Journal of
HYPERTENSION RESEARCH
www.hypertens.org/jhr

Original Article
J Hypertens Res (2021) 7(2):60-68

The combined effect of alcohol consumption and smoking on blood pressure and the achievement of blood pressure target values in treated hypertensive patients

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Received: May 3, 2021, Accepted: June 11, 2021

Abstract

The combined effect of alcohol consumption and smoking on hypertension in hypertensive patients is still not completely clear, although both are known to be cardiovascular risk factors. The aim of our study was to compare the blood pressures and the achievement of target blood pressure as well as heart rate values of middle-aged, non-smoking, and non-drinking hypertensive patients with those who smoke and drink regularly. From the Hungarian Hypertension Registry database, 12,615 patients (6,341 men and 6,274 women) aged 45-64 years were included in the current analysis, who self-reported a smoking habit and regular alcohol consumption. The mean age of the patients was 55.8±5.7 years (males) and 56.1±5.5 years (females). The percentage of regular smokers was 40.8% and 27.2% in men and women, respectively. 38.1% of males and 12.5% of females were regular alcohol drinkers. The ratio of patients reaching goal blood pressure values was higher in all investigated groups of females than in males ($p<0.001$). Regular smokers and drinkers have a lower percentage of reaching goal blood pressure values: 31.1% versus 46.6% in males ($p<0.001$) and 41.1% versus 49.8% in females ($p<0.01$), respectively. The mean pulse rate was higher in patients who are both smokers and regular drinkers. Regular alcohol consumption and smoking decrease the chance of reaching blood pressure goal values in treated hypertensive patients of middle-age.

Keywords: alcohol consumption, smoking, blood pressure, heart rate, hypertension.

Abbreviations: ACE – angiotensin-converting enzyme; BMI – body mass index; CI – confidence interval; CV – cardiovascular; DBP – diastolic blood pressure; GBD – global burden of disease; GLM – general linear model; MHR – Hungarian Hypertension Registry; OR – odds ratio; SBP – systolic blood pressure; WHO – World Health Organization.

Introduction

A 2017 analysis performed by the GBD Tobacco Collaborators Working Group examined the prevalence of smoking and the "burden of disease"

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sociated with smoking between 1990 and 2015, according to the World Health Organization (WHO) regions and 195 countries. The age-adjusted global prevalence of smokers in 2015 was 25% for men (24.2–28.7%, 95% CI). The incidence was higher in 51 countries, mainly in Central and Eastern Europe and Southeast Asia. For women, the global prevalence was 5.4% (5.1–5.7%, 95% CI), while the incidence was higher in 70 countries, primarily in Western and Central Europe. Smoking is the third most significant risk factor for all-cause mortality [1]. According to a similar worldwide survey by GBD 2016 Alcohol Collaborators published in 2018, the global proportion of regular drinkers in 2016 was 32.5% for men and 25% for women, and alcohol consumption was the seventh most significant mortality risk factor [2]. Based on a 30-year observational study, Hart *et al.* demonstrated that compared with those who did not smoke and drink alcohol regularly, the combined presence of these two risk factors significantly increased all-cause mortality in people aged 35–64 years: it doubles mortality from coronary artery disease, triples the occurrence of stroke-related death, causes a fivefold increase of mortality due to lung carcinoma, and a tenfold chance of dying as a result of chronic respiratory disease [3].

Our knowledge of the effects of alcohol consumption and smoking on blood pressure in hypertensive patients is still incomplete. Nevertheless, based on the available data, in the case of alcohol, long-term regular consumption is a decisive factor, where the correlation between the level of consumption and the increase in blood pressure shows a J-curve shape for women, while the correlation is more linear for men [4, 5]. The effect of smoking on blood pressure can be divided into two stages: in the first, acute phase, the blood pressure slightly decreases, but in the second, long-term phase, the toxic effects of nicotine and carbon monoxide make the vessel wall stiffer, and the systolic pressure begins to rise. The underlying causes for all these phenomena are increased sympathetic activation, angiotensin-II efflux, and their consequences [6, 7]. This condition is also related to elevated heart rate in all cases [8].

The aim of our study was to compare the blood pressure, the achievement of target blood pressure, and heart rate values of non-smokers and non-drinkers in middle-aged hypertensive patients with those who smoke and drink regularly.

Material and Methods

Between 1 March and 31 May 2015, 27,399 treated hypertensive patients were registered in the Hungarian Hypertension Registry (MHR). Of these, 12,615 patients (6,341 men and 6,274 women) aged 45–64 years were included in the current analysis, who self-reported smoking habits and regular alcohol consumption. The extent of the two risk factors was not examined, so only regular smokers (≥10 cigarettes per day) and alcohol drinkers (≥28 drinks/week for men, ≥7 drinks/week for women) were included. Patients were selected continuously in the general practitioner's office on consecutive days using a special Hypertension Data Sheet. Patients were checked by the general practitioner every 3 months on average. In all patients, morning blood pressure and heart rate values were measured (the average of the two measurements was taken). In each case, we measured the characteristics of obesity (body mass index – BMI, abdominal circumference, serum triglyceride levels) and registered diabetic patients.

We formed 4 groups during the analysis: Group I: non-smoker and non-drinker, Group II: only smoker, Group III: only drinker, Group IV: smoker and drinker. Differences between groups were examined as a function of systolic (SBP) and diastolic (DBP) blood pressure, target blood pressure, resting heart rate, anthropological data, triglyceride levels, and diabetes. Factors influencing blood pressure values were analyzed using the multivariate general linear model (GLM) analysis, and the chance of not reaching the target blood pressure value was analyzed by multivariate logistic regression. The difference between the two variables was considered significant at $p<0.05$.

The data collection was authorized by the Medical Research Council Scientific and Research Ethics Committee – ETT TUKEB – under the 21437/1/2015/EKU (152/2015) case number.

Results

The average age of the patients was 55.8±5.7 years for men and 56.1±5.5 years for women. The prevalence of smoking was 40.8% and 27.2% in men and women, respectively. 38.1% of the men and 12.5% of the women consumed alcohol regularly. More than two-thirds of patients had been receiving antihypertensive treatment at least for three years in both sex categories. The majority of them were on multiple antihypertensive treatments and the prevalence of monotherapy was below 15% in both genders and all subgroups. The baseline characteristics of all four subgroups are included in Tables 1 and 2. The differences in systolic and diastolic blood pressures are shown in Figure 1 and Table 3.

The average blood pressures of men were significantly higher than those of women in all subgroups. The systolic and diastolic blood pressures of regular drinkers and smokers were also significantly higher both in men and women when compared to

Table 1. Baseline data in hypertensive men aged 45–46 years according to smoking and drinking habits.

Males		I. non-smoker and non-drinker	II. only smoker	III. only drinker	IV. smoker and drinker
Number, n (%)		2737 (43,2)	1190 (18, 8)	1018 (16,1)	1396 (22,0)
Age, year (mean±SD)		55.7±5.8	55.5±5.8	56.2±5.4	55.8±5.5
BMI, kg/m² (mean±SD)		29.6±4.7	29.1±4.6	30.2±4.6	29.7±4.8
Abdominal circumference, cm (mean±SD)		100.1±14.6	98.7 ±13.9	102.7±13.9	100.9±14.8
Triglycerides, mmol/l (mean±SD)		2.14±1.63	2.28±2.05	2.25±1.41	2.33±1.78
Diabetes, %		25.1	23.7	27.8	31.8
Systolic blood pressure, mmHg (mean±SD)		138.8±14.9	140.5±15.4	140.9±14.7	144.7±16.3
Diastolic blood pressure, mmHg (mean±SD)		82.3±8.0	83.3±8.1	83.6±8.1	84.7±8.1
Pulse pressure, mmHg (mean±SD)		56.5±12.9	57.2±13.2	57.3±12.8	60.1±13.6
Heart rate, beats/min (mean±SD)		76.0±7.9	77.1±8.0	77.5±8.8	78.3±8.6
Blood pressure <140/90 mmHg, %		46.6	43.2	42.3	31.1
Monotherapy (%)		14.3	9.9	12.7	8.0
Patient distribution by duration of treatment for hypertension, %	within 1 year	13.6	15.0	13.1	14.3
	1–2 years	13.8	14.5	11.3	12.5
	3–5 years	27.4	29.1	29.5	25.6
	>5 years	45.2	41.4	46.1	47.6

BMI – body mass index; SD – standard deviation.

non-drinkers or non-smokers. In men, systolic and diastolic blood pressures are higher if they smoke or drink compared to the non-drinker, non-smoker subgroup. This does not apply to women.

Table 4 shows the factors determining systolic and diastolic blood pressure values using GLM analysis. Regular smoking and drinking have a substantial effect on systolic blood pressure in both sex cate-

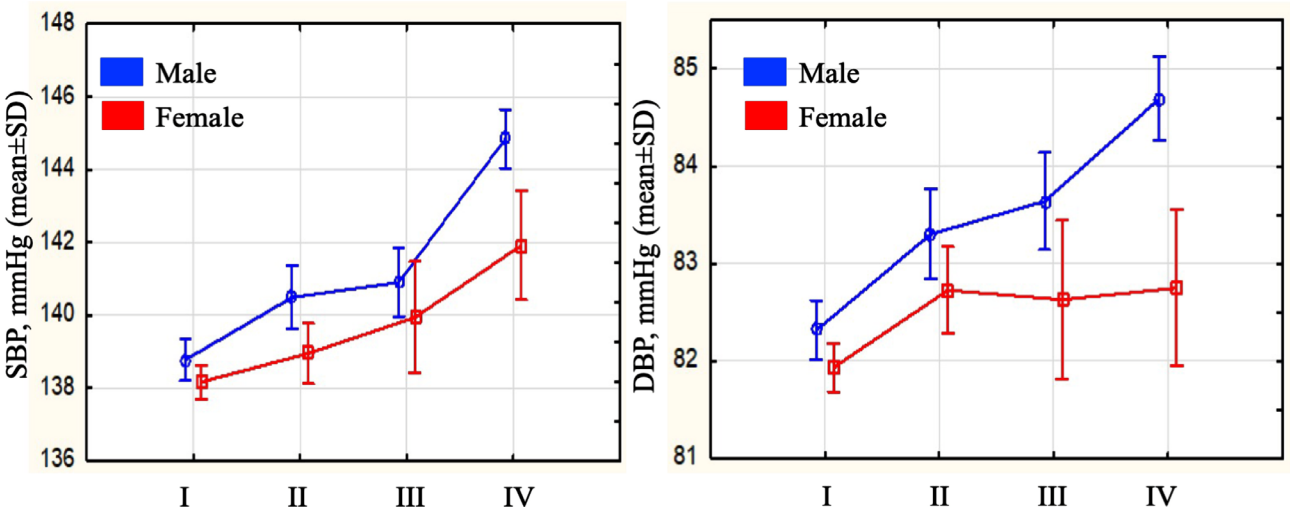


Figure 1. Mean systolic and diastolic blood pressures (±SD), according to smoking and drinking habits.
I – non-smoker + non-drinker; II – only smoker; III – only drinker; IV – smoker + drinker; DBP – diastolic blood pressure; SBP – systolic blood pressure.

Table 2. Baseline data in hypertensive women aged 45–46 years according to smoking and drinking habits.

Females		I. non-smoker and non-drinker	II. only smoker	III. only drinker	IV. smoker and drinker
Number, n (%)		4184 (66.7)	1307 (20.8)	384 (6.1)	399 (6.4)
Age, year (mean±SD)		56.3±5.5	55.3±5.6	56.2±5.3	55.4±5.6
BMI, kg/m² (mean±SD)		29.1±5.7	28.3±5.2	29.5±5.2	28.6±5.4
Abdominal circumference, cm (mean±SD)		94.2±14.9	93.1±14.4	95.6±15.3	93.7±13.9
Triglycerides, mmol/l (mean±SD)		1.98±1.19	1.99±1.03	2.3±1.27	2.18±1.15
Diabetes, %		20.4	21.7	17.7	28.8
Systolic blood pressure, mmHg (mean±SD)		138.2±15.0	138.9±16.9	139.9±16.9	141.9±16.8
Diastolic blood pressure, mmHg (mean±SD)		81.9±8.1	82.7±8.4	82.6±8.8	82.7±8.3
Pulse pressure, mmHg (mean±SD)		56.2±12.7	56.2±12.2	57.3±13.9	59.2±14.6
Heart rate, beats/min (mean±SD)		76.2±8.0	76.9±8.6	77.3±8.9	78.1±9.3
Blood pressure <140/90 mmHg, %		49.8	47.4	45.6	41.1
Monotherapy (%)		15.1	10.8	13.0	9.3
Patient distribution by duration of treatment for hypertension, %	within 1 year	15.0	16.7	19.6	15.2
	1–2 years	12.5	13.0	12.3	15.9
	3–5 years	28.3	30.9	35.4	29.3
	>5 years	44.2	39.4	32.7	39.6

BMI – body mass index; SD – standard deviation.

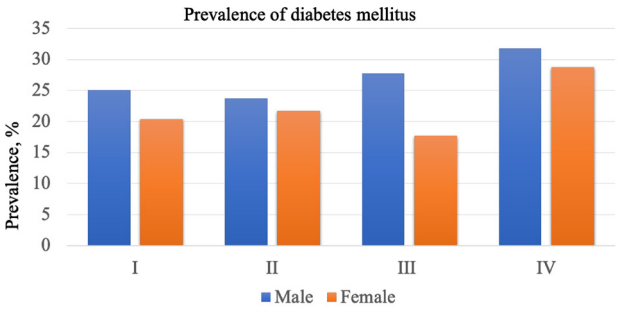
Table 3. Significance of differences in blood pressure values by groups. Group I: non-smoker and non-drinker; Group II: only smoker; Group III: only drinker; Group IV: smoker and drinker.

Systolic blood pressure	**I. vs. II.**	**I. vs. III.**	**I. vs. IV.**	**II. vs. III.**	**II. vs. IV.**	**III. vs. IV.**
Males. p-value	<0.01	<0.001	<0.001	0.92	<0.001	<0.001
Females. p-value	0.38	0.1	<0.001	0.68	<0.01	0.27
Diastolic blood pressure	**I. vs. II.**	**I. vs. III.**	**I. vs. IV.**	**II. vs. III.**	**II. vs. IV.**	**III. vs. IV.**
Males. p-value	<0.01	<0.001	<0.001	0.76	<0.001	<0.01
Females. p-value	0.013	0.38	0.23	0.99	0.99	0.99

Table 4. Analysis of the factors determining the value of blood pressure.

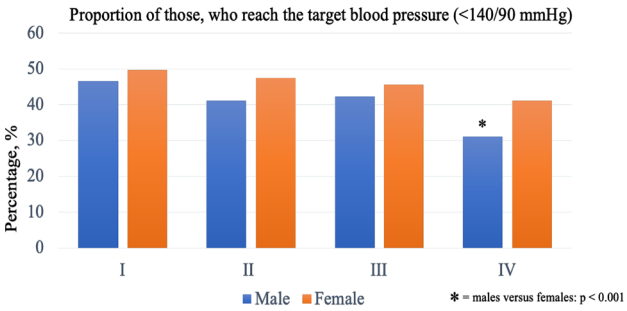
Factors	Systolic blood pressure. p-value		Diastolic blood pressure. p-value	
	Males	Females	Males	Females
Age (45–64 years)	0.012	<0.01	<0.01	<0.001
Smoking	<0.001	<0.001	<0.001	0.13
Drinking	<0.001	<0.01	<0.001	0.47
Diabetes mellitus	0.07	<0.001	0.046	<0.01
BMI	<0.001	<0.001	<0.001	<0.001
Triglycerides	<0.001	<0.001	<0.001	<0.001

BMI – body mass index.



	I vs II	I vs III	I vs IV	II vs III	II vs IV	III vs IV
Male	0.81	0.33	< 0.001	0.13	< 0.001	< 0.12
Female	0.77	0.6	< 0.001	0.34	0.011	< 0.001

Figure 2. Prevalence of diabetes in male and female hypertensive patients between 45–64 years of age, according to smoking and drinking habits. I – non-smoker + non-drinker; II – only smoker; III – only drinker; IV – smoker + drinker.



	I. vs II.	I. vs III.	I. vs IV.	II. vs III.	II. vs IV.	III. vs IV.
Male	0.19	0.08	< 0.001	0.98	< 0.001	< 0.001
Female	0.46	0.39	< 0.01	0.92	0.12	0.59

Figure 3. Percentage of men and women aged 45–64 years who achieve the target blood pressure below 140/90 mmHg, according to smoking and drinking habits. I – non-smoker + non-drinker; II – only smoker; III – only drinker; IV – smoker + drinker.

gories, while diastolic pressures are affected only in men. BMI and triglyceride levels are also significant determining factors in both genders. Diabetes prevalence differed significantly only in women.

When comparing the four subgroups, BMI, abdominal circumference, and serum triglyceride levels did not differ significantly.

The prevalence of diabetes in each subgroup is shown in Figure 2. In men, diabetes was more prevalent ($p<0.001$) in the subgroup of regular drinkers and smokers (31.8%) than in the non-smoker, non-drinker subgroup (25.1%). The same pattern was observed in women (28.8% vs. 20.4%, $p<0.001$). Diabetes is more frequent in men than women in all four subgroups ($p<0.001$).

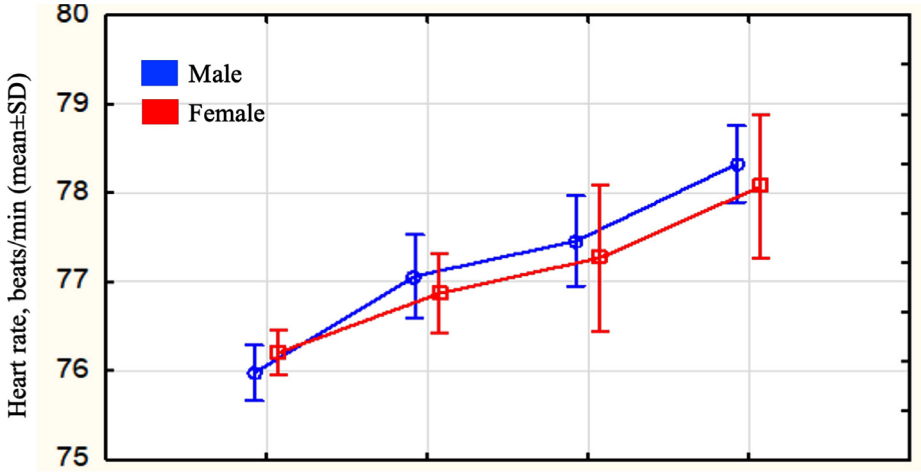
There were considerable differences among the four subgroups in reaching the target blood pressure value (<140/90 mmHg) regarding drinking and smoking habits. The differences are displayed in Figure 3.

Women reached the target blood pressure more often (<0.001) than men in all subgroups. The proportion of those reaching the target blood pressures in regular smokers and drinkers was significantly lower (particularly in men) than in non-drinkers, non-smokers (31.1% vs. 46.6% in men and 41.1 vs. 49.8% in women, respectively, <0.001). The odds ratio for not reaching the target blood pressure was analyzed using multivariate logistic regression (Table 5). Based on these results, the odds ratio for not reaching the target blood pressure was associated with the coexistence of regular drinking, smoking, obesity (defined as BMI >30kg/m^2), elevated serum triglyceride level, and the presence of diabetes mellitus.

Table 5. Odds ratio for not reaching the target blood pressure values (<140/90 mmHg) with age-adjusted multivariate logistic regression.

Factors	Multivariate logistic regression (adjusted for age)					
	Males			Females		
	OR	95% CI	p	OR	95% CI	p
Only smoker vs. non-smoker and non-drinker	1.18	1.02–1.36	0.02	1.06	0.93–1.21	0.38
Only smoker vs. non-smoker and non-drinker	1.13	0.97–1.31	0.12	1.09	0.88–1.36	0.44
Drinker and smoker vs. non-smoker and non-drinker	1.82	1.59–2.10	<0.001	1.37	1.10–1.71	<0.01
BMI ≥30 kg/m^2	1.39	1.25–1.55	<0.001	1.43	1.28–1.59	<0.001
Triglycerides ≥1.7 mmol/l	1.59	1.42–1.77	<0.001	1.54	1.38–1.71	<0.001
Diabetes	1.18	1.04–1.33	<0.01	1.28	1.13–1.46	<0.001

BMI – body mass index; CI – confidence interval; OR – odds ratio.



	I. vs II.	I. vs III.	I. vs IV.	II. vs III.	II. vs IV.	III. vs IV.
male	< 0.001	< 0.001	< 0.001	0.67	< 0.001	0.052
female	0.054	0.07	< 0.001	0.83	0.053	0.53

Figure 4. Mean heart rate values (±SD), according to smoking and drinking habits. I – non-smoker + non-drinker; II – only smoker; III – only drinker; IV – smoker + drinker.

The mean heart rates of each subgroup are shown in Figure 4. The mean heart rate of regular smokers or drinkers is higher compared to those not smoking or drinking. In both sexes, a noticeable difference ($p<0.001$) is present when the non-smoker, non-drinker group is compared to the drinker and smoker group.

Discussion

The cardiovascular (CV) effects of alcohol consumption and smoking have been described previously by several publications, although most of these analyses discuss them separately. The HARVEST study already proved that the degree of drinking (abstinent, moderate drinker, heavy drinker) has a significant effect on blood pressure in hypertensive patients [9]. In the latter group of patients, 24-hour and daytime systolic blood pressures were significantly higher; moreover, increased left ventricular mass was also observed [9].

In 2014, Holmes *et al.* used Mendelian randomization to analyze the cardiovascular effects of alcohol consumption in 261.991 European individuals [10]. It was found that lower levels of alcohol consumption are beneficial, while regular intake and large quantities are associated with elevated cardiovascular risk. Regular, heavy drinking raises the blood pressure both in normotensive and hypertensive patients; it also increases blood pressure variability and facilitates the development of hypertension. In regular drinkers, binge-drinking episodes are especially harmful regarding blood pressure [10–13]. The interrelation of alcohol consumption, hypertension, and cardiovascular risk is best described by a U-shape curve, with the two branches representing abstainers and binge drinkers [10]. These changes are independent of the acute biphasic effect of alcohol on blood pressure (an initial decrease followed by an increase) [14].

Based on the results published by Groppelli *et al.* in 1992, it is now established that smoking large quantities of cigarettes permanently increases blood pressure and heart rate [15]. Numerous studies from the same period, on the other hand, claimed that blood pressure decreases due to smoking in normotensive and hypertensive individuals [16, 17]. These views later strengthened, and smoking was thus not considered as a risk factor for hypertension [18]. Leone finally clarified the relationship between smoking and hypertension. According to these results, regular smoking has a biphasic effect on blood pressure.

In the first phase, a significant systolic and diastolic pressure drop is observed, regardless of gender and age. However, enhanced sympathetic activity and endothelial dysfunction caused by smoking are already present at this stage, when a slight decrease in blood pressure usually occurs, supposedly due to nitrogen monoxide release from the endothelium. Given the constant harmful effects of nicotine and especially carbon monoxide, arterial stiffness increases, platelet function worsens, and, as a result, hypertension and consequent hypertensive heart disease develop [6, 7]. The effects of smoking were also compared to Pandora's box by Leone [7]. A study published by Ohta *et al.* in 2016 showed that

in middle-aged hypertensive patients, 24-hour and daytime blood pressures and heart rate values were elevated; moreover, blood pressure variability was also more expressed throughout the smoking period. In Hungary, based on the nationwide Hypertension Registry, Kékes *et al.* found a positive correlation between systolic and diastolic blood pressures and the proportion of smokers in a patient population treated with hypertension [20].

Literature is scarce on the combined effects of alcohol consumption and smoking, such as a two- to threefold increase in the risk of cardiovascular events (coronary artery disease, stroke, peripheral arterial disease), which are lesser-known phenomena [3, 21]. This applies especially to hypertensive patients, particularly when left ventricular hypertrophy is present [9, 21]. Alcohol further facilitates the harmful effects of nicotine and carbon monoxide. Increased sympathetic activity, catecholamine release, and oxidative stress result in endothelium dysfunction and tissue damage [21, 22]. The combined effect is significant from a social perspective as well, considering the fact that a large number of drinkers also smoke [22].

In our study, we demonstrated that regular drinking and smoking are associated with higher blood pressure and heart rate values. In men, but not in women, we established that mean systolic and diastolic pressures were also higher both in the only smoker and only drinker subgroups. Using a multivariate logistic regression model, a strong correlation between regular smoking, alcohol consumption, and systolic blood pressure was observed in both sexes. The same applies to diastolic blood pressure, but only in men. Obesity (BMI) and serum triglyceride levels also had significant effects on blood pressure in both genders and women with diabetes.

We yearn to emphasize that in treated hypertensive patients, the combination of smoking and drinking had a highly adverse effect on reaching a target blood pressure of <140/90 mmHg. Besides these two risk factors, obesity and diabetes were also strong influencers.

In addition, interactions between nicotine and antihypertensive agents may also play a relevant role [7, 23]. Conventional beta-blockers have difficulty counteracting nicotine-induced increased sympathetic activity and decreased parasympathetic activity, with the exception of third-generation nebivolol and carvedilol [7, 24]. Regular smoking strongly influences the effect of ACE inhibitors in treated hypertensives, especially in diabetic nephropathy [25]. The main underlying pathomechanism is increased renin release and angiotensin I to II conversion due to angiotensin-converting enzyme (ACE) stimulation caused by nicotine [26]. The antidiuretic effect of nicotine antagonizes thiazide diuretics in hypertensive smoking patients [7, 24]. No difference was found in the antihypertensive effect of indapamide in smokers [27]. In patients with regular alcohol consumption, sympathetic activity and elevated angiotensin II level may play a role in not reaching the target blood pressure [28]. Calcium channel blockers proved effective regardless of the presence of smoking or drinking.

However, there are certain limitations to our study. First of all, the prevalence of alcohol consumption and smoking habits was based on self-reporting. As this method is known to underestimate the prevalence of addictions, the above findings could have been more pronounced by using an objective method for data collection. Another limitation was the lack of data on drug adherence. Regular drinking most probably has a negative effect on therapeutic adherence, which, at least in part, can be responsible for the received results. We were also unaware of the patients' level of physical activity, which may be another confounder. Finally, differences between therapeutic regimes in the four subgroups make them more difficult to compare.

Conclusion

Regular alcohol consumption and smoking decrease the chance of reaching blood pressure goal values in treated hypertensive patients of middle-age. Noentheless, further prospective studies are necessary to understand the exact cause of this phenomenon.

Acknowledgements

This paper has been published in Hungarian in the Hungarian medical journal "Orvosi Hetilap":

Dr. Kékes Ede, Dr. Paksy András, Dr. Baracsi-Botos Viktória, Dr. Szőke Vince Bertalan, Dr. Járai Zoltán: "The combined effect of regular alcohol consumption and smoking on blood pressure and on the achievement of blood pressure target values in treated hypertensive patients". [A rendszeres alkoholfogyasztás és a dohányzás hatása a vérnyomásra és a vérnyomáscélértékek elérési arányára kezelt hypertoniás betegekben.] Orv Hetil. 2020; 161(30): 1252–1259. [Hungarian]

The editors of "Orvosi Hetilap" have approved the translation of the manuscript and its publication in the Journal of Hypertension Research.

Financial support

The data collection took place in 2015, with the support of Egis Pharmaceuticals PLC who offered

to the Hungarian Society of Hypertension. However, during the data processing carried out in 2019, the authors did not receive any financial support.

The authors would like to thank Egis Pharmaceuticals PLC and the Hungarian Society of Hypertension for their support, our general practitioner colleagues for participating in the study by providing the data and to Eszter Ureczky for linguistic proofreading.

Conflict of interest

The author confirms that there are no conflicts of interest.

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