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The impact of repeated blood pressure measurements on detecting hypertension in children and youths

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Summary

Study aim: To examine the differences between the second and first measurements of blood pressure and to show the necessity of designing a standardised protocol.
Material and methods: Anthropometric data of 1618 children were assessed. Blood pressure and heart rate values were determined twice after 5-min sitting with a sphygmomanometer (Omron M5-I, Germany). The differences between the second and first measurements were assessed using Student's *t*-test.
Results: A group of 921 boys and 697 were studied. Mean systolic blood pressures in the first and second measurements were 124.9 ± 15.7 and 121.4 ± 14.9 mm Hg, respectively, mean diastolic blood pressures – 78.0 ± 13.6 and 76.0 ± 12.4 mm Hg, respectively, the between-measurement differences being highly significant ($p<0.001$). No significant differences were noted for the heart rate. The prevalence of hypertension assessed from the first and second measurement was 23.9 and 4.4 %, respectively.
Conclusion: The results point to the indispensability of designing a valid, standardised protocol of conducting blood pressure measurements in paediatric epidemiological studies.

Keywords: Hypertension – Repeated blood pressure measurement – Children – Youths

Introduction

The importance of blood pressure measurements already in childhood and adolescence, as a key factor in the diagnostics of hypertension, is undisputed [17] but no common consensus exists as to the measuring methodology, and especially the frequency and time intervals between the measurements, considering the diverse blood pressure reference values in children and adolescents [8,9,17].

Several international studies were devoted to repeated blood pressure measurements. Sorof *et al*. [22] showed that the prevalence of hypertension among school-aged children decreased from the first to the third screening from 19.4 to 4.5 %. Adrogué and Sinaiko [1] observed a decrease of systolic hypertension from 2.7 to 0.8% between the first and second screenings. In addition to these findings, the prevalence of hypertension from the first to the second blood pressure measurements was reported to vary by 11.7% (cf. [4]).

Children with hypertension are very likely to be regarded as hypertensive adults [10]. Hypertension is an important and independent predictor of cardiovascular risk and ranks under the prominent causes for morbidity and mortality world-wide in the adult age [13]; it has become clear that also childhood hypertension could contribute to an early development of atherosclerosis and other cardiovascular diseases [5]. Multiple studies showed a correlation between the relative blood pressure in children and adolescents, and that in adults [2,12,14].

In the national and international guidelines, routine blood pressure measurements are recommended within the preventive medical examinations in children, as an early recognition of increased blood pressure may prompt appropriate changes in the health-related behaviour as early as possible and possibly introduce the necessary treatment measures; the diagnosis of hypertension depends on accurate blood pressure measurements [17,23]. The aim of this study was thus to examine the difference between two consecutive blood pressure measurements.

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Material and Methods

Subjects: A group of 1618 schoolchildren (921 boys and 697 girls) aged 10 – 18 years, from 5 randomised clusters of secondary schools in the Rhineland-Westphalia region (Germany) were studied.

Methods: Body height and mass were measured by the same investigator throughout the study using a free-standing seca-stadiometer, 0.5 kg being deducted for the light clothing. The BMI was computed and classified according to the German percentile graphs [11]. Systolic and diastolic blood pressures and heart rate were measured on the left arm by trained investigators using a sphygmomanometer (Omron M5-I, Germany) recommended by the European Society of Hypertension [19]. After a 5-min rest in sitting position with the device on the arm, two measurements were taken 5 min apart. The size of the cuff was adjusted to the circumference of the arm as recommended by Rascher [20].

The definition of hypertension was based on the normative distribution of blood pressure in healthy children of 6 European countries [6] classified by gender, age and body height. Hypertension was defined as the mean blood pressure equal to or above the 95th percentile for age, gender and height.

Data analysis: The gender-related differences in blood pressure (systolic, SBP and diastolic, DBP) and heart rate (HR) were assessed by Student's *t*-test for independent data and the individual differences between the first and second measurements by the *t*-test for dependent data. Two-way ANOVA (age×measurement) with the *post-hoc* Student's *t*-test was used to compare mean values for age categories. Chi-square test was used to compare the predicted prevalence of hypertension (PHT), the level of $p \leq 0.05$ being considered significant in all cases. The analyses were performed with the use of the SPSS 16.0 software.

Results

Mean values (±SD) and ranges of body height and mass and of BMI are shown in Table 1 and those of blood pressure, heart rate and the predicted prevalence of hypertension in Table 2. According to the National BMI norms, 4.6% of all subjects were classified as underweight, 14.8% as overweight, and 14.8% as obese. No significant gender-related differences were found for age or BMI.

Table 1. Mean values (±SD and ranges) of anthropometric data in boys and girls aged 10 – 18 years

	Boys (n = 921)	Girls (n = 697)
Age (years)	14.2 ± 1.7 (10.5 – 17.9)	14.1 ± 1.8 (10.0 – 17.9)
Body height (cm)	165.4 ± 11.8 (134 – 194)	159.5 ± 8.6 (130 – 182)
Body mass (kg)	60.8 ± 16.3 (26.7 – 132.0)	56.7 ± 14.7 (24.5 – 140.0)
BMI	21.9 ± 4.5 (13.2 – 48.7)	22.1 ± 4.7 (13.3 – 49.6)

Table 2. Mean values (±SD) of the systolic (SBP) and diastolic (DBP) blood pressure, heart rate (HR) and the predicted prevalence of hypertension (PHT) in two measurements, 5 min apart, performed in schoolchildren aged 10 – 18 years

	Boys (n = 921)		Girls (n = 697)	
Measurement	1st	2nd	1st	2nd
SBP (mm Hg)	126.7 ± 16.1	123.0 ± 15.2***	122.6 ± 14.8 ^{ooo}	119.3 ± 14.2*** ^{ooo}
DBP (mm Hg)	79.6 ± 14.1	76.3 ± 13.0***	78.1 ± 12.8 ^{o}	75.6 ± 11.6***
HR (bpm)	85.2 ± 15.2	85.5 ± 14.7	88.4 ± 15.3 ^{ooo}	88.7 ± 15.1 ^{ooo}
PHT (%)	23.5	0.0***	24.4	10.3*** ^{ooo}

Significantly different from the first measurement (by *t*-test for dependent data): *** $p<0.001$; Significantly different from the respective value in boys (by *t*-test for independent data): ^{o} $p<0.05$; ^{ooo} $p<0.001$; Significances of the PHT data assessed by the chi-square test

Mean differences between the second and first blood pressure measurements ranged from 2.5 to 3.7 mm Hg (2.9 – 4.1%). Girls attained significantly lower values in SBP in both measurements (by about 4 mm Hg or 3.1%; $p<0.001$) and in DBP only in the first measurement (by 1.5 mm Hg or 1.9%; $p<0.05$). Conversely, girls attained significantly ($p<0.001$) higher heart rates in both measurements (by nearly 3.5 bpm or 4%). The prevalence of

hypertension predicted from the first measurement was in boys and girls alike and amounted to about 24%, and markedly decreased in the second measurement – to zero in boys and to 10.3% in girls ($p<0.001$) as shown in Table 2. The relations of the systolic and diastolic blood pressure to age showed a progressive increase ($p<0.001$) the between-measurement differences being significantly lower in every age category (Fig. 1)

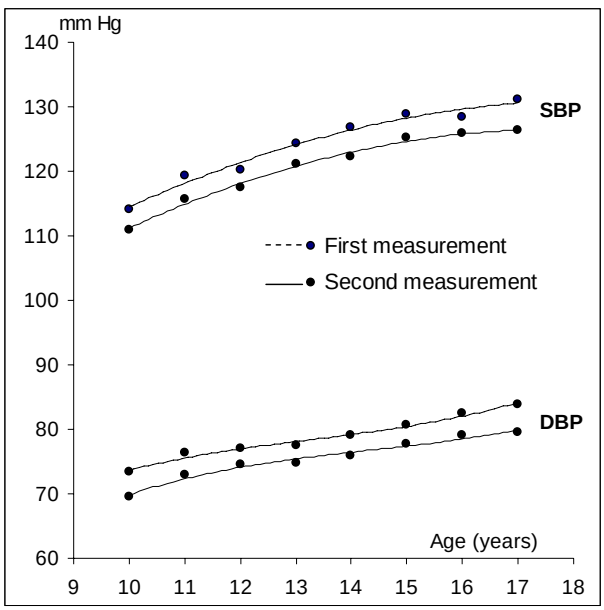


Fig. 1. Mean values of the systolic (SBP) and diastolic (DBP) blood pressures *versus* age in schoolchildren aged 10 – 18 years (n = 1618)

Discussion

In epidemiological studies, blood pressure values are frequently described in relation to several screenings or visits [1,22]. Our objective was to present the impact of the second blood pressure measurement following a defined break during a single visit.

On the whole, the systolic blood pressure in the second measurement was by about 3.5 mm Hg lower than in the first one 5 min earlier throughout the age range, and the diastolic one by about 2.9 mm Hg ($p<0.001$). In effect, false positive blood pressure values were reduced from 23.9 to 4.4 %, respectively. Similar results were reported by Sorof *et al*. [22] who showed the prevalence of hypertension decreasing from 19.4 to 4.5% between the first and third screenings among school-aged children and by McNiece *et al*. [15] who observed a decrease of hypertension from 9.4 to 3.2% between the first and third screenings. In those studies, the time interval between screenings was as high as several weeks, in contrast to our measurements spaced by 5 min. According to the Fourth Report published by the National High Blood Pressure Education Program (NHBPEP) [17], the hypertension in children is defined as average systolic and/or diastolic blood pressure equal to or exceeding the 95th percentile for sex, age, and height on three or more occasions. Gillman and Cook [8] recommended that at least 3 measurements should be made in epidemiological studies on at least two separate visits as they found blood pressure significantly decreasing at subsequent visits. In the present study, the decision to make one visit and two measurements goes partially against the above recommendation but it was made for practical reasons. Generally, in a large-scale study with a large number of children, multiple visits are not feasible for temporal and economic reasons. Yet, a single visit with two blood pressure measurements, proved equally effective compared with several visits, as the second measurement substantially reduced the incidence of false positive values.

No guidelines were found in the available literature regarding the ideal frequency and accurate time interval between blood pressure measurements, the time intervals between measurements varying from 30 s [1] or one minute [22] to 10 min [3]. In a study of Borges et al. [3], 3 measurements at 10-min intervals were made during a single visit, the consecutive values significantly decreasing and the prevalence of hypertension dropping from 8.7 down to 2.3%. The decision to choose a longer time interval between two measurements could have several benefits. The children could get used to the situation, their cardiovascular system could become steady and the measurement-related stress could be reduced. From the medical point of view, measuring blood pressure on both arms, the time interval amounting to several minutes in order to prevent the carry-over effect of the preceding measurement, seems reasonable. Apart from time spacing, the frequency of measurements varies as well from one to 3 measurements during a visit. We decided on measuring blood pressure twice instead of the triple recommended for adults. During the 3 measurements in children, the prevalence of hypertension predicted from the third measurement did not differ significantly from the second one and this finding makes the necessity of making the third measurement questionable [3].

The increases of both systolic and diastolic blood pressure with age found in this study are consistent with other reports on schoolchildren in national [18] and international [2,6] comparisons. The available evidence suggests that childhood hypertension could contribute to an early development of cardiovascular diseases [5] and that elevated blood pressure levels persisted over time and progressed to adult hypertension [2]. For this reason,

it is important to monitor blood pressure in early life. Silverman *et al*. [21] analysed the frequency of blood pressure measurements in children in emergency departments in USA. Adolescents had their blood pressure measured more frequently (93%) than those 2 – 12 years old (78%) or 1 – 24 months olds (35%). It was shown that the frequency of blood pressure measurements increased with age. In a study of Gilhotra and Willis [7], 114 out of 504 children aged 1 month to 18 years had their blood pressure measured in emergency departments in Australia. In total, 35 subjects (30.7%) exceeded the 95th percentile but only 19 of them had their blood pressure re-measured. These examples show that blood pressure measurements in the childhood are inconsistent, factors like inappropriate cuff sizes, lacking co-operation of the children, no trained medical personnel etc., being likely to be the reason.

Moreover, a comparison of reference values across several countries showed them to differ. The values for European children differ from the American ones; pooled information from 6 European studies showed that the 95th percentile for SBP was by 6 mm Hg and for DBP by 3 mm Hg higher in both sexes compared with U.S. values [6]. Menghetti *et al*. [16] found that normal values for blood pressure for Italian children differed from the American as well as from de Man´s [6], the 95th percentile values being by 3 and 8 mm Hg higher for SBP and DBP, respectively, in both sexes between 5 and 12 years of age, and by 2 – 3 mm Hg higher in older males [16]. This emphasises that in addition to standardising the measurement methodology, consistent blood pressure values have to be established.

Summing up, accurate blood pressure measurements are the key in the diagnosis of childhood hypertension. Second measurement is meaningful and seems to reflect blood pressure levels closer to the basal ones. Repeated blood pressure measurements early in life improve the prediction of adult hypertension. The results of this study confirm the necessity of a second blood pressure measurement during an examination. Nevertheless, the consistent blood pressure values ought to be established and measurement methodology standardised.

References

1. Adrogué E, A.R.Sinaiko (2001) Prevalence of hypertension in junior high school-aged children: effect of new recommendations in the 1996 Update Task Force Report. *Am.J.Hypertens.* 14:412-414.

2. Bao W, A.S.Threefoot, S.R.Srinivasan, G.S.Berenson (1995) Essential hypertension predicted by tracking of elevated blood pressure from childhood to adulthood: the Bogalusa Heart Study. *Am.J.Hypertens.* 8:657-665.

3. Borges L.M.P., M.A.Peres, B.L.Horta (2007) Prevalence of high blood pressure among schoolchildren in Cuiabá. *Midwestern Brazil. Rev.Saúde.Pública* 41:530-538.

4. Chadha S.L., R.Tandon, S.Shekhawat, N.Gopinath (1999) An epidemiological study of blood pressure in school children (5-15 years) in Delhi. *Indian.Heart.J.* 51:178-182.

5. Daniels S.R. (2002) Cardiovascular sequelae of childhood hypertension. *Am.J.Hypertens.* 15:61S-63S.

6. De Man S.A., J.L.André, H.Bachmann, D.E.Grobbee, K.K. Ibsen, U.Laaser, P.Lippert, A.Hofman (1991) Blood pressure in childhood: pooled findings of six European studies. *J.Hypertens.* 9:109-114.

7. Gilhotra Y., F.Willis (2006) Blood pressure measurement on children in the emergency department. *Emerg.Med.Austral.* 18:148-154.

8. Gillman M.W., N.R.Cook (1995) Blood pressure measurement in childhood epidemiological studies. *Circulation* 92: 1049-1057.

9. Graves J.W., M.M.Althaf (2006) Utility of ambulatory blood pressure monitoring in children and adolescents. *Pediatr. Nephrol.* 21:1640-1652.

10. Kay J.D., A.R.Sinaiko, S.R.Daniels (2001) Pediatric hypertension. *Am.Heart.J.* 142:422-432.

11. Kromeyer-Hauschild K., M.Wabitsch, F.Geller, A.Ziegler, H.Geiß, V.Hesse, v. Hippel, U.Jaeger, D.Johnson, W.Kiess, W.Korte, D.Kunze, K.Menner, M.Müller, A.Niemann-Pilatus, T.Remer, F.Schaefer, H.U.Wittchen, S.Zabransky, K.Zellner, J.Hebebrand (2001) Perzentile für den Body Mass Index für das Kindes- und Jugendalter unter Heranziehung verschiedener deutscher Stichproben. *Monatsschr.Kinderheilkd.* 8:807-818.

12. Lauer R.M., M.D.William, W.R.Clarke, L.T.Mahoney, J.Witt (1993) Childhood predictors for high adult blood pressure: the Muscatine Study. *Pediatr.Clin.North.Am.* 40:23-40.

13. Lopez A.D., C.D.Mathers, M.Ezzati, D.Jamison, C.J.L. Murray (2006) Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. *Lancet* 367:1747-1757.

14. Lurbe E., R.Cifkova, J.K.Cruickshank, M.J.Dillon, I.Ferreira, C.Invitti, T.Kuznetsova, S.Laurent, G.Mancia, F.Morales-Olivas, W.Rascher, J.Redon, F.Schaefer, T.Seeman, G.Stergiou, E.Wühl, A.Zanchetti (2009) European Society of Hypertension. Management of high blood pressure in children and adolescents: recommendations of the European Society of Hypertension. *J.Hypertens.* 27:1719-1742.

15. Mc Niece K.L., T.S.Paffenbarger, J.L.Turner, K.D.Franco, J.M.Sorof, R.J.Portman (2007) Prevalence of hypertension and pre-hypertension among adolescents. *J.Pediatr.* 150:640-644.

16. Menghetti E., R.Virdis, M.Strambi, V.Patriarca, M.A.Riccioni, E.Fossali, A.Spagnolo (1999) Blood pressure in children and adolescence: the Italian normal standards. *J.Hypertens.* 17: 1363-1371.

17. National High Blood Pressure Education Program Working Group on high blood pressure in children and adolescents (2004) The Fourth report on the diagnosis, evaluation and treatment of high blood pressure in children and adolescents. *Pediatrics* 114(Suppl. 2, 4th Report):555-576.

18. Neuhauser H., M.Thamm (2007) Blood pressure measurement in the German Health Interview and Examination Survey for Children and Adolescent (KiGGS). Methodology and initial results. *Bundesgesundheisbl.-Gesundheitsforsch.-Gesundheitsschutz* 50:728-735.

19. Omboni S., I.Riva, A.Giglio, G.Caldara, A.Groppelli, G.Parati (2007) Validation of the Omron M5-I, R5-I and HEM-907 automated blood pressure monitors in elderly individuals

according to the International Protocol of the European Society of Hypertension. *Blood Pressure Monitoring* 12:233-242.

20. Rascher W. (1997) Blood pressure measurement and standard in children. *Nephrol.Dial.Transplant*. 12:868-870.

21. Silverman M.A., A.R.Walker, D.D.Nicolaou, M.J.Bono (2000) The frequency of blood pressure measurement in children in four EDs. *Am.J.Emerg.Med*. 18:784-788.

22. Sorof J.M., D.Lai, J.Turner, T.Poffenbarger, R.J.Portman (2004) Overweight, ethnicity, and the prevalence of hypertension in school-aged children. *Pediatrics* 113:475-482.

23. Leitlinien für die Prävention, Erkennung, Diagnistik und Therapie der arteriellen Hypertonie der Deutschen Liga zur Bekämpfung des hohen Blutdrucks e.V. (2003) AWMF Leitlinien-Register Nr. 046/001 (http://leitlinien.net/).

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