbits at all levels of renal artery pressure tested (26). In the kidney, effective renal plasma flow was significantly greater and the filtration fraction lower after salt loading in women studied in the luteal phase compared with women investigated in the follicular phase. Female hormonal status does not affect the blood pressure response to Na^+ in young normotensive women. In contrast with systemic haemodynamics, the renal response to salt varies during the normal menstrual cycle, suggesting that female sex hormones play a role in the regulation of renal haemodynamics (14).

In young normotensive women during the follicular and luteal phases of the menstrual cycle daytime BP did not depend on the cycle phase. The nocturnal fall in the 24-h mean, systolic and diastolic blood pressure was preserved in both groups during the follicular and luteal phases (27). In normotensive postmenopausal women, physiological doses of estradiol amplified the nocturnal decline of systolic, diastolic and mean blood pressure, whereas daytime blood pressure was not modified (27). The peculiarities of Na^+ excretion relation to arterial BP observed in girls at luteal phase can be determined by above mentioned gender-related haemodynamic/diuresis/natriuresis relationship, which coud be under genetic as well as sex-hormones regulation (14, 25, 26, 27).

The data of our studies show that the relation between Na^+ excretion in urine and arterial blood pressure in boys and girls is different. The circadian differences in this dependence are especially evident. The mechanisms of variations in such a gender-dependent circadian Na^+ excretion relation to BP are not yet clear. Na^+ and Cl^- both together could be involved in this regulation, since Cl^- but not other anions (bicarbonates, citrates, phosphates) tend to increase arterial BP. We may suggest that a harmonised action of numerous factors predetermines such a gender-related peculiarities of Na^+ as well as Cl^- excretion.

Furthermore, height and body weight significantly correlated with BP only in boys. The height in boys and not in girls is known to be related to the risk of arterial hypertension (28, 29). No significant correlation of 24-h urinary Na^+ with height, body weight, and body mass index was found. Elucidation of the separate factors and their effects on Na^+ metabolism as well as on changes in arterial BP related to the altered Na^+ metabolism would allow a better understanding of health status and the pathogenesis of essential hypertension in both men and women.

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References

1. Chen YF, Meng Q-Ch. Sexual dimorphism of blood pressure in spontaneously hypertensive rats is androgen dependent. Life Science 1991; 48: 85–96.
2. Davidson AO, Schork N, Jaques BC, Kelman AW, Sutcliffe RG, Reid JL, Dominiczak AF. Blood pressure in genetically hypertensive rats. Influence of the Y chromosome. Hypertension 1995; 26: 452–9.
3. Yagil Ch, Sapojnikov M, Kreutz R, Katni G, Lindpaintner K, Ganten D, Yagil Y. Salt susceptibility maps to chromosomes 1 and 17 with sex specificity in the Sabra rat model of hypertension. Hypertension 1998; 31: 119–24.
4. Klungel OH, de Boer A, Paes AHP, Seidell JC, Bakker A. Sex differences in the pharmacological treatment of hypertension: a review of population-based studies. Hypertension 1997; 15: 591–600.
5. Ely DL, Turner ME. Hypertension in the spontaneously hypertensive rat is linked to the Y chromosome. Hypertension 1990; 16: 277–81.
6. Stakisaitis D, Jankūnas R, Volbekas V. Sodium, gender, and blood pressure. A review. Medicina 2000; 1: 26–9.
7. Adams-Campbell LL, Nwankwo MU, Ukoli FA, Janney C. Sex and ethnic differences associated with urinary sodium and potassium in African-American US white and Nigerian college students. J Hum Hypertens 1993; 7: 437–41.
8. Jankūnas R, Milašius A, Stakisaitis D, Drižienė Ž, Kuliešienė I. Urinary chloride in adolescents: gender-related differences and relation to blood pressure. Acta Med Lituanica 2002; 1: 26–33.
9. Dyer AR, Stamler R, Grimm R et al. Do hypertensive patients have a different diurnal pattern of electrolyte excretion? Hypertension 1987; 10: 417–24.

10. Stachenfeld NS, Splenser AE, Calzone WL et al. Sex differences in osmotic regulation of AVP and renal sodium handling. J Appl Physiol 2001; 91: 1893–901.
11. M'Buyamba-Kabangu JR, Lijnen P, Lommeelen L. Physiologic variability of erythrocyte concentrations and transport of sodium and potassium. Presse Medicale 1986; 15: 871–5.
12. Monagham JC, Willcocks DA, Sinosich MJ, Stokes GS. Erythrocyte cation fluxes during the menstrual cycle in normal female subjects. Clin Sci 1987; 73: 223–6.
13. Mackovic M, Zimolo Z, Burckhardt G, Sabolic I. Isolation of renal brush-border membrane vesicles by a low-speed centrifugation; effect of sex hormones on Na^+/H^+ exchanger in rat and mouse kidney. Biochim Biophys Acta 1986; 862: 141–52.
14. Bertschi A, Maillard M, Stadler H et al. Blood pressure and renal haemodynamic response to salt during the normal menstrual cycle. Clin Sci (Lond) 2000; 98: 697–702.
15. Garay RP, Alvarez-Guerra M. Na-K-Cl cotransporters and "salt-sensitive" arterial hypertension. Arch Mal Coeur Vaiss 1999; 92(8): 1033–8.
16. LaPointe MS, Ye M, Moe OW, Alpern RJ, Batlle DC. Na^+/H^+ antiporter (NHE-1 isoform) in cultured vascular smooth muscle from the spontaneously hypertensive rat. Kidney Int 1995; 47(1): 78–87.
17. Stakisaitis D, LaPointe MS, Battle D. Intracellular chloride of lymphocytes and hypertension. J Investig Med 1998; 45: 324A.
18. Stakisaitis D, LaPointe MS, Batlle D. Mechanisms of chloride transport in thymic lymphocytes. Am J Physiol (Renal Physiol) 2001; 28: F314–F24.
19. Brosius FC 3rd, Pisoni RL, Cao X et al. AE anion exchanger mRNA and protein expression in vascular smooth muscle cells, aorta, and renal microvessels. Am J Physiol 1997; 273(6 Pt 2): F1039–47.
20. Brown RA, Chipperfield AR, Davis JP, Harper AA. Increased ($Na^+K^+Cl^-$) cotransport in rat arterial smooth muscle in deoxycorticosterone (DOCA)/salt-induced hypertension. J Vasc Res 1999; 36(6): 492–501.
21. Biosca G, Sanchez GR, Fernandez-Cruz A et al. Menopause status and blood pressure in the WHO cardiac study 1993; 194.
22. Elliott P, Dyer A, Stamler R. The INTERSALT study: results for 24 hour sodium and potassium, by age and sex. INTERSALT Co-operative Research Group. J Hum Hypertension 1989; 3: 323–30.
23. Funke E, Scieffer B, Baikie M et al. INTERSALT in Newfoundland and Labrador. Ann Nutr Metab 1990; 34: 253–8.
24. Calhoun DA, Zhu ST, Chen YF, Oparil S. Gender and dietary NaCl in spontaneously hypertensive and Wistar-Kyoto rats. Hypertension 1995; 26: 285–9.
25. Murray BM, Brown GP, Schoenl M. Interaction of gender and dietary protein on renal growth and the renal growth hormone-insulin-like growth factor axis. J Lab Clin Med 1998; 131: 360–69.
26. Evans RG, Stevenson KM, Bergstrom G et al. Sex differences in pressure diuresis/natriuresis in rabbits. Acta Physiol Scand 2000; 169: 309–16.
27. Cagnacci A, Rovati L, Zanni A et al. Physiological doses of estradiol decrease nocturnal blood pressure in normotensive postmenopausal women. Am J Physiol 1999; 276(4 Pt 2): H1355–60.
28. Lurbe E, Cremades B, Torro I et al. Gender modifies the relationship between awake systolic blood pressure and growth in adolescents. Am J Hypertension 1998; 11: 21A.
29. Duarte JA, Guerra SC, Ribeiro JC, Mota RC. Blood pressure in pediatric years (8–13 years old) in the Oporto region. Rev Cardiol Portugal 2000; 19: 809–820.

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NATRIS PAAUGLIŲ ŠLAPIME: PRIKLAUSOMYBĖ NUO LYTIES IR RYŠYS SU KRAUJOSPŪDŽIU

S a n t r a u k a

Norėdami nustatyti su lytimi susijusius arterinio kraujospūdžio (AKS) ir natrio išsiskyrimo skirtumus bei ryšį tarp jų, paaugliams (22 vaikinams ir 22 merginoms) tyrėme natrio koncentraciją šlapime ir kas valandą matavome AKS. Siekiant nustatyti galimą lytinių hormonų įtaką natrio išsiskyrimui ir AKS, stebėjome 15 paauglių merginų analogiškus rodiklius skirtingose menstruacinio ciklo fazėse. Natrio, chlorido ir kalio koncentraciją šlapime tyrėme jonams selektyvių elektrodų metodu elektrolitų analizatoriumi EML-105. AKS matavome automatiniu ambulatoriniu AKS monitoriumi AUTO-CUFF.

Vaikinų nakties sistolinis ir pulsinis AKS buvo aukštesnis negu merginų. Vaikinų dienos pulsinis AKS buvo aukštesnis negu merginų folikulinės fazės pradžioje. Visų tirtų grupių sistolinis, diastolinis ir vidutinis AKS dieną buvo aukštesnis negu naktį. Natrio koncentracija merginų nakties šlapime folikulinės fazės pradžioje buvo mažesnė negu ovuliacijos metu. Natrio ir kalio, taip pat natrio ir kreatinino kiekio merginų nakties šlapime santykis folikulinės fazės pradžioje buvo mažesnis negu ovuliacijos metu. Merginų (bendroje grupėje ir ovuliacijos fazėje) natrio ir kalio kiekio nakties šlapime santykis buvo didesnis negu dienos. Bendrose merginų ir vaikinų grupėse natrio ir kreatinino kiekio dienos šlapime santykis buvo didesnis negu nakties. Nustatyta stipri koreliacija tarp natrio ir chlorido kiekio šlapime. Natrio kiekis šlapime dažniausiai taip pat koreliuodavo su kalio kiekiu, tačiau silpniau negu su chlorido. Nenustatyta koreliacija tarp natrio ir kalio kiekio vaikinų nakties šlapime. Bendroje merginų grupėje natrio kiekis dienos šlapime atvirkščiai koreliavo su diastoliniu AKS, o vaikinams tokios koreliacijos nenustatyta. Naktį, priešingai, – koreliacija tarp natrio kiekio šlapime ir AKS nebūdinga merginoms, o vaikinams koreliacija tarp natrio kiekio šlapime ir sistolinio AKS buvo teigiama. Natrio kiekis merginų dienos ir nakties šlapime geltonkūnio fazėje atvirkščiai koreliavo su AKS. Ovuliacijos fazėje tokio ryšio nerasta.

Paauglių AKS, natrio kiekis šlapime ir ryšys tarp šių rodiklių yra susijęs su lytimi ir nuo paros ritmo priklausančiais pokyčiais organizme. Lytiniai hormonai gali dalyvauti reguliuojant AKS ir natrio išsiskyrimą su šlapimu.

Raktažodžiai: natris šlapime, arterinis kraujospūdis, paaugliai, su lytimi susiję skirtumai