Pulse Wave Velocity in Young Adults. Study of Rio de Janeiro

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Abstract

Background: **Pulse wave velocity (PWV) can be a marker of cardiovascular impairment, but there are few studies in young adults.**

Objective: **To evaluate the association between blood pressure (BP), current anthropometric and metabolic variables and those obtained 13 years earlier, in childhood and adolescence, with PWV.**

Methods: **Sixty individuals were followed longitudinally and split into two groups according to the percentile of blood pressure (BP) obtained 13 years earlier: Group 1 (G1): BP percentile ≤ 50 (n = 25, 11M, 26.4 years old) and Group 2 (G2): BP ≥ 95 percentile (n = 35, 19M, 25.4 years old). The individuals underwent clinical evaluation, laboratory analysis and measurements of PWV through the Complior method.**

Results: **G1 showed higher mean age; G2 showed greater mean weight, systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), PWV and blood glucose, and lower mean HDL-cholesterol. SBP, MAP and heart rate (HR) obtained during childhood and adolescence significantly correlated with PWV. Current weight, height, waist-hip ratio, SBP, DBP, pulse pressure (PP), MAP and creatinine presented a positive and significant correlation with PWV. A comparison of the average PWV adjusted for SBP, DBP, SBP and DBP, MAP and PP showed no statistically significant difference between groups.**

Conclusion: **The percentile of BP in childhood/adolescence related to arterial distensibility assessed by PWV 13 years later. Changes in PWV can be identified in young individuals suggesting that early vascular impairment may be present in this age group, also related to blood pressure, anthropometric and metabolic variables. (Arq Bras Cardiol. 2011; [online].ahead print, PP.0-0)**

Keywords: **Blood flow velocity; blood pressure; body mass index; adolescent; Brazil.**

Introduction

Cardiovascular diseases (CVD) have complex origin and evolution, representing, in general, the late manifestation of the action of a set of cardiovascular risk factors, either alone or associated, which may be present early in life[1,2].

Currently, hypertension has been recognized as a systemic disease affecting multiple organs and systems, including the arteries and the heart. In these, the abnormalities observed include endothelial dysfunction, reduced arterial elasticity and changes in structure and thickness of the arterial wall and left ventricle[3,4].

Much attention has been directed to the behavior of arteries, their intrinsic mechanical, neural and hormonal endothelium-dependent properties, due to their participation in the genesis of hypertension and in the consequences of hypertension on them. Hence the great interest of many researchers in the study of arterial stiffness through various methods, including the analysis of pulse wave velocity (PWV)[5-7].

Several studies show that many of the changes in vascular structure and function occur before the onset of increased blood pressure and may be even responsible for its subsequent rise. Early identification and treatment of these changes and treatment directed towards the hemodynamic and non hemodynamic mechanisms of the disease, before the increase of BP, may offer a better chance of reversing the process, more effectively reducing the morbidity and mortality rates[4,8-11].

In this context, several studies have focused on the analysis of these factors in younger age groups. The Bogalusa[12-14] study evaluated genetic and environmental cardiovascular risk factors in childhood and their contribution to the development of established disease in adulthood. In Brazil, the study of Rio de Janeiro[15-19], which this present study is part of, has shown that the presence of cardiovascular risk factors occurs since the early stages of life and progresses with strong familial aggregation, pointing to a scenario of great preventive potential.

Thus, the purpose of this study is to evaluate the variables that make up the main cardiovascular risk factors (smoking, sedentary lifestyle, blood pressure, anthropometric and metabolic variables) in a young population stratified by

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percentiles of blood pressure obtained 13 years later, in childhood and adolescence, and to search for possible associations between the variables obtained in this phase of life and currently with the PWV.

Methods

The sample population of this study was composed of sixty individuals, aged between 22 and 29 years.

Group 1 - Consisting of 25 individuals with a mean age of 26.40 ± 1.85 years (23-29 years old), 11 males and 14 females, which stood, 13 years earlier, in the percentile of systolic and diastolic BP equal or smaller than 50;

Group 2 - Consisting of 35 individuals, 19 males and 16 females, which stood, 13 years earlier, in the percentile of systolic and/or diastolic BP equal or smaller than 95, with mean age of 25.40 ± 1.97 years (22-29 years old).

Demographic, anthropometric, clinical and laboratory parameters were analyzed. The first two included gender, age in years, weight in kilograms (kg), height in meters (m) and abdominal circumference and hip circumference in centimeters (cm). Body mass index (BMI) and waist/hip ratio were also calculated. The classification of obesity was based on BMI, according to the World Health Organization (WHO)[20]. For the blood pressure values, those of the last measure, out of three in the supine position were considered. Laboratory data included the measurement of total cholesterol, triglycerides, HDL cholesterol, LDL cholesterol, glucose, creatinine and uric acid. Clinical parameters analyzed 13 years earlier were: height, weight, BMI, HR, SBP, DBP, pulse pressure (PP) and percentile of blood pressure. Regarding lipids, normal values adopted as a reference were those recommended by the 4th Brazilian Guidelines on Dyslipidemia[21]. Diagnostic, stratification, and control criteria of hypertension followed the 6th Brazilian Guidelines on Hypertension[22].

To record and analyze pulse wave velocity (PWV), we used the automatic computerized system Complior™ (Complior, Colson, Garges les Genosse, France - Createch Industrie)[5] (Fig. 1). We obtained an average of 10 records for each patient.

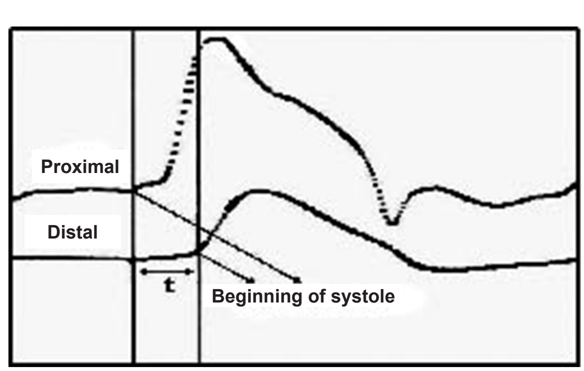

Figure 1 - Measurement of pulse wave velocity (PWV). PWV - distance between sites of proximal and distal measurement divided by the transit time (t) between the systolic beginnings of pulse waves.

In all statistical tests, 0.05 or 5% ($p < 0.05$) was established as a rejection level of null hypothesis. The following were used: chi-square test (χ^2) to compare the distributions of the variables in independent samples; Mann-Whitney test (Z) to compare continuous variables without normal distribution; analysis of covariance (F) to compare adjusted means by another variable (covariate). Blood pressure variables were used for adjustment, because these are closely related to PWV. Spearman's Bivariate Correlation Test (r) was used to analyze the correlation of continuous variables with or without normal distribution[23].

This study was approved by the Ethics in Clinical Research, *Hospital Universitário Pedro Ernesto*, *Universidade do Estado do Rio de Janeiro*.

Results

Table 1 shows the demographic, epidemiological and anthropometric characteristics of the 60 individuals evaluated. Gender distribution was homogeneous in both groups. Individuals in Group 1 had an average age higher than those in Group 2. Thus, the comparison of the average of anthropometric and hemodynamic variables, including PWV and metabolic variables, was adjusted for age. The comparative analysis of the anthropometric variables showed that the individuals of Group 2 had a mean weight higher than those in Group 1. There was no statistically significant difference in the comparisons of the anthropometric variables studied.

As for hemodynamics, HR, PP and prevalence of hypertension showed no statistically significant differences (table 2).

Table 1 - **Current demographic, epidemiological and anthropometric variables**

Variable	Group 1 (n = 25)	Group 2 (n = 35)	Significance level (p)
Female No. (%)	14 (56.0)	16 (45.7)	0.601
Age (years) mean ± SD	26.40 ± 1.85	25.40 ± 1.97	0.046
Smoking	1 (4.0)	5 (14.3)	0.386
Alcohol consumption	13 (52.0)	14 (40.0)	0.434
Physical inactivity	20 (80.0)	23 (65.7)	0.260
Weight (kg)	66.46 ± 14.61	74.25 ± 14.56	0.049
Height (cm)	167.46 ± 9.15	170.67 ± 9.12	0.191
BMI (kg/m²)	23.62 ± 4.16	25.39 ± 4.14	0.115
Waist circumference (cm)	82.24 ± 10.75	85.12 ± 10.66	0.316
Hip circumference (cm)	98.78 ± 9.35	102.79 ± 9.29	0.111
Waist/hip ratio	0.83 ± 0.07	0.83 ± 0.07	0.873
Overweight or obesity	7 (28.0)	16 (45.7)	0.131

BMI - body mass index.

Table 2 - Hemodynamic variables adjusted for age

Variable	Group 1	Group 2	Statistical test	Significance level (p)
SBP (mmHg)	118.55 ± 14.45	127.64 ± 14.43	F = 5.579	0.022
DBP (mmHg)	74.48 ± 10.85	81.71 ± 10.80	F = 6.311	0.015
PP (mmHg)	44.07 ± 9.34	45.92 ± 9.29	F = 0.557	0.459
MAP (mmHg)	89.17 ± 11.37	97.02 ± 11.31	F = 6.777	0.012
HR (bpm)	76.54 ± 9.63	72.47 ± 9.58	F = 2.526	0.118
PWV (m/s)	7.89 ± 1.05	8.51 ± 1.04	F = 5.023	0.029
Presence of hypertension			χ^2 = 1.288	0.357
Yes - No. (%)	4 (16.0)	10 (28.6)		
No - No. (%)	21 (84.0)	25 (71.4)		

SBP - systolic blood pressure; DBP - diastolic blood pressure; PP - pulse pressure, MAP - mean arterial pressure; HR - heart rate; PWV - pulse wave velocity.

The metabolic variables studied are described in Table 3. Analysis of fasting glucose and HDL-cholesterol revealed that the comparison of averages showed a statistically significant difference between groups.

Table 4 lists the correlations of PWV with the variables obtained 13 years earlier. There were positive and significant correlations of PWV with SBP (p = 0.009), with MAP (p = 0.019) and HR (p = 0.029).

Table 3 - Current metabolic variables adjusted for age

Variable	Group 1 (n = 25)	Group 2 (n = 35)	Significance level (p)
Cholesterol (mg/dl)	179.76 ± 37.90	179.01 ± 36.13	0.947
HDL-Chol (mg/dl)	53.10 ± 12.59	44.27 ± 11.57	0.008
HDL-Chol (mg/dl)	107.49 ± 35.13	119.96 ± 32.27	0.170
Triglycerides (mg/dl)	89.24 ± 40.25	77.47 ± 38.37	0.267
Blood glucose (mg/dl)	83.37 ± 11.52	90.10 ± 10.99	0.029
Urea (mg/dl)	24.12 ± 8.68	26.36 ± 9.11	0.349
Creatinine (mg/dl)	0.85 ± 0.19	0.85 ± 0.19	0.983
Uric acid (mg/dl)	4.70 ± 1.68	5.08 ± 1.51	0.393

Table 4 - Correlations of PWV with variables obtained 13 years earlier

Variable	r (Spearman)	p
Systolic blood pressure	0.333	0.009
Diastolic blood pressure	0.244	0.060
Pulse pressure	0.206	0.115
Mean arterial pressure	0.303	0.019
Weight	0.184	0.162
Height	0.180	0.174
Body mass index	0.063	0.633
Heart rate	0.284	0.029

Table 5 lists the correlations of PWV with the variables studied in the current stage, and positive and significant correlations of PWV were observed, such as: weight, height, waist-hip ratio, SBP, DBP, PP, MAP and creatinine.

When the mean PWV were adjusted for age, weight, SBP, DBP, MAP and PP (Table 6), there was no significant difference between groups.

Discussion

The relatively recent methodology developed for the analysis of vascular compliance, measured by PWV, has

Table 5 - Correlations of PWV with current variables

Variable	r (Spearman)	p
Age	0.052	0.694
Weight	0.403	0.001
Height	0.301	0.019
Body mass index	0.219	0.093
Waist	0.347	0.007
Hip	0.144	0.273
Waist/hip ratio	0.328	0.011
Systolic blood pressure	0.444	< 0.001
Diastolic blood pressure	0.318	0.013
Pulse pressure	0.274	0.034
Mean arterial pressure	0.424	0.001
Total cholesterol	0.001	0.995
HDL-cholesterol	0.094	0.503
LDL-cholesterol	0.022	0.874
VLDL-cholesterol	0.090	0.527
Triglycerides	0.031	0.819
Urea	0.007	0.965
Creatinine	0.400	0.004
Uric acid	0.061	0.671
Fasting glucose	0.042	0.753

Table 6 - Comparison of mean PWV adjusted for age. weight. and hemodynamic variables

Variable	Group 1 (n = 25)	Group 2 (n = 35)	Significance level (p)
PWV adjusted for SBP (m/s)	8.05 ± 1.01	8.40 ± 1.00	0.208
PWV adjusted for DBP (m/s)	8.05 ± 1.03	8.40 ± 1.02	0.210
PWV adjusted for SBP and DBP (m/s)	8.06 ± 1.02	8.40 ± 1.00	0.232
PWV adjusted for MAP (m/s)	8.06 ± 1.02	8.39 ± 1.00	0.235
PWV adjusted for PP (m/s)	7.80 ± 1.03	8.44 ± 1.02	0.109

PWV - pulse wave velocity; SBP - systolic blood pressure; DBP - diastolic blood pressure; MAP - mean arterial pressure. PP - pulse pressure.

brought a major breakthrough in research of vascular markers of hypertension, especially in the elderly[5,24-26]. So far, there have been few references on the use of PWV as a measure of vascular damage in younger individuals. Therefore, this study evaluated young individuals who had been under clinical follow-up since childhood in the study of Rio de Janeiro[15-19].

Despite the small size, the sample evaluated in this study is of great interest because it was derived from a non-hospital population, which has not had any type of intervention for 13 years and has been systematically monitored and subjected to further evaluations, allowing the construction of knowledge on the behavior or cardiovascular risk factors in this age group.

As for demographic and epidemiological variables, except for age, the groups had all similar data, with no statistical difference between them. The groups showed a statistically significant difference as for mean age, and this could create an interference factor on the results of the study, since the hemodynamic, metabolic and anthropometric parameters studied are, in the literature, related to age. In this respect, the fact that the group with higher BP percentile (Group 2) has shown a lower average age could not account for the differences observed in the comparisons of other variables. Still, all variables were adjusted for age, prior to the comparisons.

It is worth noting, in relation to demographic and epidemiological variables, the clear predominance of some variables in Group 2, such as higher BMI, waist-to-hip ratio and overweight/obesity, characterizing results of clinical importance but, probably due to small sample size, it has not reached any statistical relevance.

There is a high level of current evidence of the relationship of overweight/obesity, translated by increased BMI, with blood pressure and cardiovascular morbidity[1,9,10,22,27-30]. More recently, waist-hip ratio or waist circumference alone has been used as a marker of central obesity, which, in turn, in addition to correlating with insulin resistance, appears to correlate better with CV risk than general obesity indexes such as BMI[28].

In this study, Group 2 had lower mean HDL-cholesterol and higher mean fasting glucose compared with Group 1. It should be noted that, although statistically different, the mean fasting glucose was within the limits considered normal. Note also that although only two individuals have shown abnormal fasting glucose, these cases occurred in Group 2.

Except for HDL-cholesterol, none of the groups had a higher prevalence of abnormal values of serum levels of other metabolic variables. The average values of the other metabolic variables are within the ranges of normality.

The relationship of dyslipidemia, diabetes mellitus, and especially the combination of both with atherosclerosis and cardiovascular morbidity has been long known. Similarly, the significant association of LDL-cholesterol with risk of coronary artery disease has been reported in several series, both in individuals with evident coronary artery disease as those without the disease, regardless of gender[9,21,22,29,30]. Even the earliest stage of diabetes mellitus type 2, which characterizes impaired glucose tolerance or impaired fasting glucose, is associated with increased CV risk and has often been accompanied by situations that usually occur concomitantly in association with type 2 diabetes, such as hypertriglyceridemia, low levels of HDL-cholesterol, higher prevalence of hypertension, central obesity and hyperinsulinemia, reflecting resistance of peripheral tissues to insulin action[30,31].

The observations of the study of Bogalusa[12-14,32], which followed children from birth to 26 years of age, have indicated that cardiovascular risk factors had a constant behavior throughout childhood and adolescence; this would imply that children who had an adverse cardiovascular profile (located at the highest percentile of the variables) might be more prone to cardiovascular diseases in adulthood. Among the anthropometric, hemodynamic and metabolic variables, weight, height, SBP and LDL-cholesterol showed the highest correlation coefficients over eight years. This study showed that in children and adolescents aged between 5 and 14 years, there had been an association of variables above the 75th percentile of BP, clearly demonstrating the tendency for aggregation of cardiovascular risk factors.

The results in relation to the anthropometric and metabolic characteristics of this study, higher weight, lower HDL-cholesterol and higher fasting glucose levels in the individuals of the group at the highest percentile of BP confirm literature data and corroborate the results obtained in 1998 in the same group of individuals. At that time, the group had higher mean anthropometric indexes and lower mean HDL-cholesterol, emphasizing the importance of the presence of overweight associated with changes in BP, as future markers of higher BP, weight and metabolic changes. It should be noted that lower values of HDL-cholesterol have been valued as initial lipid change in young adults[14,32].

As for hemodynamics, Group 2 had higher mean SBP, DBP, MAP and PWV. Although there is a higher prevalence of hypertensive individuals in Group 2 (10 individuals - 28.6%) than in Group 1 (4 individuals - 16%) there was no statistically significant difference.

Group 2 had a mean of PWV (8.51 m/s) significantly higher than that of Group 1 (7.89 m/s), suggesting some degree of vascular impairment in individuals who presented in childhood/adolescence a higher percentile of arterial pressure.

Several series have evaluated regional population groups to establish standards of PWV behavior. In Brazil, Zilli[33] studied PWV in 463 healthy Brazilian individuals. In 204 individuals of both sexes, aged 19-39 years, he found an average PWV (Complior method) of 8.27 $\pm$ 1.22 m/s. With the same objective, Maldonado et al[34] evaluated 202 normal Portuguese individuals of both sexes, who were analyzed after stratification by age group of 10 years from 10 years of age. In 38 individuals aged 20-30 years, the average PWV (Complior method) was 7.52 $\pm$ 1.42 m/s. There was a trend without statistical significance of higher levels in men, when the group was evaluated in its entirety.

In this study, the mean PWV was 7.89 $\pm$ 1.05 m/s and 8.51 $\pm$ 1.04 m/s in groups 1 and 2, respectively, resembling thus the values found in the two studies cited before, and showing lower values than those of the study by Asmar et al[5], which assessed individuals younger than those included in this study[5].

Seeking to evaluate the relationships between the variables studied with PWV, correlations of PWV were drawn with the anthropometric variables (weight, height and BMI) and hemodynamic variables (SBP, DBP, PP and HR) obtained 13 years earlier, and it can be observed that HR, MAP, and especially SBP showed a positive and significant correlation with the current PWV. This data is greatly relevant, since the casual measurement of BP in childhood and adolescence was able to relate with the PWV obtained 13 years later.

Then, the correlation of PWV with those variables derived from the current approach of the group was analyzed and statistically significant correlations of PWV were observed with weight, height, waist circumference, waist-hip ratio, SBP, DBP, PP, MAP and creatinine.

Asmar et al[26], in a study cited above, showed that the major determinants of PWV were age ($p < 0.001$) and SBP ($p < 0.001$) in normotensive and hypertensive patients, and there is no influence of sex, weight, blood glucose, cholesterol and HDL-cholesterol. Amar et al[24] have shown that in a sample of individuals at high risk for CV events, the accumulation of risk factors was an independent determinant of arterial stiffness assessed by PWV.

The relationship of HR with PWV is controversial and not yet fully defined. Lantelme et al[35] showed that there is a significant and proportional effect of HR on PWV in a population of 22 elderly individuals.

Several genetic factors, besides those directly responsible for the function and composition of the great arteries, showed a relationship with PWV, such as are the cases of those acting on the classical CV risk factors - hypertension, dyslipidemia, salt sensitivity, diabetes mellitus type II. The relationship of PWV with fasting glucose levels in untreated diabetic and hypertensive patients has been well identified[25].

The correlation of PWV with BMI in hypertensive individuals, as well as the height and waist circumference in hypertensive patients and those with severe renal failure is well known[36].

The role of lipid metabolism on arterial distensibility is not completely understood and needs further investigation. In the general population and in healthy individuals, no correlation is observed in arterial distensibility with total cholesterol, there is a correlation with HDL-cholesterol, and the relationship with LDL-cholesterol is controversial. So far, results that can be generalized on the relationship between arterial distensibility and lipid levels in hypertensive individuals have not been observed[25].

As it can be seen in the studies that evaluated PWV in young individuals, their results were similar to those found in this study, i.e., association of several variables that make up the CV risk factors with PWV. Similarly, the mean differences of PWV adjusted for age, weight, and hemodynamic variables made the comparison of average PWV between the two groups to be devoid of statistical significance, possibly demonstrating the involvement of these variables in the determination of PWV. Although PWV cannot be identified as an independent variable of difference between the groups, its association with various cardiovascular variables constitutes an adverse profile of risk factors for a group of young individuals stratified by a variable obtained 13 years earlier.

Thus, the assessment of PWV in young adults seems to allow the early identification of the process of vascular involvement associated with early changes in BP. A preventive approach to CVD related to younger age groups places the measurement of PWV as a relevant method, because it is a potential marker of vascular injury.

Conclusions

Our study has shown that the percentile of BP in childhood/adolescence could influence arterial distensibility, assessed by PWV obtained after 13 years. This behavior suggests that vascular involvement, translated by this variable, may appear early; however, further studies are needed to determine the significance of PWV as a predictor of morbidity and mortality in this age group.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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