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The Role of Modifying Risk Factors as Well as Body Mass Index, Waist Circumference and Hip to Waist Ratio as Anthropometric Indicators and Parameters of Obesity in the Occurence of Stroke

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ABSTRACT

Background: Evaluated values of body mass index (BMI), waist circumeference (WC) and waist-to-hip ratio (WHR) increase the risk of stroke, but the extent to which this is mediated by hypertension, diabetes, lipid status, smoking and alcohol consumption is not fully understood. **Objective:** The aim of this research is to examine the influence of modifying and non-modifying factors as well as obesity defined through BMI, WC and WHR on the occurrence of stroke. **Methods:** A total of 440 subjects were included in the cohort divided in to two groups. The first group were patients with stroke and another without stroke. We investigate modifable factor for stroke (hypertension (HTA), lipid status, diabetes mellitus (DM), smoking, alcohol consumption, educational status) as well as WHR, BMI and WC as determinants for obesitiy. **Results:** The majority of respondents in both groups had a secondary level of education. Smoking and alcohol consumption were slightly more prevalent in the group without stroke, while HTA and DM were slightly more prevalent in the group with stroke, but without a statistically significant difference. The largest number of respodents without stroke had HDL cholesterol values in the range of optimal >1.5, 70.9%, while 35.5% of respodents with stroke had values in the risk range, as well as 32.3% in the high risk range. LDL cholesterol values were on average statistically significantly higher in the group of respodents with stroke - 3.77±1.29 compared to the values in respodents without stroke - 3.20±1.20. The largest WC had patients with a hemorrhagic stroke 96.4 ± 15.5 cm. The average BMI was slightly higher in the group of patients with embolic stroke (28.5 ± 2.8) compared to patients with hemorrhagic stroke (28.4 ± 5.9) and thrombotic stroke (28.1 ± 4, 2). WHR was almost identical in all three types of stroke. **Conclusion:** There is correlation between modifable risk factor and obesity in stroke occurence.

Keywords: Stroke, body mass index, waist circumference, waist to hip ratio, risk factor. adiposity.

1. BACKGROUND

Stroke is ranked as the second leading cause of death worldwide with an annual mortality rate of about 5.5 million (1). Ischemic stroke is a multi-factorial disorder (2). The traditional risk factors of stroke can be classified into two, which include risk factors that are modifiable and those that are nonmodifiable (1). The modifiable risk factors of stroke include factors such as hypertension, diabetes mellitus, high blood, cholesterol, cardiovascular diseases, sedentary lifestyle, atrial fibrillation, smoking, and alcohol consumption (3, 4). The non-modifiable risk factors are relatively few and include factors such as age and gender (3, 4). Generally, the status of body fat accumulation can be described by four indicators: waist circumference (WC), body mass index (BMI), waist-to-height ratio (WHtR), and waist-to-hip ratio (WHR).

Obesity is a chronic disease defined as an abnormal or excessive fat accumulation which may impair health (5). Body mass index (BMI), defined as weight (kg) divided by the square of height (m) (kg/m2), is a simple anthropometric measure interrelating height and weight that is commonly used to identify the presence and severity of excess body fat in adults (5). Waist circumference (WC) is generally recommended to assess fat distribution which adds information concerning cardiometabolic disease risk; however, waist to height ratio (WHtR), and WC divided by height 0.5 (WHR.5R) (6) have been proposed as improved estimations of relative abdominal fat distribution (5). Higher body mass index (BMI), waist circumeference (WC) and waist-to-hip ratio (WHR) increase the risk of stroke (7), as well as modifable and non modifable risk factor but the extent to which this is mediated by hypertension, diabetes, lipid status, smoking, alcohol consumption and level of education is not fully understood.

2. OBJECTIVE

The aim of this research is to examine the influence of modifying and non-modifying factors as well as obesity defined through BMI, WC and WHR on the occurrence of stroke.

3. MATERIAL AND METHODS

A population-based prospective cohort study was conducted from June 2022 to June 2023 in Bosnia and Herzegovina. A total of 440 subjects were included in the cohort divided in to two groups. The first group were patients with stroke and another subjects without stroke. We investigate modifable factor for stroke (HTA, lipid status, DM, smoking, alcohol consumption, educational status) as well as WHR, BMI and WC as determinants for obesitiy.

BMI is a calculation of a body person's weight (in kilograms) divided by the square of their height (in meters). According to BMI subjects were grouped in four groups: underweight - less than 18.5, healthy weight - 18.5 to less than 25, overweight - 25 to less than 30, obesity - 30 or greater (Class 1 obesity - 30 to less than 35, Class 2 obesity - 35 to less than 40, Class 3 obesity - 40 or greater) (8).

WC is measured halfway between lowest rib and the top of hipbone.We define excessive WC as ≥ 85 cm for males and ≥ 80 cm for females (9). Greatly increased risk for female is if WC measurement is 88 cm or more and for male 102 cm or more.

WHR is used as a measurement of obesity. The Wordl Health Organisation (WHO) states that abdominal obesity is defined as a waist–hip ratio above 0.90 for males and above 0.85 for females.

All subjects filled the questionnaires through face-to-face survey and physical measurements. The questionnaire included basic personal information, health status and information about previous stroke. Physical measurements included height measurement, weight measurement, waist measurement and blood pressure as well as blood testing (lipid status, glucose level) and questions about smoking and alcohol consumption and level of education. Measurements were carriedout by trained and qualified investigators using standard methods.

For the identification of stroke cases, we used the information from the previously mentioned questionnaire. According to the International Classification of Diseases, 10th Revision (ICD-10), the stroke outcomes in our study were intracerebral haemorrhage (ICD-10 code I61) and cerebral infarctiondue to a thrombosis (ICD-10 code I63. 0) or embolic event (ICD-10 code I63. 40).

All methods were performed in accordance with the Declaration of Helsinki. All survey respondents have signed informed consent.

Statistical analysis

Study results are presented in tabular form by number of cases, percentage, and mean with standard deviation depending on the type of data. For statistical testing nonparametric tests were used, Chi-Square test, and Mann-Whitney U test, as the data des not conform with the normal distribution. Test results were considered as statistically significant at the 95% confidence level, or with p values <0.05. Analysis was performed used the statistical package for biomedical sciences MedCalc v 12.3 (Antwerp, Belgium).

4. RESULTS

The total sample included 220 respodents in both groups, average age 72.2±12.9 years (range 23-98 years)

The comparison of gender representation shows an almost identical distribution in both groups without a statistically significant difference.

		Stroke postive	Stroke negative	p
Gender	Male	101 (45,9%)	100 (45,5%)	0,500
	Female	119 (54,1%)	120 (54,5%)	
Age (Years)		75,3±10,9	69,2±13,9	0,0001

Table 1. Comparison of sociodemographic characteristics

Patients with stroke were statistically significantly older with an average age of 75.3±10.9 compared to respondents without stroke with an average age of 69.2±13.9.

As it shown in Table 2 no statistically significant difference was observed in relation to the level of education. The majority of respondents in both groups had a secondary level of education.

Smoking and alcohol consumption were slightly more prevalent in the group without stroke, while HTA and DM were slightly more prevalent in the group with stroke, but without a statistically significant difference.

The average total cholesterol levels were slightly higher in the group of respodents without stroke - 5.79±1.36 compared to respodents with stroke - 5.69±1.49. The majority of respodents in both groups had normal cholesterol values.

The average triglyceride values were higher in the group of subjects with stroke - 1.93±1.03 compared to subjects without stroke - 1.60±0.95. However, the largest number of subjects in both groups had triglyceride values within the normal range.

All of the above without statistically significant differences between groups.

On average, HDL cholesterol values were statistically significantly higher in the group of respodents without stroke - 2.46±1.35 compared to values in respodents with stroke - 1.43±0.78. Similarly, the largest number of respodents without stroke had HDL cholesterol values in the range of optimal >1.5, 70.9%, while 35.5% of respodents with stroke had values in the risk range, as well as 32.3% in the high risk range.

LDL cholesterol values were on average statistically significantly higher in the group of respodents with stroke - 3.77±1.29 compared to the values in respodents without stroke - 3.20±1.20. Thus, 60.9% of respondents without a stroke had normal values, while 29.1% of respondents with a stroke had values in the medium risk range and 30.9% in the high risk range.

Characteristics of the study participants in relation to the obese (Table 3) showed that in the largest number of patients, the type of stroke was thrombosis in 166 or 75.5%, followed by embolism in 30 or 13.6%, and hemorrhage in 24 or 10.9%. Patients with hemorrhagic stroke had the largest WC 96.4±15.5 cm, compared to patients with thrombotic stroke 94.9±11.9 and embolic stroke 94.5±10.2 cm. The risk itself, assessed on the basis of WC, was usually high in all three types of stroke. In relation to BMI categories in all three types, the largest number of patients was in the category of increased body weight. The average BMI was slightly higher in the group of patients with embolic stroke 28.5±2.8 compared to patients with hemorrhagic stroke 28.4±5.9 and thrombotic stroke 28.1±4.2.WHR was almost identical in all three types of stroke.

		Stroke postive	Stroke negative	p
Educational status	No formal education	3 (1,4%)	3 (1,4%)	0,096
	Primary	61 (27,7%)	39 (17,7%)	
	Secondary	132 (60,0%)	149 (67,7%)	
	Graduate	24 (10,9%)	29 (13,2%)	
Smoking		77 (35,0%)	80 (36,4%)	0,421
Alcohol consumption		29 (13,2%)	33 (15,0%)	0,341
Hypertension		191 (86,8%)	172 (78,2%)	0,012
Diabetes mellitus		74 (33,6%)	86 (59,5%)	0,206
Cholesterol	x±SD	5,69±1,49	5,79±1,36	0,513
	Normal value <5,2	89 (40,5%)	76 (34,5%)	0,283
	Slightly elevated 5,3-6,2	62 (28,2%)	60 (27,3%)	
	Very high >6,2	69 (31,4%)	84 (38,2%)	
Triglycerides	x±SD	1,93±1,03	1,60±0,95	0,760
	Normal value <1,69	108 (49,1%)	105 (47,7%)	0,811
	Medium risk 1,69-2,25	59 (26,8%)	65 (29,5%)	
	High risk >2,25	53 (24,1%)	50 (22,7%)	
HDL	x±SD	1,43±0,78	2,46±1,35	0,0001
	Optimal >1,5	71 (32,3%)	156 (70,9%)	0,0001
	Medimu risk 1,03-1,55	78 (35,5%)	25 (11,4%)	
	High risk <1,03	71 (32,3%)	39 (17,7%)	
LDL	x±SD	3,77±1,29	3,20±1,20	0,0001
	Normal <3,36	88 (40,0%)	134 (60,9%)	0,0001
	Medimu risk 3,36-4,11	64 (29,1%)	48 (21,8%)	
	High risk >4,11	68 (30,9%)	38 (17,3%)	

Table 2. Modifable risk factor for stroke

		Thrombosis	Embolisam	Hemorrhage	P
Waist circumference (WC)		94,9±11,9	94,5±10,2	96,4±15,5	0,831
WC risk	Normal	60 (36,1)	3 (10,0)	5 (20,8)	0,049
	Low risk	28 (16,9)	8 (26,7)	5 (20,8)	
	High risk	78 (47,0)	19 (63,3)	14 (58,3)	
BMI		28,1±4,2	28,5±2,8	28,4±5,9	0,843
BMI category	Healthy Weight	32 (19,3)	1 (3,3)	4 (16,7)	0,199
	Overweight	90 (54,2)	23 (76,7)	14 (58,3)	
	Obesity - Class I	38 (22,9)	6 (20,0)	5 (20,8)	
	Obesity - Class II	5 (3,0)	0 (0,0)	0 (0,0)	
	Obesity – Class III	1 (0,6)	0 (0,0)	0 (0,0)	
Waist to hip ratio		0,56±0,07	0,56±0,06	0,56±0,08	0,848
WHR category	Under weight	2 (1,2)	0 (0,0)	1 (4,2)	0,450
	Skiny and healthy	10 (6,0)	1 (3,3)	1 (4,2)	
	Normal weight	45 (27,1)	4 (13,3)	4 (16,7)	
	Overweight	45 (27,1)	7 (23,3)	6 (25,0)	
	Obesity	29 (17,5)	11 (36,7)	6 (25,0)	
	Dengerously obese	35 (21,1)	7 (23,3)	6 (25,0)	

Table 3. Characteristics of the study participants in relation to the obese

The results of the regression analysis (R2 = 0.205) indicate that the variables included in the model significantly influence and explain 20.5% of belonging to the group of patients with stroke.

The following independent predictors of stroke stand out (Table 4):

* Age - with an increase in the age of the subjects by 1, the probability of CVI increases by 29.7% (p = 0.000 < 0.05).

* Estimated risk of stroke in relation to HDL cholesterol level - with an increase in risk of 1 (e.g. from no risk to mild risk) there is an increase in the probability of stroke of 30.4% (p = 0.000 < 0.05).

* Estimated risk for stroke in relation to LDL cholesterol level - with an increase in risk by 1 (e. g no risk to mild risk) there is a 27.4% increase in the likelihood of stroke (p = 0.000 < 0.05).

Regression analysis (N=440)				
Dependent variable: Group				
Variable	Coefficient	Std. error	t	p (Sig.)
Constant	2,885	0,301	9,573	0,000
Gender	0,018	0,052	0,349	0,727
Education status	-0,037	0,037	-0,796	0,426
Age (Years)	-0,297	0,002	-6,375	0,000
Waist cimcuference	-0,022	0,044	-0,279	0,780
Bodi mass index (BMI)	0,001	0,039	0,015	0,988
WHR	0,009	0,032	0,120	0,905
Smoking	-0,029	0,049	-0,622	0,534
Alcohol consumption	0,007	0,069	0,143	0,887
Hypertension	0,021	0,058	0,478	0,633
Diabetes melltius typ 2	-0,016	0,048	-0,369	0,712
Cholesterol	0,093	0,034	1,612	0,108
Triglycerides	0,029	0,028	0,639	0,523
HDL	-0,304	0,029	-6,176	0,000
LDL	-0,274	0,033	-5,078	0,000
Correlation coefficient (R) = 0,480				
Coefficient of determination (R2) = 0,205				
Adjusted coefficient of determination (Adjusted R2) = 0,205				
F = 9,067; p(Sig.) = 0,000 < 0,05				
Durbin Watson = 0,354				

Table 4. Regression analysis

When talking about the reliability of the model, this model meets the specified characteristic because the tolerance for the independent variables exceeds the required value of 0, while. The Variance Inflation Factor (VIF) has a value between 1 and 10. The Durbin-Watson coefficient in this case is 0.354 which tells us that there is still an autocorrelation between the variables, or the influence of multiple predictors on the dependent variable.

5. DISCUSSION

The discussion present study compared risk estimates for ischemic stroke across a wide range of risk factors. Stroke is preventable, for those with modifable risk factors. The ten top modifable risk factors for stroke were hypertension, lack of physical activity, abnormal lipids, unhealthy diet, abdominal obesity, psychological factors, current smoking, cardiac causes, alcohol consumption, and diabetes (10). Together, these 10 risk factors accounted for close to 90% risk of stroke (10). In this study, we showed that there was no difference in the level of education between healthy participant and patients who had a stroke. On the other hand, Wen X at al. 2020 showed that participants with higher education were associated with a decreased rate of total stroke and ischemic stroke incident, but not hemorrhagic stroke incident (11). A recent prospective cohort study with a mean follow-up time of 4.7 years in 253 657 participants also revealed that low education was associated with increased stroke risk in both sexes (12). A recent MR study revealed that BMI, systolic blood pressure, and smoking behavior mediated a substantial proportion of the protective efect of education on the risk of cardiovascular (coronary heart disease, stroke, myocardial infarction, and cardiovascular disease) outcomes (13). Also, current smoking, ApoA1, ApoB, male sex and education level showed stronger associations with coronary events whereas age was preferentially associated with ischemic stroke (14).

Our study also showed that smoking and alcohol consumption were slightly more prevalent in the group without stroke. Previous studies (Kuo at al.2013, Gill at al.1986, Hillbom at al. 1999, Klatsky at al. 2001, Mazzaglia at al, 2001, Wannamethee at al. 1996) cited in Boehme 's at al. 2017 showed the relationship of alcohol consumption to stroke risk depends on stroke type. There is evidence of a J-shaped relationship between alcohol consumption and risk of ischemic stroke, with light to moderate alcohol consumption (up to 2 drinks per day in men and up to one drink per day in women) being protective against stroke, and heavy drinking associated with an increased risk of ischemic stroke (15). Alcohol consumption has a more direct linear relationship with hemorrhagic stroke, such that consumption of even small amounts of alcohol appear to increase risk of hemorrhage. Heavy alcohol consumption is linked to hypertension, as well as poor blood pressure control in hypertensive patients who consume alcohol (Rantakomi at al. 2009, Hillborn at al. 2011, Judd at al 2011, Wakabayashi at al. 2010, Foerster at al. 2009, Ohira at al. 2009, Taylor at al. 2009 cited in Boeheme at al. 2017) (15).

HTA and DM were slightly more prevalent in the group with stroke, but without a statistically significant difference. The previous study showed similar results. Hypertension has shown to be preferentially associated with incidence of stroke (16). Uncontrolled diabetes puts subjects at risk for both ischemic and hemorrhagic strokes (17).

The preferential association of cholesterol with stroke observed in this study is in line with previous studies The average total cholesterol levels were slightly higher in the group of respodents without stroke compared to respodents with stroke. The majority of respodents in both groups had normal cholesterol values. Strong correlations between plasma lipoprotein concentrations and the risk of stroke have never been clearly established (18). Previous study (Soler EP, Ruiz VC 2015, Collaboration PS. Stroke 2003 and Bowman at al. 2003) cited in Firam's showed taht elevated cholesterol levels have been more strongly linked to coronary events than stroke (14). Unlike coronary heart disease, there is no significant direct relation between an increased risk of stroke and increased plasma total cholesterol or low density lipoprotein (LDL) cholesterol; nor is there an inverse relation with high density lipoprotein (HDL) cholesterol (19).

In our study the average triglyceride values were higher in the group of subjects with stroke. According to Haung at al. elevated triglyceride levels were an independent risk factor for the development of first ischaemic stroke after adjustment for other confounding factors (20).

In 2017, the International Atherosclerosis Society (IAS) and International Chair on Cardiometabolic Risk (ICCR) Working Group on Visceral Obesity convened in Prague, Czech Republic, to discuss the importance of abdominal obesity as a risk factor for premature atherosclerosis and CVD in adults. In this Consensus Statement, we summarize the evidence that BMI alone is not sufficient to properly assess, evaluate or manage the cardiometabolic risk associated with increased adiposity and recommend that waist circumference be adopted as a routine measurement in clinical practice alongside BMI to classify obesity (21). Abdominal obesity measures such as WC, WHR, and WHtR were shown to be a more accurate measure of body fat distribution (22).

The results from our study showed the highest number of patients with stroke are in the WC group with high risk. Zhong at al. also show that the risk of stroke increased significantly, by 28% for WC and by 32% for WHR (23). In our study patients with hemorrhagic stroke had the largest WC compared to patients with thrombotic and embolic stroke. Preyanka at al. also showed that WC is positively associated with ICH(24) but in other study by Feigin at al . BMI and waist circumference were associated with ischemic stroke, not associated with ICH (24).

In relation to BMI categories in all three types, the largest number of patients was in the category of increased body weight. The large prospective study by Zhengming at al showed that adiposity was strongly positively associated with systolic blood pressure, and that systolic blood pressure was strongly positively related to stroke incidence, particularly intracerebral haemorrhage (25).

Compared to the WHR categories, a higher number of patients was recorded in the dangerously obese category. In recent years, some studies have shown that WHR was considered as a powerful representative of abdominal obesity because of its stability independent of age and body type (26). Gao et al. showed that no matter how WHR changed over time, it was still significantly positively correlated with the risk of incident CVD, heart failure and all-cause death (hazard ratio: 2.32-4.03), which also highlighted the importance of long-term management of abdominal fat (27).

6. CONCLUSION

About 90% of the stroke burden is attributable to modifiable risk factors, with about 75% being due to behavioural factors such as smoking, poor diet and low physical activity. Achieving control of behavioural and metabolic risk factors could avert more than threequarters of the global stroke burden (28). This may be useful in order to construct better risk stratifcation profles.

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