The relationship between exposure to traffic noise and resting blood pressure in children and adolescents from Belgrade

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Summary

Contrary to numerous studies on noise and blood pressure in adults, similar investigations in children and adolescents are still scarce and with equivocal results. The aim of this study is to investigate the relationship between exposure to noise at school and at home and children's resting blood pressure. A cross sectional study was performed on 467 children and adolescents (203 boys and 264 girls) aged 11-15 years, from six elementary schools in Belgrade. A medical doctor measured children's resting blood pressure with sphygmomanometer in a school setting. Body mass index for age percentile was calulated after measurement of body mass and height. Noise was measured on the streets where children lived in one evening interval and in two night intervals and in front of each school in two daily periods (Leq school). Multiple regression analysis, after allowing for age, gender and BMI, shows that a 4.5 mmHg rise of systolic pressure may be expected per 10 dB increase of Leq school.

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1. Introduction

Urban road-traffic is a major environmental nuisance accounting for about 80 % of total urban noise pollution [1]. It affects about a quarter of EU population by exceeding the internationally accepted day-evening-night equivalent noise level (Lden) limit of 55 dB (A) in residential areas [2].

Among numerous extra-auditive effects of noise its relation to hypertension deserves special scientific attention as high blood pressure is related to life-threatening myocardial infarction, stroke and renal diseases [3]. Noise is a potent stressor that stimulates hypothalamic-pituitary-adrenal axis and sympathetic nervous system and reticular formation. If the consequent increases in the circulatory adrenaline, nor-adrenaline and cortisol are long-term this may permanently disturb blood pressure regulation [4]. Based on the large scientific body of evidence it has been estimated that the prevalence of hypertension in adults raises by 7% per 10 dB (A) increase of daytime road-traffic noise level [5].

However, the studies on noise exposure and blood pressure in children are still scarce and with equivocal results [6-14]. Our attitude expressed in our previous studies on this problem was that combined noise exposure at school and at home should be investigated as well as nighttime noise exposure, as children spend a larger part of their evening and nighttime sleeping at home than the adults [15]. Our research in Belgrade on preschool children [11] and schoolchildren aged 7-11 years [12-14] showed that nighttime noise exposure at home and daytime noise-exposure in schools were related to elevated children's blood pressure.

This study is the continuation of our previous similar investigations on younger children. We test whether noise exposure at home and at school affects blood pressure in schoolchildren and adolescents. The aims of our study are: to objectively estimate exposure to noise at home and at school of children from the center of Belgrade, to measure children's blood pressure and to investigate the noise-blood pressure relation taking into account relevant confounding factors.

2. Methods

2.1. Study sample

A cross-sectional study was performed on schoolchildren and adolescents aged 11–15 years, from six elementary schools in a central municipality of Belgrade. The children spend five to six hours daily in school starting from 8 a.m. Parental and children's written inform consent was obtained before participating in the study. Out of 950 delivered parental letters, approval was obtained for 632 children (67 %)**.** The inclusion criteria for the study sample were**:** living on the present address for three or more years, and the orientation of child's bedroom towards the streets. If chronic diseases affecting arterial blood pressure (diabetes mellitus and/or renal diseases) were present a child was excluded from the study. There were 160 and 5 children who did not meet the inclusion and exclusion criteria, respectively. The final sample included 467 children (203 boys and 264 girls) aged 13.0 ± 1.1 years (Mean ± SD).

2.2. Noise measurements

Equivalent noise levels (Leq) were recorded in the middle of all streets where children lived, once during evening (between 6 p.m. and 8 p.m.) and twice during night (between 10 p.m. and 12 p.m., and between midnight and 2 a.m.). In front of six elementary schools measurements were performed in two daily periods (between 9 a.m. and 11 a.m. and between noon and 2 p.m.). Each noise recording lasted 15 minutes. We used a Hand-Held noise level analyzer type 2250 "Brüel and Kjær" according to the recommendations of the International Standard Organization for the measurement of community noise [16]. From the obtained Leq a composite evening- night Leq was calculated for each street and a daytime Leq for each school.

During noise measurements the numbers of light and heavy vehicles were registered on the streets were children lived and in front of the schools.

2.3. Anthropometrics

Child's body height and weight were measured in the morning, in light clothes, without shoes. Software available on the website of the Centers for Disease Control and Prevention (http://nccd. cdc.gov/dnpabmi/ Calculator.aspx) was used to calculate body mass index-for-age percentile [17].

2.4. Blood pressure measurement

Children's blood pressure was measured with mercury sphygmomanometer. Cuff sizes 7.5 cm × 19.5 cm or 11 cm × 27 cm were used according to arm measurement criteria [18]. The measurements were performed after a 15 minute rest, in a sitting position, with a child's right arm at heart level. Two measurements were performed on the right arm with five-minute interval. If the difference between measurements exceeded 5 mmHg, the third measurement was performed and mean values of systolic and diastolic arterial blood pressure were calculated.

2.5. Statistical analysis

Pearson correlation analysis was performed to test the association between variables from the questionnaire and children's blood pressure. Based on the results of univariate analyses, variables significantly related to blood pressure were included in a multiple linear regression.

3. Results

Concerning basic sociodemographic data, maternal and paternal education were predominantly university and secondary level (45% and 39%, respectively). The majority of mothers and fathers were employed (84% and 91%, respectively). Most of the children lived with both parents (82%). For 18% of the families monthly income was insufficient to cover basic needs. Average apartment area per dweller was satisfactory (18.8 m^2) and the mean period of residence was 13 years.

The results of noise measurements showed that Leq evening-night at home ranged from 51.9 to 83.7 dB (A) with the Mean ± SD values of 64.8±7.8 dB (A). Noise measurements at schools showed that outdoor L day levels ranged from 55.0 -72.3 dB (A) and the average values were 64.6±7.0 dB (A).

As expected, traffic flow was about 13 times higher during day in front of schools compared to evening night period on the streets where children lived (Table I).

Table I. Traffic flow in front of children's homes (evening/night) and schools (day) (vehicles/hour; Mean ± SD)

Vehicles	*Home*	*School*
Light	184±261	827±871
Heavy	11±22	65±82

High correlation coefficients between traffic flow indicators and noise levels at children's home and at school pointed to road traffic as the major source of children's noise exposure (Table II).

Table II. Pearson correlation coefficients between traffic flow indicators and noise levels on the streets where children live (Leq home) and in front of schools (Leq schools).

Vehicles	*Leq home*	*Leq school*
Light (per hour)	0.68*	0.73*
Heavy (per hour)	0.65*	0.76*

** P < 0.01

Correlation analysis pointed that age, gender and BMI percentile were relevant variables to be included in multiple regression between noise exposure indicators and children's blood pressure (Table III).

Table III. Correlation coefficients between noise exposure at home and at school and sociodemographic variables and children's blood pressure (N=467)

Variable	*Systolic*	*Diastolic*
Age (months)	0.23**	0.19**
Gender (m=1; f. =2)	-0.18**	-0.02
BMI percentile	0.48**	0.34**
Monthly income (1= insufficient; 2 = sufficient)	-0.01	-0.02
Leq (home)	0.14**	0.01
Leq (school)	0.22**	0.01

*P < 0.05; ** P < 0.01 (Pearson's correlation)

Multiple regression shows that noise exposure at school is a significant independent predictor of children's systolic pressure when adjusted for age, gender and BMI percentile. Noise exposure at home and at school are not significantly related to children's diastolic pressure. (Tables IV and V).

Table IV. Multiple regression between indicators of noise exposure and other relevant predictors (independent variables) and children's **systolic pressure** (dependent variable) / N = 467/

Independent variable	*B*	*Std. Error*	*t*	*P*	*95% CI for B*
Leq school (per dB)	0.45	0.09	4.73	< 0.001	0.26 – 0.63
Leq home (per dB)	-0.10	0.07	-0.14	0.891	-0.15 – 0.13
Age (per month)	0.20	0.03	6.26	< 0.001	0.13 – 0.26
BMI (per percentile)	0.18	0.01	11.60	< 0.001	0.14 – 0.20
Gender	-1.99	0.89	-2.24	0.026	-3.73 – -0.24
(Constant)	41.65	9.00	4.63	< 0.001	23.97 – 59.33

Table V. Multiple regression between indicators of noise exposure and other relevant predictors (independent variables) and children's **diastolic pressure** (dependent variable) / N = 467/

Independent variable	*B*	*Std. Error*	*t*	*P*	*95% CI for B*
Leq school (per dB)	0.03	0.09	0.36	0.718	0.26 – 0.63
Leq home (per dB)	-0.03	0.06	-0.54	0.590	-0.12 – 0.18
Age (per month)	0.12	0.03	4.85	< 0.001	0.07 – 0.17
BMI (per percentile)	0.11	0.01	8.83	< 0.001	0.08 – 0.13
Gender	0.75	0.72	1.04	0.297	-0.67 – -2.17
(Constant)	36.91	7.32	5.04	< 0.001	22.52 – 51.31

Discussion

Children are exposed to relatively high average levels of noise both at home (evening/night) and at school (day), exceeding by 20 dB and 15 dB the respective limits from Serbian regulations of 45 dB (A) and 50 dB (A) Leq, respectively [19]. This finding is typical for the center of Belgrade with rather narrow streets and a high traffic flow.

We show that a 10 dB (A) increment of noise exposure at school is related to a 4.5 mmHg increase of children's systolic pressure when adjusted for relevant confounders.

In our two previous studies on schoolchildren systolic blood pressure was related to noise exposure, while diastolic pressure was not [12,14]. In our third study on schoolchildren aged 7-11 years both systolic and diastolic pressure were significantly related to Leq in front of schools (B = 0.57 and 0.11, respectively /per dB)/ [13]. These results support the attitude that additive effect on blood pressure of noise exposure at home and at school may be expected.

Our findings are congruent with the results of a study on German children aged 8-14 years in which significant increases of systolic and diastolic pressure were found per 10 dB (A) increment of traffic noise level in front of children's home (1mm Hg and 0.6 mmHg, respectively) [10]. In the Inn Valley study on schoolchildren from the fourth grade a borderline significant difference was found between average resting systolic pressure of children exposed to day/night noise levels exceeding 60 dB compared to less noise exposed children (Ldn < 50 dB) [7]. However, in the study on schoolchildren from London and Amsterdam the relation between road-traffic noise and children's systolic pressure was negative while nighttime aircraft noise was positively and significantly related to children's systolic pressure [9]. In the Tyrol study on children aged 8-12 years no significant relationship between highway noise and children's blood pressure was found [8]. It seems that children's bedroom window orientation plays an important role in moderating the effect of noise on children's blood pressure. In a study on German children aged 10 years it was shown that children's bedroom window orientation towards the street raised the strength of the relation between both diastolic and systolic pressure with minimum Lden

and Lnight [20]. Similarly, after adding the orientation of bedroom towards the street as an inclusion criterion in a study on African-American schoolchildren there was a positive relation between noise levels at homes and children's systolic pressure [21].

Although changes in children's blood pressure provoked by noise might be insignificant from the clinical point of view we consider these investigations important because even small elevations of blood pressure in childhood may predict hypertension in adults [22].

In our opinion, the obvious heterogeneity of the results in the studies on the effect of noise on children's blood pressure may be abated by simultaneous investigating noise exposure both at home and at school, by adopting recommendations for children's blood pressure measurements in field studies [23] and by adding bedroom orientation toward the street as an inclusion criterion.

Conclusions

Noise exposure at school might be significantly related to elevated systolic blood pressure in schoolchildren. We recommend some method improvements in order to abate the present heterogeneity of the results of similar studies.

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