

# Analysis of chosen factors affecting the incidence of a brain stroke – a preliminary report.

ARTUR Andrzej KANTELUK (✉ [akanteluk@op.pl](mailto:akanteluk@op.pl))

Uniwersytet Medyczny w Białymstoku <https://orcid.org/0000-0002-0769-5963>

Elzbieta Krajewska-Kułak

Medical University of Białystok: Uniwersytet Medyczny w Białymstoku

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## Research Article

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# Abstract

The risk of stroke is directly proportional to the occurrence of hypertension and the simultaneous occurrence of other risk factors. The main goal was to find out which age group was most at risk of having a stroke. The study was performed among 138 people randomly chosen from Michałowo borough in the Białystok county. The examined were divided into the following 5 age groups. The following measurements were performed: arterial blood pressure, blood glucose level, total cholesterol and its fractions level, triglycerides level, sodium and potassium level, prothrombin time, activity. Additionally, a patient's history was taken and an author's survey questionnaire was completed. Due to the small number of men surveyed (13 persons), statistically significant analysis of data within this group cannot be carried out. An analysis was made, broken down by age, of data obtained after examining 125 women. People in age group III are most at risk of developing stroke. People in the IV and V age groups are those who are at risk of having a stroke or who have had a stroke. People in groups 1 and 2 are at moderate risk of stroke. In the III age group people are the most at risk of having a stroke.

## Introduction

A current definition of a stroke was published by the WHO in 1980 year. A stroke is a clinical syndrome characterized by a sudden focal, or sometimes global, functional disorder of the brain whose symptoms last longer than 24 hours or lead to death and have no other cause than vascular [1],[2].

The following types of stroke can be distinguished:

- a. ischemic brain strokes,
- b. intracerebral hemorrhagic strokes,
- c. subarachnoid hemorrhage,
- d. venous strokes [1].

Transient ischemic attack (TIA) is characterized by focal vascular symptoms lasting up to 24 hours without structural changes in the brain, in view of which TIA is not regarded as a stroke [3].

The WHO quotes that every year about 15 million people have a stroke. An ischemic stroke is the most frequent type of strokes (incidence rate/ morbidity 70–80%), whereas 20–30% of strokes refer to hemorrhagic strokes. Subarachnoid hemorrhage (SAH) constitutes 5–7% of all strokes. A venous stroke belongs to the rarest strokes, because its incidence rate ranges from 1 to 5 in 1000 strokes [4].

The death due to a stroke is reported in 5,5 million of the world population [5]. It also is mainly responsible for disability (50% of patients with a recognized stroke) and the second cause of dementia syndrome (25% of those suffering from stroke). A stroke after cardiac and neoplastic diseases has become the most frequent cause of death among the population of the developed countries [5],[6]. The probability of developing a stroke increases with age, e.g. after the age of 55 – by 50 % in the consecutive ten years of life [7]. In people aged from 35 to 44 years, the incidence rate of a stroke ranges from 30 to 120 in 100 000 people a year. At the age of 55–64 years, the first episode occurs in 300/100 000, while for the population from 65 to 74 years old, in 670–970/100 000 a year [5],[8]. In children, in the scale of a year, a stroke occurs with the incidence rate of 2,52 – 2,7 in 100 thousand and usually it affects boys up to the age of 6. In children below 18 years old, in contrast to adults, it is reported more rarely compared to a hemorrhagic stroke, constituting 30–45% of cases [9]. Based on the data of the National Health Fund the morbidity of a brain stroke decreases in Poland. The diagram below presents the data obtained (Fig. 1.)

Health prophylaxis is the most efficient way to decrease the incidence rate of diseases, and the knowledge about factors predisposing to an increase in the morbidity of a given disease facilitates the activities aimed at health maintenance. There are distinguished modifiable factors (man-dependent) and non-modifiable (man-independent, e.g. age, sex, race) [10]. The INTERSTROKE study the appropriate number of controls proved that about 90% of strokes refers to 10 modifiable risk factors: 1) arterial hypertension, 2) diabetes, 3) cardiac causes, 4) nicotine smoking, 5) abdominal obesity, 6) hyperlipidemia, 7) lack of physical activity, 8) alcohol consumption, 9) diet and 10) psychosocial stress and depression [11]. To illustrate better an increase in the probability of a vascular brain stroke, The Polish Arterial Hypertension Society published the following figure (Fig. 2)[12],[13]

Arterial hypertension is one of the most important risk factors of a brain stroke. Its blood pressure (BP) refers proportionally to an increase in the probability of the brain stroke occurrence as well as heart infarct, cardiac and renal failure. Systolic blood pressure defines more precisely a risk of cardio-vascular diseases, because it informs about the pressure of the blood in the arteries during the heart systole. The value of diastolic blood pressure informs about the value of the pressure inside the heart chamber, between contractions.

DBP value can be used to define the first episode of a brain stroke [15],[16]. Arterial hypertension is established when the mean values of BP, at the minimum two various measurements, in significant time intervals, equal or exceed 140 mmHg for systolic pressure and/or 90 mmHg for diastolic pressure [14],[13]. In patients whose BP value equals  $\geq 180/\geq 110$  mmHg, arterial hypertension can be found at one measurement[13], [12]. However, the case history should be taken if high values of BP are not caused by pain emotions or drugs consumption (e.g. alcohol, psychoactive substances).

Czech A. et al.[16] define diabetes as an independent risk factor of a brain stroke, which has been underestimated. They emphasize that the mortality in patients with diabetes type II at the age 45+ increases 6–8 folds and 12 folds when it is accompanied by arterial hypertension. Additionally, they underline that arteriosclerosis develops two folds more frequently in the diabetics, which contributes to a cerebro-vascular stroke [16]. The table below shows the levels of fasting blood glucose and their explanation.

Table 1  
Interpretation of fasting blood glucose levels [17]

Blood glucose level	Interpretation
< 70mg/dl ( mmol/l) (< 3.9 mmol/l)	Hypoglycemia
70-99mg/dl (3.9– 5.5 mmol/l)	Normal value
100–125 mg/dl (5.6–6.9 mmol/l)	Abnormal value – prediabetic state
> 125 mg/dl (> 6,9 mmo/l)	diabetes

An ischemic stroke of the thrombotic origin can be caused by too high number of blood thrombotic factors. To define the efficiency of the blood coagulation system, the prothrombine time assay is used [18]. Oral contraceptives influence the blood density. When they are chosen inappropriately, their usage may lead to thrombosis [19]. A hemorrhagic stroke can be caused by a high INR. The norms of INR levels are presented the Table 2.:

Nicotine smoking is common, despite the knowledge of negative consequences affecting the health. The literature states that it belongs to the most important factors of a brain stroke via an increase in the level of fibrinogen, i.e. enhancing the density of blood [8]. Pan B.[21] determined that a risk of developing a stroke was two-fold higher when compared to non-smokers. Kasprzak and Figiel[22] report that in people with arterial hypertension smoking nicotine,

a risk of brain stroke increases five folds in comparison with non-smokers after TIA or with women taking oral contraceptives. The probability of a thrombotic embolic disease increases with a rise in the dose of estrogen > 50µg up to 24–25 cases /100,000 women in a year [23].

Another modifiable factor of a brain stroke is alcohol. Its influence on the human body depends on its amount consumed. Kasprzak and Figiel[22] define that 12-24g/24 hours of red wine decrease a risk of developing cardiovascular diseases, whereas > 30g/24 hours increase 2–4 folds the probability of a brain stroke, especially, hemorrhagic [22]. Inebriation is characterized by arrhythmia, decreased blood flow in the cerebral vessels and arterial hypertension [8].

Cholesterol, composed of High Density Lipoprotein (HDL) and Low Density Lipoprotein (LDL) fractions, is a lipoprotein that builds up the cellular membranes as well as is responsible for normal functioning of the blood system[24]. HDL is cholesterol of high density, commonly called 'a good cholesterol'. Its main task is to transport lipids from the peripheral tissues where they are metabolized [25]. A normal concentration of HDL in women should be above 50mg/dl, while in men > 40g/dl [26]. A fraction of low-density lipoprotein (LDL) is cholesterol of low density, commonly called 'a bad cholesterol' with an acceptable level of LDL up to 115mg/dl (3.0mmol/l) [12],[26]. Its task is to transport lipid molecules to the peripheral cells [27]. It causes the formation of atheroma due to spreading lipids around the whole human body. Cholesterol level depends on, among others, physical activity and a diet. Dyslipidemia induces sclerosis, coronary disease and a brain stroke [24]. Triglycerides (TG) are lipid molecules which play two important roles in the human body. The first function is to provide the human body with energy, while the other is to accumulate lipid molecules in the cytoplasm of a lipid cell. Their level should not be higher than 150mg/dl (1.7mmol/l) [26],[28]. The risk of an ischemic stroke consists in the process of lipid cell aggregation in the atheromata leading to a decrease in the vascular lumen. Finally, the vascular lumen is blocked and closed or the thrombus forms on the atheroma. An ischemic stroke is caused by closing the blood vessel or atheroma or a clot formed on its surface .

A physical activity, a diet and exposure to stressogenic factors are defined as a life style. In the analysis of brain stroke factors, all mentioned above influence this disease. During the controlled physical activity a decreased aggregation of blood cells, enhanced HDL and lowered LDL are reported, which decreases the risk of brain stroke and death by 27% [29]. Patients suffering from the ischemic heart disease doing aerobic exercises for 30 minutes 3–5 times a week [30]. One of the most favorable diets in the vascular diseases is Vegan or Mediterranean diet. A change of saturated acids into EFA ( essential fatty acid) or complex carbohydrates reduces by 25% a relative risk of brain stroke [31][32]. It is recommended to consume 30 mg of walnuts, hazelnuts, almonds, but in a natural form, without spices [12]. Glycemia level affects significantly the development of a brain stroke, which is caused by the fact that saccharides are transformed into fat molecules enhancing the level of lipids [33]. Fizzy drinks are sweetened and affect markedly a blood sugar level. Thus, it is recommended to supplement liquids with mineral water of low sodium content.

An emotional condition influences the whole human body. Stress, aggression, lack of acceptance and rejection are strong stimuli affecting the behavioral and hemodynamic sphere. Negative emotions cause atheroma formation on the vascular endothelium. Secondary hypertension is caused by the release of catecholamine and cortisol and activated macrophages intensify an inflammatory process inducing the increased aggregation of blood cells [34], [35]. The examples mentioned above confirm a definition of health given by the WHO, that is 'Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity' [6],[36]. This definition informs that strengthening the health via prophylaxis (prevention of a disease), not merely a treatment, must be in the focus of interest and attention of all concerned with a health care.

## Methods

The project was financed by public funds within a status work numbered: N/ST/MN/17/003/3310 and N/ST/MN/18/003/3310. The study was performed among 138 people randomly chosen from Michałowo borough in the Białystok county. The examined were divided into the following age group:

- I group – 18–40 years old
- II group – 40–60 years old
- III group – 60–80 years old
- IV group – 80+ years old

The following measurements were performed :

- arterial blood pressure
- blood glucose level
- Total cholesterol and its fractions level
- Triglycerides level
- Sodium and potassium level
- Prothrombine time (PT) INR
- PT activity
- INR.

Additionally, a patient's history was taken and an author's survey questionnaire was completed. The statistical analysis was based on the Shapiro-Wilks test for normality and t-Student test of probability. Due to a low number of the men examined, the data obtained are not statistically significant. It is recommended to repeat the study in the large population.

## Results

The study included 138 people divided into the following groups :

Table 3  
The number of the examined with regard to sex and age

	The age category of men					The age category of women				
	I	II	III	IV	suma	I	II	III	IV	suma
NUMBER OF PARTICIPANTS	3	2	3	5	13	20	36	52	17	125
PERCENTAGE ACCORDING TO SEX	23.08	15.38	23.08	38.46	100.00	16.00	28.80	41.60	13.60	100.00
PERCENTAGE	2.17	1.45	2.17	3.62	9.42	14.49	26.09	37.68	12.32	90.58

The data above show that women constituted 90.58% of all participants. Men above 80 years old were the most numerous while women were in the III age group. Female residents of Michałowo, unlike men, took part most

preferably (Fig. 3.).

The study participants were mainly men, who required consultation from the physician of Primary Health Care. Generally, women living in the town participated preferably in the prophylactic examinations and were more aware of their health status. Overall, men were unwilling to participate in such examinations.

Biochemistry of the venous blood defined an absolute risk of brain stroke occurrence. The respective test results in the population studied were discussed below. They prove that the population studied had a normal potassium level in the blood (Fig. 4.). The concentrations of sodium and potassium were within normal values. The concentration of sodium at the level of 135 mmol/L was regarded as normal (Fig. 5.). Prothrombin time value included in the range of 0.8–1.2 was normal in the study population. The increased value of Prothrombin time was considered therapeutically normal in women, because they took acenocumarol. The Fig. 6 below shows the data obtained.

The guidelines of PTNT (Polish Society of Arterial Hypertension) from 2015 year group the values of arterial blood pressure. The table below presents the values of BP and their classification in the study population [13].:

Table 4  
Values of arterial blood pressure with regard to grade, study group, and sex.

	Age group								Total
	I		II		III		IV		
	Men	Women	Men	Women	Men	Women	Men	Women	
Optimum BP	1	7	0	7	1	5	0	2	23
Normal value	0	6	1	6	1	7	0	2	23
High normal BP	2	4	1	5	1	15	1	4	33
Arterial hypertension I	0	2	0	11	0	10	3	2	28
Arterial hypertension II	0	1	0	3	0	11	1	4	20
Arterial hypertension III	0	0	0	4	0	4	0	3	11
Total	3	20	2	36	3	52	5	17	138

The data above indicate that more than 42.5% of the surveyed had abnormal arterial blood pressure and the problem intensified with age. In people after 80 years old, the number of the examined in each age group did not differ statistically significantly. In women to the age of 80, a marked increase in abnormal arterial blood pressure was determined. In men, the study results were similar. However, the data cannot be considered statistically significant due to the low number of the men examined. The results obtained are shown in the Fig. 7. and Fig. 8.

No correlation was found between the age and arterial blood pressure, which may suggest that arterial hypertension is not related to aging of the human body.

Diabetes is one of factors contributing to a brain stroke. The level of glycemia in the study population is presented below.

Table 5

Classification of the study population according to glycemia level with regard to the age group and sex

Age group	I		II		III		IV		TOTAL
	MEN	WOMEN	MEN	WOMEN	MEN	WOMEN	MEN	WOMEN	
Sex									
Hypoglycemia	1	0	0	4	0	3	0	1	9
NORMAL	2	18	2	25	2	33	2	9	93
Prediabetic state	0	1	0	5	0	14	1	4	25
Diabetes suspected	0	1	0	2	1	2	2	3	11
TOTAL	3	20	2	36	3	52	5	17	138

In the study population, more than 67% of the examined had a normal level of glycemia. A normal fasting glycemia level was reported in nearly 12% of the over- 80 –aged. Hypoglycemia was found in 9 people of whom 8 in 9 were women. A prediabetic state was determined in 14 women from the III age group. More than 125mg % glycemia was reported on empty stomach in 11 participants of whom five were over 80 years old.

The scatter diagram below presents the values of triglycerides regarding a maximum value (150mg/dl). There is no statistically significant correlation between the age and the level of triglycerides in the study population (Fig. 9.). A statistically significant correlation between the age and a decrease in the level of HDL in the study population is shown in the Fig. 10. A correlation between an increase in the arterial blood pressure and cholesterol was reported in women. The table 11. shows statistically significant data. The level of cholesterol increased proportionally with age as well as the systolic and diastolic blood pressure.

Statistically significant correlations between the level of cholesterol and age cannot be taken into consideration due to too low number of participants (Fig. 12.).

Coexisting diseases contributing to development of a brain stroke are the following: arterial blood pressure, diabetes, cardiac diseases including cardiac fibrillation, atherosclerotic disease, obesity, disorder of blood coagulation, neurosis and osteoporosis. The diagram 13. shows the number of disease cases in a given age group.

## Discussion

The problem of a brain stroke is discussed by many scientists. Członkowska A.[1] proves that a classification of brain stroke is difficult and its definition has been changed many times. The course of the disease is very severe and ends up with death or disability[5]. This is confirmed by numerous authors dealing with a brain stroke. Książkiewicz B. and et al.[37] compare the scale of cardiovascular disease risk and prove that there is no ideal. The authors of the study pay attention to the fact of an increase in the risk of developing a brain stroke in women after the age of 50 and in men after the age of 65, with dyslipidemia and arterial hypertension. It is also emphasized that the incidence of a brain stroke after the age of 55 increases two-fold every 10 years [8]. Czarnańska and Kloch-Badełek[15] report that 85% of all ischemic strokes are caused by arterial hypertension. Each increase by 20mmHg SBP or by 10mmHg BDP from the value 115/75mmHg enhances two-fold the probability of death from brain stroke. This information is confirmed in Polish and foreign literature. In the present study, as many as 42.5% of the examined had abnormal arterial blood pressure and the problem became worse with age. In people up to the age of 80, together with age, a

significant increase in abnormal arterial blood pressure was reported. However, in men due to a low number of the examined, the results cannot be considered statistically significant.

Doncor E.S.[6] underlines that a brain stroke is a disease caused by modifiable factors (e.g., life style, diet) and nonmodifiable (e.g., race, sex). It is known that diabetes, atherosclerosis, obesity, alcoholism, sleep apnea belong to the main diseases predisposing to a brain stroke. A normal level of glycemia was determined in more than 67% of the examined. Hypoglycemia was found in 9 participants of whom 8 were women. A prediabetic state was determined in 14 women from the age group III. Glycemia of above 125mg % on empty stomach was reported in 11 people of whom five were after 80 years old. The value of Prothrombine time was normal in the study population, because was included in the range of 0.8–1.2. The levels of sodium and potassium were within norm.

In 2011 and 2019 year, Polish Society of Arterial Hypertension published the guidelines of arterial hypertension management. They conclude that the restriction in table salt consumption (NaCl) to 4.35-5.8g (75-100mmol) in 24 hours decreases arterial blood pressure by 2–8 mmHg. Thus, 24-hour salt consumption should not exceed 5g (85 mmol)[13],[38].

To minimize the probability of developing a brain stroke, Śliz D.[32] indicates a vegetarian diet and active life style as an important constituent of a brain stroke prevention. The elements mentioned above are aimed at the maintenance of a proper body weight and protection from impaired self-assessment and deterioration in health and social well-being.

A brain stroke is an interdisciplinary disease which requires application of primary and secondary prophylaxis. The study participants from the III age group were at the most risk of a brain stroke. The examined from the age group IV and V were the people at risk of brain stroke or the ones who already underwent a brain stroke. The participants in the I and II age group were at a moderate risk of a brain stroke. Modifiable factors of a brain stroke orientate preventive activities in the group III.

## Declarations

### Compliance with ethical standards

Authors declare that they have no conflict of interest. The consent of the Bioethics Committee of the Medical University of Białystok was obtained for the research.

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## Table 2

Table 2 is available as a download in the Supplementary Files section.

## Figures

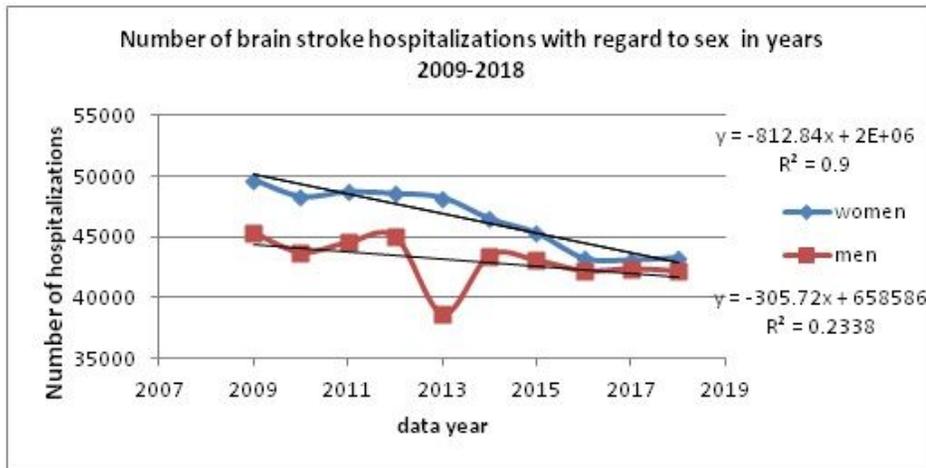


Figure 1

The diagram presents the data obtained.

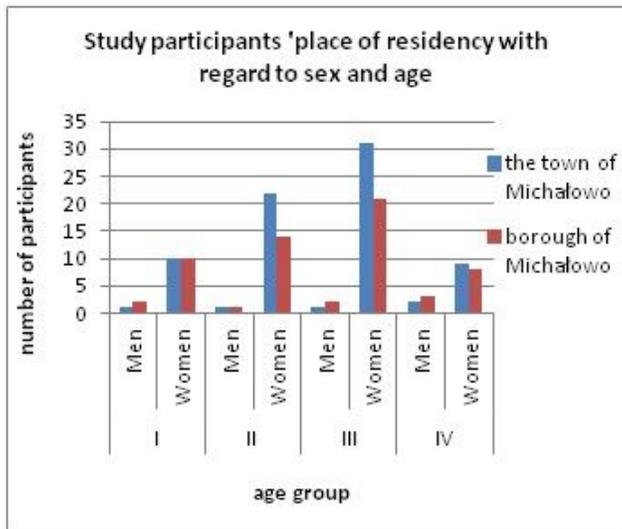


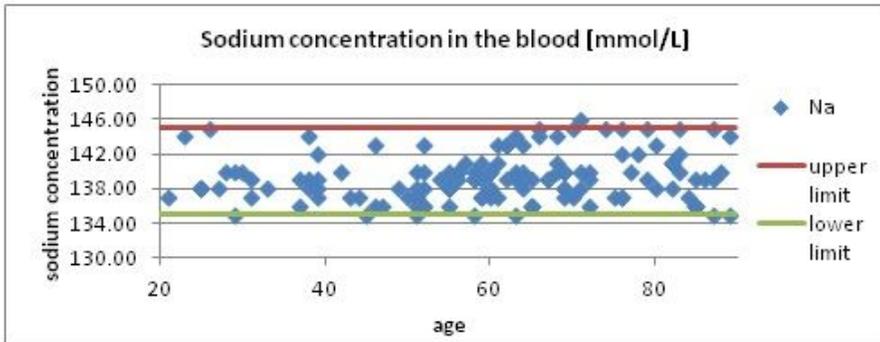
Figure 2

To illustrate better an increase in the probability of a vascular brain stroke, The Polish Arterial Hypertension Society published the following figure.

Figure 3 was not provided with this version of the manuscript.

### Figure 3

The data show that women constituted 90.58% of all participants. Men above 80 years old were the most numerous while women were in the III age group. Female residents of Michałowo, unlike men, took part most preferably.



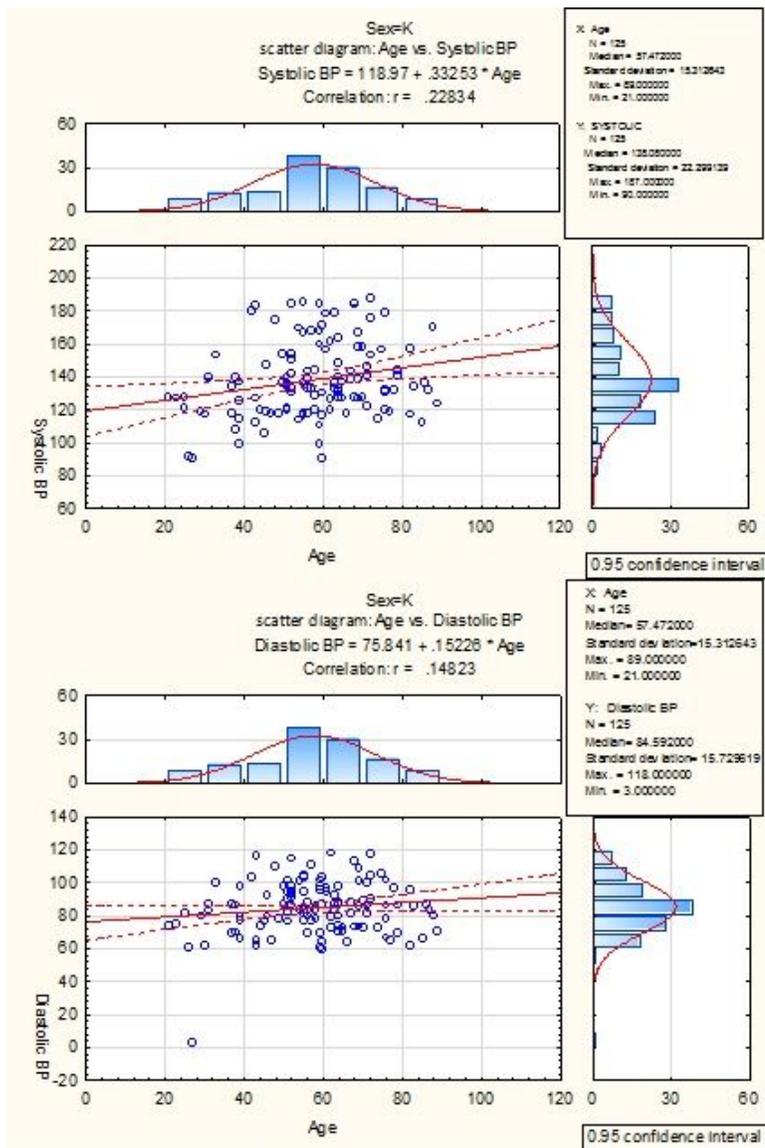
### Figure 4

Biochemistry of the venous blood defined an absolute risk of brain stroke occurrence. The respective test results in the population studied were discussed below. They prove that the population studied had a normal potassium level in the blood

Figure 5 was not provided with this version of the manuscript.

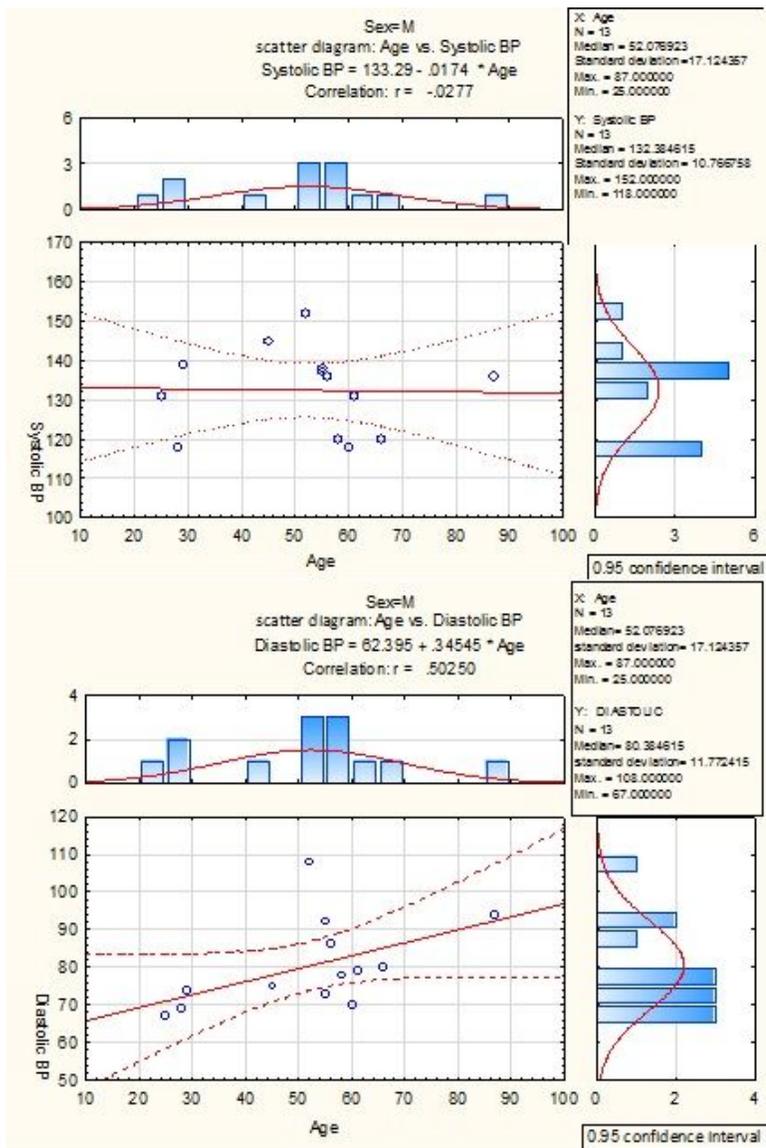
### Figure 5

The concentrations of sodium and potassium were within normal values. The concentration of sodium at the level of 135 mmol/L was regarded as normal.



**Figure 6**

Prothrombin time value included in the range of 0.8-1.2 was normal in the study population. The increased value of Prothrombin time was considered therapeutically normal in women, because they took acenocumarol. The fig. 6 below shows the data obtained.



**Figure 7**

The data above indicate that more than 42.5% of the surveyed had abnormal arterial blood pressure and the problem intensified with age. In people after 80 years old, the number of the examined in each age group did not differ statistically significantly. In women to the age of 80, a marked increase in abnormal arterial blood pressure was determined. In men, the study results were similar. However, the data cannot be considered statistically significant due to the low number of the men examined. The results obtained are shown in the Fig.7. and Fig. 8.

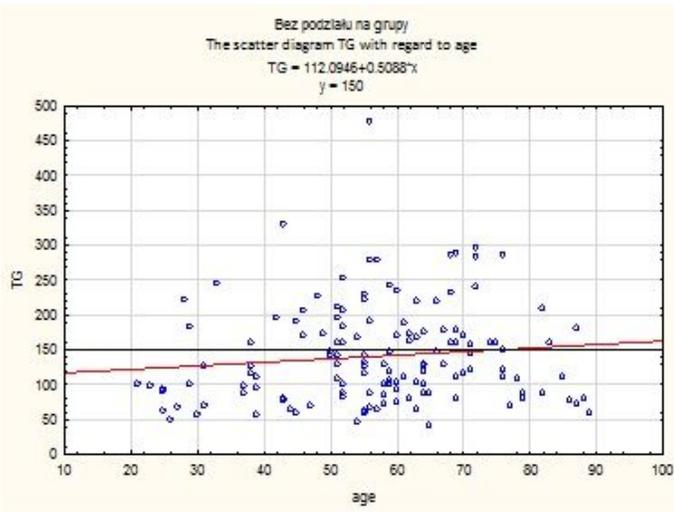


Figure 8

The data above indicate that more than 42.5% of the surveyed had abnormal arterial blood pressure and the problem intensified with age. In people after 80 years old, the number of the examined in each age group did not differ statistically significantly. In women to the age of 80, a marked increase in abnormal arterial blood pressure was determined. In men, the study results were similar. However, the data cannot be considered statistically significant due to the low number of the men examined. The results obtained are shown in the Fig.7. and Fig. 8.

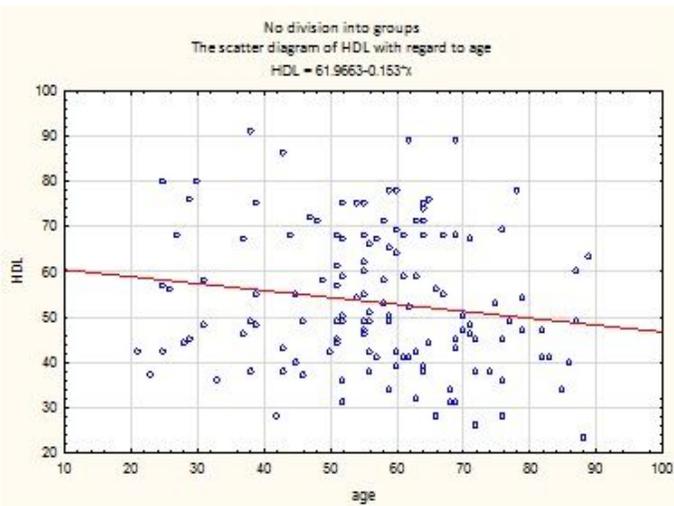


Figure 9

The scatter diagram below presents the values of triglycerides regarding a maximum value (150mg/dl). There is no statistically significant correlation between the age and the level of triglycerides in the study population.

Sex=K Correlations (study data) The correlation factors indicated are significant at p<0.0500 N=125		
variable	age	Cholesterol
age	1.000000	-0.056156
Systolic BP	0.228344	0.393031
Diastolic BP	0.148227	0.437831

Figure 10

A statistically significant correlation between the age and a decrease in the level of HDL in the study population is shown in the figure 10

Sex=M		
Correlations(the study data)		
Correlation factors indicated are significant at $p < .0500$		
N=13		
variable	age	Cholesterol
age	1.000000	0.343786
Systolic BP	-0.027745	-0.116186
Diastolic BP	0.502499	0.400713

Figure 11

The Figure 11 shows statistically significant data. The level of cholesterol increased proportionally with age as well as the systolic and diastolic blood pressure.

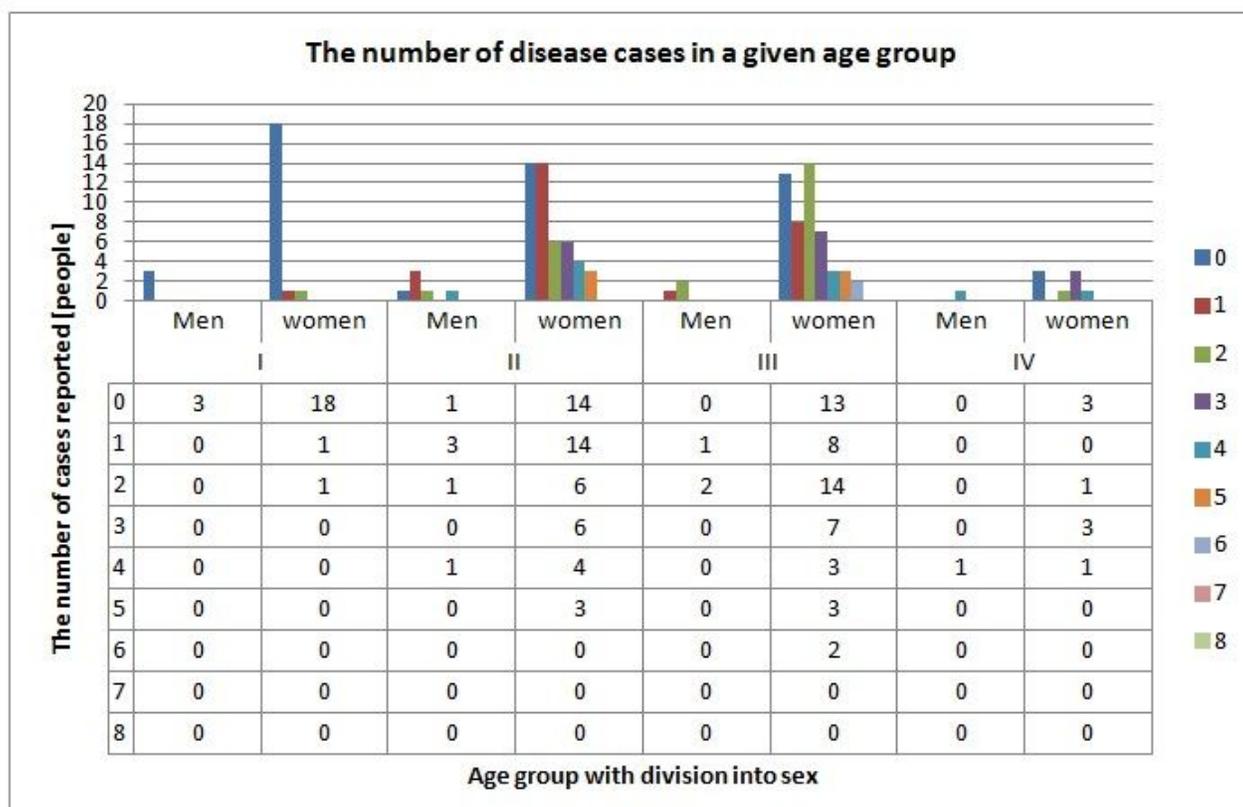


Figure 12

Statistically significant correlations between the level of cholesterol and age cannot be taken into consideration due to too low number of participants.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Tab.1..jpg](#)