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AUTONOMIC CONTROL OF THE HEART IN RELATION TO ANTHROPOMETRIC CHARACTERISTICS IN CHILDREN AND ADOLESCENTS

NOVÁKOVÁ Z.[1], FIŠER B.[1], HONZÍKOVÁ N.[1], ZÁVODNÁ E.[1], HRSTKOVÁ H.[2], HAK J.[3], VÁCLAVKOVÁ P.[2]

[1]Department of Physiology and [2]Department of Paediatrics, Faculty of Medicine, Masaryk University, Brno
[3]Paediatric Health Centre, Luhačovice, Czech Republic

A b s t r a c t

The aim of this paper was to study the relation of baroreflex sensitivity, expressed in ms/mmHg (BRS) and Hz/mmHg (BRSf), to age and anthropometric characteristics, i.e., body height, weight and body mass index (BMI), in normotensive children and normotensive and hypertensive adolescents. We examined 185 healthy normotensive children aged 11 to 15 years (group A), 116 normotensive adolescents (group B), and 11 hypertensive adolescents whose mean 24-hour systolic blood pressure was less than 125 mmHg (group H). BRS and BRSf were determined by the spectral analysis of blood pressure and pulse interval variability (PI) and their values were related to age and each of the anthropometric characteristics by Spearman's correlation coefficient. Differences among the groups were compared by means of the Mann-Whitney test. BRS did not correlate with age; it correlated positively with height in group B and with PI in all three groups. BRSf correlated negatively with age, height and weight in group A and with BMI and PI in group B. The finding of higher weight and BMI values in the hypertensives was in agreement with the assumption that adipose tissue is involved in the development of hypertension.

K e y w o r d s

Age, Baroreflex sensitivity, Anthropometric parameters, Spectral analysis

INTRODUCTION

The baroreceptor reflex is a powerful mechanism involved in the beat-to-beat regulation of arterial pressure by a negative feedback mechanism. In addition to responding to changes in arterial pressure, the baroreflex also provides tonic inhibition of sympathetic activity and tonic excitation of parasympathetic activity, as reflected in the mean arterial blood pressure. Tonic inhibition and excitation are important regulatory mechanisms in both normal and pathological states (*1*).

Many studies have been performed to explain the role of a decreased baroreflex sensitivity in patients after myocardial infarction (*2*) or in the development of hypertension in adults (*3*). On the other hand, the role of baroreflex sensitivity in a developing organism, i.e., in children and adolescents,

has not yet been investigated profoundly. This is understandable because the method commonly used for baroreflex sensitivity estimation employed an invasive phenylephrine approach and therefore, for ethical reasons, was not suitable for children (*4*).

The assessment of baroreflex sensitivity developed at our department is based on non-invasive, beat-to-beat recording of spontaneous variability in pulse intervals and blood pressure. In this study, we investigated normotensive children and normotensive and hypertensive adolescents in order to find out relationships between their age and baroreflex sensitivity when anthropometric characteristics, i.e., body height, weight and body mass index (BMI), were taken into consideration.

MATERIALS AND METHODS

Normotensive subjects were placed into two groups. Group A consisted of 185 children, 98 girls and 87 boys, between 11 and 15 years of age and group B comprised 116 normotensive adolescents, 55 girls and 66 boys, aged 16 to 19 years. These subjects were further distributed into subgroups, each involving children or teenagers of the same age. The numbers of subjects in the respective age subgroups were as follows: 11yr/34, 12yr/30, 13yr/31, 14yr/41, 15yr/49, 16yr/30, 17yr/28, 18yr/33, 19yr/25.

Adolescents were diagnosed as hypertensive when, on three different occasions at least one week apart, their casual systolic blood pressure was found by their physicians to be higher than 140 mmHg. Twenty four of them were investigated by ambulatory blood pressure monitoring and those whose 24-hour mean systolic blood pressure was higher than 125 mmHg were further studied (group H, 11 subjects). This approach was based on the Guidelines for the Management of Hypertension (*5*).

Ambulatory blood pressure monitoring

Blood pressure was monitored for 24 h by an oscillometric device (Space Lab International) carried by each hypertensive subject. The cuff was applied to the non-dominant arm and the subjects were instructed to relax the arm during measurement; this was made every 10 or 15 min during the daytime and every 30 min at night. In each adolescent, at least 40 recordings were made in the 24-hour period.

Baroreflex sensitivity determination

Blood pressure and pulse intervals were recorded on finger arteries by non-invasive, continuous measurement (Finapres, Ohmeda) during a five-minute interval in the morning. The subjects were examined in a sitting, resting position. Their breathing was synchronised by a metronome to be 20 breaths per minute (0.33 Hz) and they were advised to adjust the tidal volume to be comfortable.

Beat-to-beat values of systolic pressure (SBP) and pulse intervals (PI) were obtained for further analysis. Baroreflex sensitivity determined by the spectral analysis of spontaneous variability in SBP and PI was expressed in ms/mmHg and designated BRS (*6*); baroreflex sensitivity based on the spectral analysis of spontaneous variability in SBP and heart rate was expressed in Hz/mmHg and designated BRSf (*7*).

Anthropometric characteristics included height expressed in metres, weight in kilograms and body mass index calculated from the formula: $BMI = \text{weight [kg]}/(\text{height [m]})^2$.

Statistical analysis

Spearman's correlation coefficients were calculated between pairs of selected parameters (BRS, BRSf, age, PI, height, weight and BMI). Differences in the mean values of all the selected parameters were compared among the three groups by means of the Mann-Whitney test.

RESULTS

The mean height of age subgroups was compared and a significant increase (P<0.05) was found in 11yr to 15yr subgroups. From 15 years on, there was no difference in height when the adolescent subgroups were compared and, therefore, the age of 16 was taken to divide the normotensive population into groups A and B (*Table 1*). A statistically significant increase in PI (P<0.01) was found in group B when compared with group A. The values of weight and BMI were significantly higher in the hypertensive (group H) than in the normotensive (group B) adolescents (P<0.01). Correlations between baroreflex sensitivity (both BRS and BRSf) and each of the parameters, i.e., age, PI and anthropometric characteristics, are shown in *Tables 2* and *3*. BRS did not correlate with age in any of the groups but it correlated positively with height in group B (P<0.01) and with PI in all groups (groups A and B, P<0.01; group H, P<0.05). BRSf correlated negatively with age, height and weight in group A (P<0.01) and with BMI and PI in group B (P<0.01).

Table 1

Characteristics of age groups

Parameters	Normotensives 11 to15 years old (n=185)	Normotensives 16 to19 years old (n=116)	Hypertensives 16 to 19 years old (n=11)
Pulse interval (ms)	709±115	773±123 **	734±120
BRS (ms/mmHg)	10.4±5.7	10.3±5.4	8.8±4.2
BRSf (Hz/mmHg)	0.0196±0.008	0.0171±0.008	0.0160±0.006
Weight (kg)	54±14	67±11 **	83±13 ++
Height (cm)	163±12	174±8 **	176±6
BMI (kg/m^2)	19.9±4.1	21.9±3.2 **	26.4±4.4 +

Values are presented as mean ± standard deviation; BRS and BRSf, baroreflex sensitivity in ms/mmHg and Hz/mmHg, respectively; BMI, body mass index ; ** , A versus B, P < 0.01; ++, B versus H, P < 0.01 (statistical evaluation by the Mann-Whitney test)

Table 2

Correlations between BRS and each of the selected parameters

Parameter	Group A		Group B		Group H	
	R	P	R	P	R	P
Age	0.019	NS	0.080	NS	-0.180	NS
Height	0.002	NS	0.260	< 0.01	-0.043	NS
Weight	0.014	NS	0.098	NS	-0.080	NS
BMI	-0.017	NS	-0.090	NS	-0.070	NS
PI	0.53	< 0.01	0.39	< 0.01	0.27	< 0.05

R, Spearman's correlation coefficient; P, level of statistical significance; BMI, body mass index; PI, pulse intervals; NS, not significant. Groups A and B had physiological levels of blood pressure. In group H, a 24-hour blood pressure value was higher than 125 mmHg.

Table 3

Correlations between BRSf and each selected parameter

Parameter	Group A		Group B		Group H	
	R	P	R	P	R	P
Age	-0.25	< 0.01	-0.09	NS	-0.1	NS
Height	-0.22	< 0.01	0.16	NS	-0.28	NS
Weight	-0.19	< 0.01	-0.11	NS	0.03	NS
BMI	-0.11	NS	-0.27	< 0.01	0.12	NS
PI	-0.06	NS	-0.29	< 0.01	-0.05	NS

R, Spearman's correlation coefficient; P, level of statistical significance; BMI, body mass index; PI, pulse intervals; NS, not significant. Groups A and B had physiological levels of blood pressure. In group H, a 24-hour blood pressure value was higher than 125 mmHg.

DISCUSSION

Our results support the hypothesis that BRS is PI dependent. On the other hand, BRSf was PI independent in children and hypertensive adolescents. A similar finding was made in young adults before and after psychological stress and exercise (*7*). A relatively small but significant negative correlation between BRSf and PI in adolescents indicated that BRSf may not have always been PI independent; in that case, however, the dependence was much weaker than that between PI and BRS. This implies that a more reliable measure of dependence between baroreflex sensitivity and PI is obtained by calculating a regression coefficient between BRS and PI.

A decrease in BRSf related to age, which has recently been observed in our laboratory (*8*), was also confirmed in the present study. This age-dependent decrease in BRSf can be explained on the basis of an age-dependent decrease in compliance of the carotic sinus (*9*). In our study it was balanced by an age-dependent increase in PI, with the result that BRS values were equal in both the children and the adolescent group.

In the hypertensive adolescents, BMI and weight were higher that in the normotensive subjects. This is in agreement with the view that the development of hypertension is associated with an increased amount of adipose tissue. This secretes leptin that increases the sympathetic activity of the nervous system and thus produces an increase in the resistance of peripheral vessels (*10, 11*).

The assumption that baroreflex sensitivity may play a role in blood pressure control was not confirmed. We observed lower values of both BRS and BRSf in the hypertensive adolescents but the difference between them and the normotensive subjects was not significant. However, it may be that the small number of hypertensives available for our study and a relatively high variation in BRS and BRSf were responsible.

A c k n o w l e d g e m e n t s

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REFERENCES

1. *Chapleau MW, Abboud FM*. Neuro-cardiovascular regulation. From molecules to man. Ann NY Acad Sci 2001; 940: 1–19.
2. *Honzíková N, Semrád B, Fišer B, Lábrová R.* Baroreflex sensitivity determined by spectral method and heart rate variability, and two-years mortality in patients after myocardial infarction. Physiol Res 2000;49:643–650.
3. *Fišer B, Siegelová J, Dušek J.* The gain of the baroreflex mechanism in patients with essential hypertension. Physiol Res 1996; 45: P22.
4. *Smyth HS, Sleight P, Pickering GW*. Reflex regulation of arterial pressure during sleep in man. Circ Res 1969; 24:109–121.
5. Guidelines Subcommittee:1999 World Health Organization-International Society of Hypertension Guidelines for the Management of Hypertension. J Hypertens 1999; 17: 151–183.

6. *Honzíková N, Fišer B, Honzík J*. Noninvasive determination of baroreflex sensitivity in man by means of spectral analysis. Physiol Res 1992; 41:31–37.
7. *All-Kubati MAA, Fišer B, Siegelová J.* Baroreflex sensitivity during psychological stress. Physiol Res 1997; 46:31–37.
8. *Fišer B, Honzíková N, Nováková Z, Hrstková H.* Baroreflex sensitivity in children and young adults. J Physiol (Lond.) 1998; 511:113P.
9. *Semrád B, Fišer B, Honzíková N.* Ageing and cardiac autonomic status. In: Malik M, ed. Clinical Guide to Cardiac Autonomic Tests. Dordrecht, Boston, London: Kluwer Academic Publishers, 1998: 285–300.
10. *Hall JE, Hildebrandt DA, Kuo J*. Obesity hypertension: role of leptin and sympathetic nervous system. Am J Hypertens 2001;14:103–115.
11. *Mark AL, Correia M, Morgan DA, Shaffer RA, Haynes WG.* State-of-the-art-lecture: obesity-induced hypertension: new concepts from the emerging biology of obesity. Hypertension 1999; 33: 537–541.

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AUTONOMNÍ KONTROLA SRDCE VE VZTAHU K ANTROPOMETRICKÝM PARAMETRŮM U SKUPINY DĚTÍ A DOSPÍVAJÍCÍ MLÁDEŽE

S o u h r n

Cílem předkládané práce bylo studium vztahů mezi citlivostí baroreflexu (vyjádřenou v ms/mmHg – BRS a v Hz/mmHg – BRSf), která hraje důležitou úlohu v autonomní regulaci srdce, věkem a antropometrickými parametry (tj.výškou, hmotností, body mass indexem-BMI) u dětí a dospívajících. Vyšetřili jsme 185 dětí ve věku 11–15 let (skupina A) a 116 dospívajících ve věkové kategorii 16–19 let (skupina B). Obě tyto skupiny vykazovaly fyziologické hodnoty systolického krevního tlaku (STK). Dále jsme vyčlenili skupinu jedenácti adolescentů, kterým při 24–hodinovém ambulantním monitorování krevního tlaku (z důvodu záchytu STK >140 mmHg v ordinaci praktického lékaře) průměrné hodnoty STK přesáhly 125 mmHg (skupina H). Citlivost baroreflexu (BRS i BRSf) byla určena metodou spektrální analýzy a její hodnoty byly vztaženy k věku a každému z antropometrických parametrů pomocí Spermanova korelačního koeficientu. Statistická významnost rozdílů v průměrných hodnotách sledovaných charakteristik mezi danými skupinami byla porovnána Mann-Whitney testem.

BRS nekorelovala s věkem, pouze s tepovým intervalem (PI) u všech skupin a s výškou u skupiny B. BRSf se s věkem snižovala, negativně korelovala s výškou a hmotností u skupiny A a s PI a BMI u skupiny B. Vyšší hmotnost a BMI u skupiny adolescentů se záchytem hypertenze je ve shodě s diskutovanou účastí tukovou tkání produkovaného leptinu v rozvoji tohoto onemocnění. Statisticky významný pokles hodnot BRS a BRSf u této skupiny však nebyl potvrzen.