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BLOOD PRESSURE CHANGES AMONG SUBJECTS WITH NORMAL BLOOD PRESSURE OR HYPERTENSION PRACTISING TREKKING

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Abstract: *The aim of this study was to monitor systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR) and symptoms of effort on climbing between 850 and 2500 m, in a group of 164 subjects aged between 35 and 65. The results were: subjects of all ages with normal tension at the beginning of the tour had moderate increases in systolic blood pressure and heart rate; subjects with moderately high blood pressure showed significant increases in systolic and diastolic blood pressure, but below 160/95 mmHg, 10 minutes after the effort ended. Untreated hypertensive subjects had blood pressure values up to 170 / mm Hg, and those with very high additional cardiovascular risk had SBP average values above 170/100 mmHg. Hypertensive subjects treated with ß-blockers and diuretics and those treated with inhibitors of the angiotensin converting enzyme (ACE inhibitors) had significant increases in SBP, but there were no significant changes in DBP.*

Key words: *blood pressure, heart rate, ß-blockers, ACE inhibitors.*

1. Introduction

Hiking in the mountains is practiced by people of all ages, healthy or diagnosed with subclinical cardiovascular disease. Some studies in Austria on hypertension among practitioners of hiking reported that subjects with a history of hypertension can temporarily develop at low altitude an increase in blood pressure even if they are under treatment or control their blood pressure values at low altitude. A small percentage of patients with controlled hypertension present hypertensive jumps due to effort at altitude [4]. Hypertension is the most frequent cardiovascular disease in the population, with a prevalence between 39.1 and 40, 1 after some population studies in Romania [2], [1].

The main objective of this research was to study the cardiovascular adaptation to effort of normotensive or hypertensive subjects by evaluating changes in systolic (SBP) and diastolic (DBP) blood pressure, heart rate (HR), electrocardiogram (ECG) at the beginning of the tour, after the climbing effort from an attitude of 850m to 2505 m and after the descending effort back to 850 m.

The secondary objective was to evaluate the subjective tolerance to effort and the cardiovascular symptoms.

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2. Material and method

The research was carried out between 30th June to 25th August 2011, July 5th to 15th August 2012 and from 26th June to 10th August 2013 on 164 subjects who trekked on Cerbului Valley between an altitude of 850 m (Busteni resort) and 2505 m (Omu Peak), with descent on the same itinerary. The tour included trails of moderate difficulty between 2000 and 2505 m. The weather conditions were favorable; the atmospheric pressure at 2505 m was 560 mmHg.

Of the 164 subjects, 125 were men (76.30%) and 39 women (23.70%), aged between 35 and 65 (with a mean age of 47.15 years±10.49). They were in a relatively good physical condition, appropriate for the climbing effort of 6-7 hours and the descending one of 4-5 hours, with an equipment of 8 kg on average.

Blood pressure and heart rate were measured on the ascent trail, at the altitude of 850 m and 2000-2505m, and along the route of descent at the altitudes of 2000 and 850 m. The measurement of blood pressure and heart rate were reiterated after an average pause of 10 minutes. Data on age, sex, body mass index, personal history of hypertension and cardiovascular disease, antihypertensive medication in the last 14 days and on the hiking day, the symptoms occurred during hiking (with reference to the nature of chest pain angina, palpitations, dyspnea, vertigo, faintness or intermittent claudication) were also recorded.

Hypertension was defined and staged using the criteria in the report of the Joint National Committee Eight (JNC 8) [7] and was measured with Omron M6 Comfort.

The research data were collected by two nurses, a doctor, two rescuers, a mountain guide and a worker at the station on the Omu Peak, located at an altitude of 2505m. All participants in the research gave their informed consent.

3. Statistics

The data processing programme used was IBM SPSS Statistics, Version 20. Data were reported as mean and standard deviation for continuous variables (SBP, DBP and HR). Significance of difference between means SBP, DBP and HR at 850 m and 2505 m were calculated by parametric t-student test. P value less than 0.05 was considered statistically significant, p=0.01 and p = or < 0.001 highly significant statistically. In the case of homogeneous variables I used the non-parametric Mann Whitney U. The correlation coefficient was calculated by means of Spearman test for non-parametric correlations. The coefficient of significance for the difference between each symptom and the medication was calculated by means of the parametric t-student test. The value of p less than 0.05 was considered statistically significant, p = 0.01, highly significant statistically, p = or <0.001 very highly significant statistically and p> 0.05 was considered statistically insignificant.

4. Results

The 164 subjects included in this evaluation were divided into subgroups by age: subgroup I aged 35-45, subgroup II aged 46-55, and subgroup III aged 56 -65. Subgroup I consisted of 59 subjects (35, 97%), of which 41 (69.41%) had normal and high-normal blood pressure; 9 (15.25%) 1st degree hypertension without antihypertensive treatment; 4 (6.71%) under treatment with ß-blocker, with or without diuretics, and 5 (8.47%) under treatment with ACE inhibitors, with or without diuretics.

Subgroup II included 56 subjects (34.14%), of which 24 with normal and high-normal BP (42.85%), 17 with hypertension grade 1 without antihypertensive treatment (30.35%), 15 patients under hypertension treatment (26.78%), 7 under treatment with beta-blockers and diuretics (12.5%) and 8 treated with ACE inhibitors and diuretics (15.28%%). Among the subjects under treatment, 10 (66.66%) had moderate and high cardiovascular risk and 5 (33.33%) very high cardiovascular risk.

Subgroup III consisted of 49 subjects (29.87%), including 15 with normal and high normal blood pressure (30.61%), 11 patients with hypertension grade 1 without antihypertensive treatment (22.44 %), 23 (46.93) under treatment for hypertension, of which 9 (18.36%) with ß-blocker in combination with diuretics and 14 (28.57) with ACE inhibitors and diuretics. Among the treated subjects, 16 had additional moderate and high-risk blood pressure (69.55%) and 7 very high-risk blood pressure (30.45%).

For the three subgroups of subjects, the demographic and clinical data showed that the average values of the Body Mass Index (BMI) for the subjects in subgroup I was 26.71 kg / m²±2.28 (between 23.74 and 30.32 kg / m²), 26 subjects were overweight (44%), 2 obese or overweight grade 2 (3.38%%); for the subjects in subgroup II, the mean BMI was 28.29 kg / m²±2.21 (between 23.32 and 31.40 kg / m²), 36 of the subjects were overweight (64.28%), 4 obese or overweight grade 2 (17 , 14%); for subgroup III the mean BMI was 27.97 kg / m²±2.71 (between 23.5 and 31.6 kg / m²), 28 of the subjects were overweight (57.14%), 2 obese or overweight class 2 (4 , 08%).

Of the 47 subjects (28.62%) under treatment for hypertension, 25 (53.19%) were evaluated with moderate cardiovascular risk (SBP over 140 mmHg and DBP 90 mmHg, overweight grade 2, dyslipidemia); 10 with high cardiovascular risk (21.27%) (hypertension grade 1 or 2 with type 2 diabetes mellitus (5 cases), obesity, dyslipidemia, smoking), and 12 subjects with very high cardiovascular risk (23.53%) (SBP over 180 mmHg with diabetes and dyslipidemia (6 subjects); SBP below 180 mmHg, but with old myocardial infarction (2 subjects); dyslipidemia, obesity and peripheral arterial disease (3 subjects); hypertension grade 2 and stable effort angina of was known in 1 subject.

The mean values of SBP, DBP, HR at the altitude of 850 m and 2505 m are illustrated for the subjects in subgroup I in Tables 1 and 2, for those in subgroup II in Tables 3, 4 and 5 and for those in subgroup III in Tables 6, 7 and 8.

The results show that for subjects aged between 35 and 45, with normal and high normal blood pressure, the ascent from 850 m to 2 500 m caused significant increase in mean SBP, DBP and heart rate. A significant increase in mean SBP, DBP and heart rate was also recorded in untreated hypertensive participants. In hypertensive patients undergoing treatment with ACE inhibitors and thiazide diuretics significant increases in systolic blood pressure and heart rate were recorded, while in those under treatment with beta blockers and thiazide diuretics the mean values of SBP, DBP and heart rate did not change significantly (Tables 1 and 2).

Average values of blood pressure and heart rate in the age group 35-45 Table 1

	Normal blood pressure			High normal blood pressure		
	SBP	**DBP**	**HR**	**SBP**	**DBP**	**HR**
850m altitude	122,73	78,03	86	134	87,14	83,88
2505m altitude	145,11	84	89,92	146,76	92,42	86,76
p	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	=0,055

Table 2

Average values of blood pressure and heart rate in the age group 35-45

	Untreated hypertensive subjects			Hypertensive subjects treated with ß-blockers and diuretics			Hypertensive subjects treated with ACE inhibitors and diuretics		
	SBP	**DBP**	**HR**	**SBP**	**DBP**	**HR**	**SBP**	**DBP**	**HR**
850m altitude	146,11	92	83,77	144,75	86,5	71	144,4	88	88
2505m altitude	158,55	94,55	94,55	157,5	88,5	82	159,8	89	107,2
p	=0,004	0,090	=0,001	=0,039	=0,139	=0,022	=0,001	=0,189	<0,001

For subjects in the age group 46-55, the ascent to 2500 m resulted in significant increases in the mean values of SBP, DBP and heart rate in both normotensive and high normal hypertensive subjects. Both hypertensive subjects treated with ACE inhibitors and diuretics and those treated with beta-blockers and diuretics experienced significant increases in heart rate and systolic blood pressure, the climbing effort having no significant influence on the values of DBP of subjects treated with beta blockers and diuretics influence on the values of DBP of subjects treated with beta blockers and diuretics (Tables 3 and 4).

Table 3

Average values of blood pressure and heart rate in the age group 46-55

	Normal blood pressure			High normal blood pressure		
	SBP	**DBP**	**HR**	**SBP**	**DBP**	**HR**
850m altitude	126,8	77,9	75,6	136,9	87,14	77,85
2505m altitude	149,5	81,5	97	160,5	92,42	108,28
p	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001

Table 4

Average values of blood pressure and heart rate in the age group 46-55

	Untreated hypertensive subjects			Moderate and high-risk hypertension			Very high-risk hypertension		
	SBP	**DBP**	**HR**	**SBP**	**DBP**	**HR**	**SBP**	**DBP**	**HR**
850m altitude	146,3	94	86	150,70	94,2	83,6	157,6	102	86,2
2505m altitude	167,4	97,7	108,1	164,70	97,8	104,2	173,8	108,6	104,2
p	<0,001	<0,005	<0,001	<0,001	=0,019	<0,001	=0,020	=0,008	=0,005

The ascent resulted in significant increases in the mean values of systolic blood pressure in the normotensive subjects of the age group 56-65, while subjects with high-normal blood pressure presented considerable increases in the mean values of SBP, DBP and heart rate (Tables 5 and 6).

Table 5

Average values of blood pressure and heart rate in the age group 46-55

	Hypertensive subjects treated with ß-blockers and diuretics			**Hypertensive subjects treated with ACE inhibitors and diuretics**		
	SBP	**DBP**	**HR**	**SBP**	**DBP**	**HR**
850m altitude	145,42	94,42	73,42	147,87	95	85,75
2505m altitude	158	98,28	86	159,75	100	106,5
p	<0,001	=0,073	=0,003	=0,007	=0,025	<0,001

*p < 0,001, for HR at 850 m, treated with ß-blockers and ACE inhibitors, diuretics
p < 0,001, for HR at 2505 m, , treated with ß-blockers and ACE inhibitors, diuretics

Table 6

Average values of blood pressure and heart rate in the age group 56-65

	Normal blood pressure			**High normal blood pressure**		
	SBP	**DBP**	**HR**	**SBP**	**DBP**	**HR**
850m altitude	128	83	80	138,2	88,1	84,2
2505m altitude	155	86,2	88	161	94	104,6
p	= 0,001	= 0,061	=0,037	< 0,001	< 0,001	< 0,001

At this age subgroup, the hypertensive subjects under treatment had a significant increase in systolic blood pressure and heart rate, regardless of the cardiovascular risk (Tables 7 and 8). Hypertensive aged 56-65, treated either with ACE inhibitors and diuretics or beta-blockers and diuretics had a significant increase in SBP, DBP and heart rate on ascent (Table 8).

Table 7

Average values of blood pressure and heart rate in the age group 56-65

	Untreated hypertensive subjects			**Moderate and high-risk hypertension**			**Very high-risk hypertension**		
	SBP	**DBP**	**HR**	**SBP**	**DBP**	**HR**	**SBP**	**DBP**	**HR**
850m altitude	157,54	96,45	81,18	155,06	93,12	82,50	158,85	100,85	84
2505m altitude	171,09	96,81	104,18	169,43	95,50	105	166	102,85	103,71
p	=0,002	=0,659	<0,001	<0,001	=0,023	<0,001	=0,017	=0,111	<0,001

Average values of blood pressure and heart rate in the age group 56-65 Table 8

	Hypertensive subjects treated with ß-blockers and diuretics			**Hypertensive subjects treated with ACE inhibitors and diuretics**		
	SBP	**DBP**	**HR**	**SBP**	**DBP**	**HR**
850m altitude	148,55	95,77	72	145,71	93,57	83,85
2505m altitude	158,44	97,88	88	155,85	95,50	103,85
p	<0,001	=0,021	<0,001	<0,001	<0,001	<0,001

*p < 0,001, for HR at 850 m, treated with ß-blockers and ACE inhibitors, diuretics
p = 0,001, for HR at 2505 m, treated with ß-blockers and ACE inhibitors, diuretics

During the ascent to 2500 m, were recorded the most common symptoms which created discomfort on effort and resolved late, after a period of rest. Of the 47 subjects with hypertension under treatment, 20 were treated with ß-blockers and diuretics and 27 with ACE inhibitors and diuretics. From the subjects treated with ß-blockers, 5 had palpitations, frequently between 2000 and 2500 m, 7 vertigo, 7 mild headache, which were not associated with digestive disorders. Symptoms were more frequent between 55 and 65 years, predominantly in women. Dyspnea on effort was recorded especially in the final part of the ascent, between 2300 and 2500 m, in individuals aged between 50 and 65. Symptomatic dyspnea gradually resolved within 15 minutes of rest. Chest pain was present in 2 subjects. The statistical analysis showed no correlation between the symptoms described by these subjects and the treatment with beta-blockers associated with diuretics or with angiotensin-converting enzyme inhibitor associated with diuretics (Table 9).

Table 9

The correlation between symptoms and antihypertensive medication

Symptoms	Palpitations	Vertigo	Headache	Chest pain	Dyspnea
ß-blockers	5	7	7	2	8
ACEI	11	12	9	4	10
r/p	r = - 0.182 p= 0.444	r = + 0.043 p= 0.858	r = - 0.242 p= 0.303	r = + 0.250 p= 0.288	r = - 0.010 p= 0.960

ACEI = angiotensin converting enzyme inhibitors

5. Discussions

The interest in this subject is justified because hypertension is common with practitioners of trekking at medium altitude and moderate exercise is recommended in patients with hypertension [9]. The effort is recognized as "a drug-free approach to lowering high blood pressure" when it is moderate and constant, hypertension management guidelines indicating that the non-pharmacological method to reduce blood pressure as moderate exercise (30 min / day exercise every day or at least 5 times / week). The 2013 ESH / ESC Guidelines for the management of arterial hypertension recommends as the first kind of moderate effort walking, then jogging, cycling or swimming on 5-7 days per week [9]. The decrease of blood pressure through moderate effort refers to blood pressure values obtained between periods of moderate effort and achieved through constant exercise, for weeks or months. The values of SBD decrease on effort by 15 mmHg and the decrease over this value in the untrained one may indicate coronary artery disease or dehydration [6].

During the exercise, including the moderate one, the adaptation to effort of untrained persons is made by the sympathetic system which increases the heart rate and the systolic blood pressure. The metabolic vasodilation caused by the release of metabolites after effort [3] prevents large increases in blood pressure and influences the post-effort behavior of blood pressure in trained patients. Normotensive and high-normal blood pressure subjects adapt to effort by moderate increase in SBP, DBP and HR. The increases in high blood pressure during exercise define the by values of blood pressure ≥ 250 / 130 mmHg recorded at standardized maximal effort. In subjects with normal blood pressure at rest the emergence of the "hypertension of effort" identifies a population subset which will develop hypertension at rest, the large increases in SBP being potentially involved in triggering cardiovascular events in hypertensive patients. Endothelial dysfunction and increased stiffness of large vessels are described as pathogenic mechanisms of high stress [11], [12]. The predictive value for the occurrence of hypertension and of the increases in SBP with less than 250mmHg at effort have not been evaluated increases the effort SBP. After the effort, the blood pressure values decrease by decreasing the occurrence of vasodilatation after effort due to sympathetic nervous system activity and metabolic vasodilation [5]. The decrease in BP after effort starts 3 minutes after the end of the exercise [6].

Our study revealed moderate increase in systolic blood pressure and heart rate values in normotensive subjects of all subsets of age after moderate effort during hiking up to an altitude of 2500m. Subjects with moderate high blood pressure, regardless of age, showed significant increases in SBP and DBP, which 10 minutes post-effort were ≤ 160/95 mmHg. Untreated hypertensive subjects had significant increases in mean SBP and DBP during moderate effort of ascent, which at the age subgroup 35- 45 were ≤ 160/95 mmHg. Untreated hypertensive subjects from the age subgroups 46-55 and 46-65 years had significant increases in the mean SBP during the climbing effort, which was < 170/100 mmHg. Hypertensive subjects with very high additional cardiovascular risk from the age subgroup 45-55 had mean values of SBP > 170 / 100mmHg.

Our results show that symptoms are common in patients with hypertension and they can sometimes be linked to increased blood pressure, but that is not influenced by the quality of antihypertensive medication. Clinical observations have suggested that treatment with ß-blockers, by reducing heart rate, may reduce tolerance to effort and symptoms in patients with hypertension [8]. Recent data included in the *Australian Association for Exercise and Sports Science Position Statement on Exercise and Hypertension* emphasize that ß-blockers "may, therefore, BE APPROPRIATE to use more of perceived exertion rating, rather than target heart rates to gauge the intensity of prescribed exercise" [10]. Data on antihypertensive medication and exercise stresses that diuretics may limit tolerance to effort by the hypovolemia determines [3] and that drugs that produce moderate vasodilatation without compensatory tachycardia seem the most well tolerated antihypertensive drugs in patients engaged in physical effort.

6. Conclusions

1. The effort associated to hiking to an altitude of 2500 m causes moderate increases in systolic blood pressure and heart rate both in subjects with high normal blood pressure and in treated or untreated hypertensive ones.

2. With hypertensive subjects with high additional cardiovascular risk and the age subgroup 46-55 the average BP value exceeded 170/105 mmHg and were frequently symptomatic.

3. Antihypertensive medication does not seem to differentiate the increase in blood pressure or influence the appearance and type of symptoms occurring during the hiking up to 2500m.

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