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Original article

STUDY OF THE DIFFERENCES IN THE ARTERIAL BLOOD PRESSURE VALUES IN HEALTHY PEOPLE MEASURED SIMULTANEOUSLY ON LEFT AND RIGHT ARMS

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ABSTRACT

Arterial blood pressure measurement constitutes a fundamental aspect of nursing practice. The clinical significance of this measurement lies in its ability to assess systolic and diastolic blood pressure, which serve as crucial indicators of cardiovascular health and significant predictors of cardiovascular events.

The purpose of the study is to investigate the difference in arterial pressure values after simultaneous measurement of the left and right arm in healthy people.

Materials and methods. Data from 160 volunteers, including 125 healthy individuals (men and women), were analyzed. The mean age of the participants was 38.72±12.134 years, with 54 (43.2%) male and 71 (56.8%) female participants.

Results. The subjects demonstrated normal blood pressure values**.** Statistically significant differences were found between systolic pressure (SBP) of the right and left arm (p=0.05), between diastolic pressure (DBP) of the right and left arm (p=0.05), as well as a difference in measurements between men and women. Absolute differences in systolic blood pressure between the two arms in healthy subjects were 2.184 ± 8.960 mmHg at ($t_{|124|}$ = 2,726, p =0.007). The mean absolute difference between the two diastolic values was 0.880 ± 6.474 mmHg at ($t_{|124|}$= 1.520, p=0.1315), respectively. The influence of various risk factors on these differences has been established. A relationship was established with gender, age, alcohol use, smoking, weight (BMI).

Conclusions. No significant disparity was observed between bilateral systolic blood pressure measurements in healthy individuals. The findings indicate a minimal difference in arterial pressure measured simultaneously in both arms of healthy subjects (5 mmHg). However, these results are reliable and may serve as an indicator of heightened cardiovascular risk.

Keywords: blood pressure, systole, diastole, inter-arm differences in blood pressure, nursing,

INTRODUCTION

Arterial blood pressure measurement stands as a cornerstone in nursing practice. Its clinical relevance lies in the crucial role of systolic and diastolic blood pressure as primary indicators of cardiovascular health and potent predictors of cardiovascular events, both fatal and non-fatal. Numerous publications advocate for the incorporation of bilateral arterial blood pressure measurement into routine cardiovascular assessments [1].

It's generally recognized that there exists a disparity in arterial blood pressure between the arms, although it should ideally not surpass 5 mmHg. Clinically, a notable difference in systolic blood pressure readings, when measured on both upper extremities, is deemed significant if exceeding 10 mmHg. Such a dichotomy in bilateral systolic blood pressure measurements serves as a crucial indicator of vascular health and can prognosticate cardiovascular events. A discrepancy of 10 mmHg suggests potential atherosclerosis, while a variance of 15-20 mmHg warrants investigation for great vessel stenosis or other developmental abnormalities [2].

At present, there are few recommendations on how to assess blood pressure differences between the two arms. In their study, a group of authors compared simultaneous versus sequential measurement of mean arterial pressure and pressure differences between the two arms in patients stratified by age and arterial pressure. A comparison was made between the two methods, with three simultaneous and three consecutive measurements performed on each patient. The authors found that mean arterial pressure was 1.3 ± 7.5 mmHg lower during sequential compared to simultaneous measurement (p<0.01). Absolute differences in systolic blood pressure between arms were smaller in simultaneous (6.2 ± 6.7; 3.3 ± 3.5 mmHg) compared to sequential BP measurement (7.8 ± 7.3; 4.6 ± 5.6 mmHg) at p<0.01 for both. In conclusion, it is argued that simultaneous measurement of blood pressure in both arms reduces the sequence effect and leads to smaller differences in blood pressure between the two arms [3, 4].

The literature contains extensive data on the rela-

tionship between arterial blood pressure and factors such as gender, age, nutrition habits, and diet [6, 7]. Epidemiological studies confirm that factors such as salt intake, alcohol consumption, and body mass are directly related to arterial blood pressure. [5, 6] Arterial blood pressure profiles are known to change with age, with diastolic blood pressure rising until the age of 50 and then declining, while systolic blood pressure increases from adolescence to old age [7, 8]. Other risk factors influencing arterial blood pressure, such as diabetes mellitus, smoking, and total and HDL cholesterol, have been identified [9].

Another group of authors investigated the differences in blood pressure values measured on both arms in patients with atherosclerotic disease, peripheral vascular disease, ischemic heart disease and cerebrovascular disease, comparing them with the values of a control group of healthy individuals. A difference is found in blood pressure values measured on both arms, with the difference being greater in patients than in healthy individuals. The authors summarized in their study that among all patients with a systolic difference between the arms greater than 10 mmHg, 60% had higher pressure in the right arm, and 40% had higher pressure in the left arm [10].

By measuring the blood pressure simultaneously on both arms in elderly people with normal and high blood pressure, researchers demonstrate the clinical significance of the difference in blood pressure between the two arms and its role in clinical decision making. The authors categorized the differences as follows: up to 5 mmHg, up to 10 mmHg, and less than 20 mmHg for systolic and diastolic blood pressure (SBP/DBP) and derived values of clinical significance from these categories. The data points to higher blood pressure in the right arm. The researchers found the relative differences in systolic and diastolic brachial pressure (SBP 1.1±7.1 mmHg and DBP 0.21±5.0 mmHg). Although no statistical significance was found, the authors stated that the absolute differences were significant at the individual level, with a systolic difference of 5.4 ± 4.8 mmHg and a diastolic difference of 3.9 ± 3.2 mmHg. Absolute differences in SBP/DBP between the arms greater than 5 mmHg and greater than 10 mmHg were defined as significant. The range of differences between the two arms was clinically significant in hypertensives, with SBP/DBP ranging from 13.2 to 15 mmHg and in nonhypertensives ranging from 12.9 to +15.6 mmHg. Recommendations are made for the initial blood pressure measurement to be done on both arms, with subsequent measurements being made on the arm with the higher blood pressure [11].

In a prospective observational study, another group of researchers investigated the presence and magnitude of differences in simultaneous blood pressure measurements on each arm and determined the influence of various factors (such as age, gender, arm circumference, smoking, hypertension, diabetes, history of cardiovascular disease) on these differences. They found significant differences between right and left arm systolic blood pressure (p=0.005), significant differences in right and left arm diastolic blood pressure (p=0.05) and significant differences in right and left arm pulse pressure (p=0.006). The mean differences in systolic and diastolic blood pressure measurements were 1.2 ±5.0 mmHg and 0.4 ±4.2 mmHg, respectively. The authors concluded that because of the frequent occurrence of significant differences in systolic and diastolic blood pressure between the two arms, measurement of blood pressure on only one arm may mask the diagnosis or delay effective treatment of hypertension [12].

In another similar prospective observational study, significant differences in systolic and diastolic blood pressure that were perceived as normal were found between arms. The mean and standard deviation of the differences in systolic and diastolic blood pressure between the arms were determined to be 1.81 ± 8.6 mmHg and 0.23 ± 8.3 mm/Hg, respectively, at ($t_{|399|}$=4. 20; p<0.0001) and the mean absolute difference between both systolic ($t_{|399|}$ = 20.65; p<0.0001) and diastolic ($t_{|399|}$=15.39; p<0.0001) pressures. The authors obtained similar results, finding no association with sex, ethnicity, arm circumference, hypertension, diabetes, and prior history of cardiovascular disease. Age was the only significant predictor of clinically significant inter arm blood pressure difference and mean absolute blood pressure differences [13, 14].

Despite numerous reports of difference in arterial blood pressure values in various parts of the body, comprehensive nursing studies on the prognostic value of the difference in blood pressure values measured in the left and right arm are scarce. Studies capable of deriving average values and norms with prognostic value are almost nonexistent among healthy individuals. Even the latest guidelines do not specify which arm should be used for routine arterial blood pressure measurement, although they often recommend measuring the left arm due to its proximity to the heart [15, 16].

The purpose of the present study was to investigate the difference in arterial blood pressure values with simultaneous measurement of the left and right arm in healthy people.

MATERIALS & METHODS

The study was conducted at the Health Care Educational Research Centre at Neofit Rilski South-West University, Blagoevgrad, during the period of July to September 2021 as part of Project RP-A1/21 titled: "Creating a scientific and educational environment for conducting measurements and working with equipment, applying the concept of evidence-based nursing". The study included 160 self-identified healthy volunteers, aged between 19 and 70 years (mean 42.26±13.062), who provided informed consent before participating. The participants were briefed on the study's objectives and the confidentiality of their data. The experimental procedure adhered to ethical guidelines and was approved by the Committee on Ethics of Scientific Research at Neofit Rilski University of Applied Sciences un-

der Protocol No. 2103-3/30.03.2021

Measurements were conducted using the MESI ABPI MD instrument, employing oscillometry and volume plethysmography techniques at standardized values determined by the instrument. Arterial pressure (BP) was simultaneously measured in the extremities for 1 minute. Participants were positioned in a supine posture, ensuring a state of psychophysical rest. In addition to blood pressure measurements, participants underwent electrocardiogram (ECG) and anthropometric assessment. Height and weight were measured using a standard scale and height meter. Furthermore, participants were evaluated for any specific cardiovascular symptoms or complaints.

For statistical analyses, data processing, and graphical presentation, we utilized the statistical software packages SPSS 23.0, Graph Pad Prism 6.0, and Excel. The statistical results are presented in the text using the following conventions: M (Mean) represents the average arithmetic value, SD (Std. Deviation) indicates the mean square deviation, r denotes the Pearson correlation coefficient value, and p signifies the significance level of the correlation coefficient.

RESULTS

Out of 160 volunteers, 35 (21.9%) were excluded from this study due to the presence of conditions such as arm injuries, vascular abnormalities, or other factors that could cause a blood pressure discrepancy between the right and left arms. Upon analyzing the collected data, a total of 125 individuals without cardiovascular diseases and not undergoing drug therapy were included in the study. The mean age of the participants was 38.72±12.134 years, with 54 (43.2%) being male and 71 (56.8%) female. For the purposes of the study, data were collected on hereditary cardiovascular diseases, cardiovascular risk factors and symptoms (Table 1)

Table. 1. Characteristics of the persons surveyed.

	Total number of persons surveyed		**Selected to participate in the study**	
	N	**Percent**	**N**	**Percent**
Gender				
Women	96	60	71	56,8
Men	64	40	54	43,2
Age (Mean± Std. Deviation)		42,23±13,062		38,72±12,134
Height cm		170,69±8,755		171,23±8,894
Weight kg (BMI)	160	74,86±18,200 (25,46±4,868)	125	74±18,673 (25,00±4,647)
Risk factors				
Smoking	78	48,8	69	55,2
Physical activity	45	28,1	37	29,6
Alcohol use	37	23,1	30	24,0
Stress in everyday life	69	43,1	53	42,4
Rational nutrition	92	57,5	72	57,6
Family history of any of the following diseases				
Diabetes mellitus	12	7,5	10	8,0
Cardiovascular disease	55	34,4	34	27,2
Cerebrovascular diseases	14	8,8	7	5,6
Other	15	9,4	11	8,8
Associated diseases				
Diabetes mellitus	2	1,2	-	-
High blood pressure	24	15,0	-	-
Cardiovascular disease	9	5,6	-	-
Cerebrovascular diseases	35	21,9	-	-
Another	74	46,2	47	37,6
Not			78	62,4

After applying the statistical procedure for data analysis, a difference was found in the mean values of brachial blood pressure during systole and diastole (SYS, DIA) measured on the left and right arms, respectively: M $_{LEFT\ SYS}$ = 120.31; SD= 17.515; M$_{LEFT\ DIA}$ = 76.96; SD= 11.812; M$_{RIGHT\ SYS}$ = 122.50; SD=17.414; M$_{RIGHT\ DIA}$ = 77.84; SD=12.617. The absolute difference in systolic blood pressure between the arms in healthy subjects was 2.184 ±8.960 mmHg, at ($t_{|124|}$ = 2.726, p =0.007). The mean absolute difference between the two diastolic values was respectively 0.880 ± 6.474 mmHg at ($t_{|124|}$ = 1.520, p=0.131) (Fig.1, Table.2)

Fig. 1. Visual representation of mean values of brachial blood pressure during systole and diastole measured on the left and right arms.

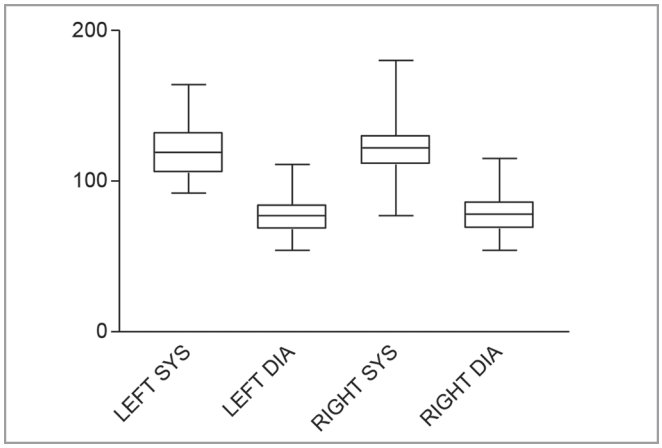

Table. 2. Results of a statistical procedure T-test (Paired Samples Statistics) to establish significant differences for the difference in arterial pressure measured simultaneously in both arms.

		N	Mean	Std. Deviation	Correlation	Sig.	Mean	Std. Dev.	t	df	Sig. (2-tailed)
SYS	*LEFT SYS*	125	120, 31	17,515	,868	,000	-2,184	8,960	-2,726	124	,007
	RIGHT SYS	125	122,50	17,414							
DIA	*LEFT DIA*	125	76,96	11,812	,862	,000	-,88000	6,474	-1,520	124	,131
	RIGHT DIA	125	77,84	12,617							

After applying a statistical procedure, the mean values of the difference in arterial pressure in men and women during systole and diastole, respectively, were calculated. After analyzing the data, the difference in the average values of the arterial pressure measured on the left arm during systole in men and women, respectively (M $_{male\ sys}$ =124.54; SD=17.394 mmHg; M$_{women\ sys}$= 117.10 ±17.032 mmHg), at ($t_{|123|}$ = 2.39, p =0.018). The difference in mean values measured on the right arm during systole in men and women, respectively (M$_{male\ dia}$ = 127.00; SD=14.302mmHg; M$_{female\ dia}$ = 119.07±18.834mmHg) at ($t_{|123|}$ = 2.58, p = 0.011). The difference in mean arterial pressure values measured on the left arm during diastole in men and women, respectively (M$_{men\ dia}$= 80.16; SD= 11.436 mmHg; M$_{female\ dia}$= 74.52; SD=11.584 mmHg), at ($t_{|123|}$ = 2.71, p =0.008). The difference in mean values measured on the right arm during diastole in men and women, respectively (M$_{male\ dia}$ = 82.07; SD= 12.010 mmHg; M $_{female\ dia.}$ = 74.61; SD=12.183mmHg at ($t_{|123|}$ = 3.41, p =0.001). In men, the indicators are higher than in women, with statistically significant differences being reported (Table 3).

Table. 3. Results of a statistical procedure T-test (Test for independent samples) to establish significant differences by gender

	Gender	N	Mean	Std. Deviation	t	df	Sig. (2-tailed)	Mean Difference
LEFT SYS	Male	54	124,54	17,394	2,39	123	,018	7,44
	Female	71	117,10	17,032				
LEFT DIA	Male	54	80,16	11,436	2,71	123	,008	5,64
	Female	71	74,52	11,584				
RIGHT SYS	Male	54	127,00	14,302	2,58	123	,011	7,93
	Female	71	119,07	18,834				
RIGHT DIA	Male	54	82,07	12,010	3,41	123	,001	7,45

Table 4 presents data on the relationship between the individual factors and the values of the correlation coefficient, the corresponding level of significance and the number of observed cases. A directly proportional relationship between increased arterial pressure and the following factors was indicated: age, weight, BMI, Hb, HDL. On the other hand, gender, smoking, alcohol consumption were significantly associated with non-elevated blood pressure among respondents. No statistically significant correlations of arterial blood pressure in both arms with ECG and oxygen saturation were found (Table 4)

Table. 4. Results of the correlation analysis.

		gender	age	smoking	alcohol intake	BMI	weight	Hemoglobin (Hb)	Cholesterol (HDL)
LEFT SYS	Pearson Correlation	-,211*	,335**	-,305**	-,236**	,463**	,450**	,196*	,122
	Sig. (2-tailed)	,018	,000	,001	,008	,000	,000	,028	,177
	N	125	125	125	125	125	125	125	125
LEFT DIA	Pearson Correlation	-,238**	,323**	-,268**	-,263**	,447**	,414**	,220*	,253**
	Sig. (2-tailed)	,008	,000	,002	,003	,000	,000	,014	,004
	N	125	125	125	125	125	125	125	125
RIGHT SYS	Pearson Correlation	-,227*	,363**	-,275**	-,239**	,404**	,395**	,110	,171
	Sig. (2-tailed)	,011	,000	,002	,007	,000	,000	,224	,056
	N	125	125	125	125	125	125	125	125
RIGHT DIA	Pearson Correlation	-,294**	,290**	-,087	-,274**	,476**	,407**	,352**	,229*
	Sig. (2-tailed)	,001	,001	,334	,002	,000	,000	,000	,010
	N	125	125	125	125	125	125	125	125

DISCUSSION

In summary, our findings indicate that in healthy men and women, simultaneous measurement of arterial blood pressure on both arms reveals statistically significant differences. However, these differences, which fall below the threshold of 5 mm/Hg as indicated by guidelines in the literature, are considered insignificant. Nonetheless, there appears to be a trend towards higher brachial blood pressure values in men compared to women, with the parameters on the right arm exhibiting higher values.

In the study sample, no individuals exhibited elevated systolic or diastolic blood pressure. However, a statistically significant relationship was observed between arterial blood pressure values, gender, and age among healthy individuals, with slightly higher values detected in men and with increasing age. Factors such as diabetes, smoking, physical activity, and diet were not found to be associated with differences in blood pressure between the right and left arms. Among the participants, 69 (55.2%) were current smokers, and 24% reported alcohol consumption within the previous seven days. Additionally, 37 (29.6%) engaged in moderate physical activity lasting less than 150 minutes per week.

A statistically significant relationship was observed between increased systolic and diastolic blood pressure and the following factors: age, BMI, weight, Hb, and HDL. Conversely, gender, smoking, and alcohol intake were significantly associated with non-elevated systolic and diastolic pressure among respondents.

CONCLUSION

Although the differences are small (5 mmHg), differences in systolic arterial pressure between the arms in healthy people are reliable and, in this sense, can be indicative. This difference may be an important indicator of increased cardiovascular risk. Routine bilateral blood pressure measurements to detect differences should be incorporated into initial cardiovascular evaluations. This approach is effective and straightforward for assessing atherosclerotic involvement and identifying patients at higher cardiovascular risk.

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