

*Medical Sciences*

## Statistical Characteristics of Blood Pressure and Heart Rate Variation in Different Blood Pressure Categories

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**ABSTRACT:** In this work different data sets of the blood pressure and heart rate characteristics of persons from different blood pressure categories have been investigated. In particular, the systolic, diastolic and heart rate time series obtained from 24h ambulatory monitoring were recorded. These data have been collected from 160 persons (91 men and 69 women) residents of Tbilisi. The age of patients for the present investigation was in the range of 30–70 years. Blood pressure and heart rate variability data in these patients have been recorded in the standard calm sitting conditions. Together with these, recorded during the investigation data sets, additionally we have carried out analysis of calculated data sets. Namely time series, such as the pulse pressure and the mean arterial pressure data sets have been analyzed. Patients have been grouped into four different blood pressure categories according to the guidelines of the European Society of Hypertension and the European Society of Cardiology.

Statistical features of these data sets, both measured and calculated, for patients from different blood pressure categories were calculated and compared. Standard statistical test was used and coefficients of variation of heart rate and blood pressure time series were calculated.

It was shown that there is clear correlation between statistical properties of the analyzed characteristics and level of blood pressure in different categories. Normal and high normal blood pressure categories of patients from different blood pressure categories reveal a clear difference in terms of the statistical features of blood pressure and heart rate characteristics. ©2012 Bull. Georg. Natl. Acad. Sci.

**Key words:** *hypertension, blood pressure categories, heart rate, statistics.*

Today association between elevated systolic as well as diastolic blood pressure (SBP and DBP, respectively) and the risk of cardiovascular disease is well established [1, 2]. Therefore, classification of hypertension and identification of different blood pressure categories is recognized as an important prerequisite for risk assessment and prophylactic measures. Correct classification helps to make deci-

sions concerning the blood pressure thresholds and appropriate treatment strategies at different forms of hypertension [3]. In 2007 the European Society of Hypertension (ESH) and the European Society of Cardiology (ESC) produced updated guidelines on the diagnosis and treatment of hypertension. In this guidelines blood pressure levels are defined corresponding to 7 categories: optimal (SPB <120 mmHg,

DBP <80 mmHg), normal (SPB in range 120–129 mmHg, DBP in range 80–84 mmHg), high normal (SPB in range 130–139 mmHg, DBP in range 85–89 mmHg) and grade 1 hypertension (SPB in range 140–159 mmHg, DBP in range 90–99 mmHg) categories (see Table 1 in ESH-ESC 2007 guidelines [3]. Such division, in itself, does not necessarily mean that variation of analyzed characteristics of patients from various blood pressure categories could differ by their statistical or distributive features. Moreover, reliability of the above division of blood pressure groups has not been accepted unambiguously because there is discrepancy with The USA Joint National Committee Guidelines (JNC 7) on hypertension published in 2003 [4] in which the normal and high normal blood pressure categories are unified into a single entity termed “prehypertension”.

**Materials and methods.** In the present research we aimed to investigate the question of similarity or dissimilarity between normal, high normal blood pressure categories. To this end we compare the statistical features of measured and calculated blood pressure characteristics of patients, groups from optimal, normal, high normal blood pressure categories as well as of first grade hypertension. Study was performed at the Department of Hypertension of the Institute of Cardiology in Tbilisi, Georgia on appropriate data sets obtained from 160 persons (91 men and 69 women) residents of Tbilisi (of the age of 30 to 70). Additional details about the data bases used can be seen in [5]. We analyzed SBP, DBP and RR interval time series obtained from 24h ambulatory monitoring recordings at 15 min sampling time. Patients have been grouped in four blood pressure categories according to ESH guidelines [3] (Fig. 1). We also considered data sets of pulse pressure (PP), defined as SBP minus DBP, and the mean arterial pressure MAP, defined as  $1/3(\text{SBP}) + 2/3(\text{DBP})$  data sets.

**Results and discussion.** We showed that differences between mean values in different categories are significant for all groups ( $P < 0.001$ ). Moreover, the mean

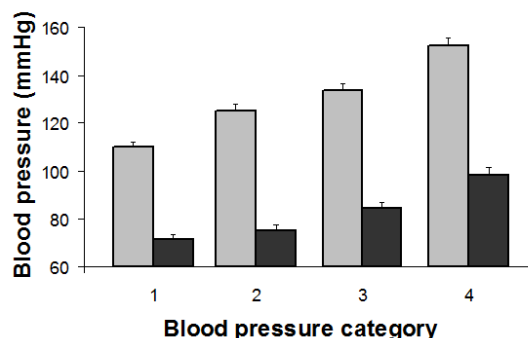
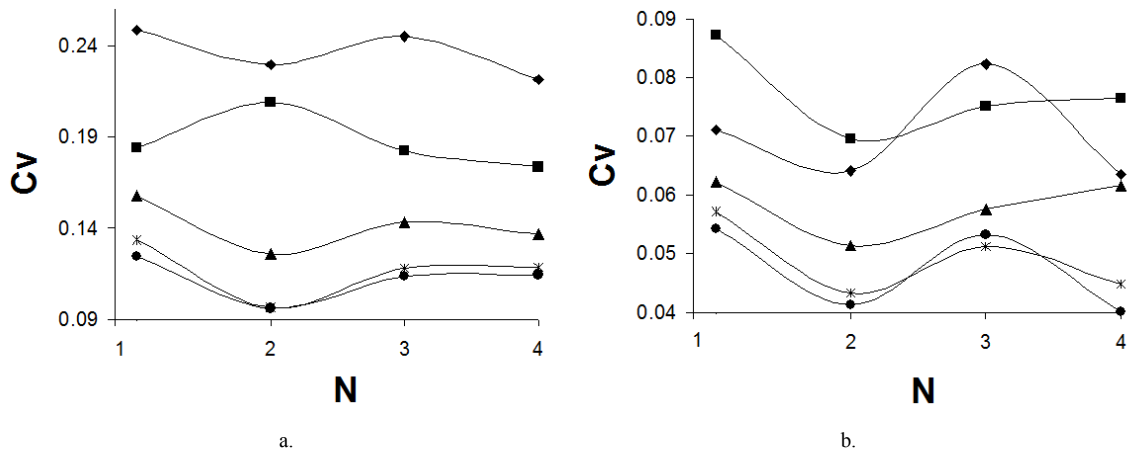


Fig. 1. Mean values with standard errors of systolic (grey columns) and diastolic (dark columns) blood pressures of patients from groups of optimal (1), normal (2), high-normal (3) and grade 1 hypertension categories (4).

values of diastolic blood pressure data, the sorting of which according to ESC guidelines was not perfect, also differing significantly ( $P < 0.001$ ) in different categories. These results seem to provide arguments to assume that normal and high normal groups, targeted in this work, can be statistically different.

At the same time contrary to measured SBP, DBP and heart rate data, time series of calculated MAP and PP characteristics do not always differ statistically in normal and high normal categories.

In order to exclude incorrect conclusions about the difference between normal and high normal blood pressure categories, we accomplished dispersion testing of blood pressure time series. Calculated values of dispersion characteristics,  $C_v$ , are presented in Fig. 2. It is understandable that  $C_v$ , calculated for averaged data is smaller than for pooled ones, where individual differences between patients from the same blood pressure category predominate. Results for both pooled as well as averaged, by consecutive 15 min intervals data, show that observed differences in the dispersion features are mainly connected with the type of the analyzed blood pressure data rather than with the blood pressure category. Indeed, it follows from Figs. 2a and 2b, that data sets of measured blood pressure characteristics, such as SBP and DBP, reveal much lower variability as compared to RR intervals time series. Data sets of calculated blood pressure characteristics, PP and MAP, also show



**Fig. 2.** Coefficient of variation vs. blood pressure category for pooled (a) and averaged (b) blood pressure data sets: SBP (circles), DBP (triangles), RR intervals (squares), PP (diamonds) and MAP (asterisks). On the x axis blood pressures categories are shown: optimal (1), normal (2), high-normal (3) and hypertension (4).

clearly different dispersion features; pulse pressure reveals much more variability than mean arterial pressure.

At the same time it should be pointed out that there are also smaller but still detectable changes which can be related to certain blood pressure categories. Namely, in Fig. 2a, we observe some changes in the Cv values at normal blood pressure category. It is worth mentioning that these are results obtained for long, pooled data sets described in methods section, which account for features of the individual blood pressure variation of patients grouped in a certain blood pressure category. In the case of averaged time series of the same characteristics presented in Fig. 2b, we also discern some changes which are mostly similar to pooled ones, excluding RR data. In this last case changes at normal category for averaged data persist, though they are in opposition to what was observed for pooled ones. These results possibly indicate increased scatter of the considered characteristics for individuals at transition from optimal to normal blood pressure category.

At the same time, as follows from Fig. 2, in terms of deviation from dispersion features found in opti-

mal blood pressure category, normal category is not an exception and that some changes take place for other categories too. Most important for the present research purposes is that all these small changes in dispersion features of the analyzed characteristics mostly occur between normal and high normal categories, notwithstanding unavoidable individual deviations or averaging effects throughout the category groups.

It should be underlined that, aiming at comparison of statistical features of blood pressure and heart rate characteristics of patients from different guidelines categories, we studied the representative groups with no regard for frequently used criteria such as ethnicity, gender or age. Thus the findings presented in this research indicate clear references between statistical properties of different blood pressure characteristics and changes occurring at transition from healthy to hypertension condition in persons from different blood pressure categories. According to these results normal and high normal blood pressure categories are clearly different in terms of the analyzed statistical and distributional properties.

## სამედიცინო მეცნიერებანი

# სისხლის წნევისა და გულის რიტმის ცვლილებათა სტატისტიკური მახასიათებლები არტერიული წნევის სხვადასხვა კატეგორიაში

## მ. ჯანიაშვილი

მ. წინამძღვრიშვილის კარდიოლოგიის ინსტიტუტი, თბილისი

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ნაშრომის მიზანს წარმოადგენდა შეგვედარებინა ნორმალური და მაღალი ნორმის კატეგორიის პაციენტების სისტოლური სისხლის წნევის, დიასტოლური სისხლის წნევის, გულის რიტმისა და პულსური წნევის სტატისტიკური მახასიათებლები. ანათვალეს ვიდედით 15 წუთიან ინტერვალში არტერიული წნევის 24 სთ-იანი მონიტორირების ჩანაწერების მიხედვით. ჯგუფები წარმოდგენილი იყო ფროპის კარდიოლოგთა ასოციაციის გაიდლაინის მიხედვით. გამოკვლეული იქნა 160 ადამიანი. აქედან 91 იყო მამაკაცი და 69 ქალი, რომელთა წლოვანება მერყეობდა 30-დან 70 წლამდე.

კვლევის შედეგებმა გვიჩვენა, რომ მიუხედავად საშუალო სიდიდეების სიახლოვისა, არტერიული წნევის ორი განხილული კატეგორიის სტატისტიკური მახასიათებლები სარწმუნოდ განსხვავდება.

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