LABORATORY AND ANTHROPOMETRIC PARAMETERS IN THE ASSESSMENT OF THE RISK OF CARDIOVASCULAR DISEASE

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ABSTRACT

Introduction: Laboratory and anthropometric parameters for assessing lipid metabolism disorders are important for atherogenesis and the occurrence of cardiovascular disease. Material and Methods: The study was designed as a prospective longitudinal study, meant to assess the risk of cardiovascular disease, which included initial measurement of lipid status, CRP, and BMI, and repeated measurement after DASH diet and exercise. It was conducted on a sample of 60 female respondents. Results: Following the WHO categorization of BMI, the study found that 62% of respondents were overweight, 26% were obese, and only 12% of respondents were at ideal body weight. After the DASH diet and exercise program, the average value of BMI M = 27.02 was established. Analyzing the values of the CASTELLI 1 index in 95.9% of respondents, high values of M = 5.3 were observed, which indicates a high risk of CVD. The study results indicate that the average value of cholesterol, triglycerides, LDL-C significantly reduced after two months of adherence to the DASH diet and exercise. With the help of Spearman’s rank, the correlation coefficient indicated the existence of a positive relationship between the CASTELLI 1 index and total cholesterol, triglycerides and HDL-C. In the initial analysis, CRP had a high value (M = 10 mg/L). In contrast, after the program, the CRP value decreased to (M = 4 mg/L), and a significant negative correlation (p <0.01) was observed between CRP and HDL-C, indicating that HDL-C value as a protective lipoprotein for blood vessels increased. CRP decreased after two months of DASH diet and exercise. Conclusion: With this research, we aim to draw attention to the importance of promoting healthy lifestyles and creating adequate risk assessment models with a well-developed strategy that will include anthropometric, laboratory and other multidisciplinary aspects to combat cardiovascular disease.

KEYWORDS cardiovascular risk, lipids, BMI, CRP

Introduction

Cardiovascular diseases are chronic non-communicable diseases and one of the most important causes of death.[1] According to the study on the state of health of the adult population conducted by the Institute of Public Health of the Federation of BiH (2016.), there is an unfavourable trend of all risk factors for morbidity and mortality from cardiovascular disease.[2] Therefore, a strategy for preventing, early detection or delay of cardiovascular disease by risk assessment is an important tool to identify individuals who are more likely to get the disease. Several risk assessment protocols have been developed, most derived from the Framingham study. The majority of the risk assessment tools were based on the laboratory parameters and the non-laboratory models. The laboratory parameter assessment model is primarily based on determining lipid status and inflammatory parameters. In contrast, the non-laboratory model is based on determining Body Mass Index (BMI) and lifestyle reduction.[3,4]

The fact is when we talk about the laboratory and non-laboratory model that, disorders of lipid metabolism are important for atherogenesis and the occurrence of cardiovascular disease (CVD), so they are most often associated with hyperglycemia, hypertension, and obesity.[5]

According to the European Society of Cardiology (ESC) and the European Atherosclerosis Society (EAS) guidelines, lipid status reference values include total cholesterol values <5.0 mmol/L, LDL (low-density lipoprotein cholesterol) <3.4 mmol/L, triglycerides <1.7 mmol/L, and HDL-C >1.0 mmol/L in women and >1.2 mmol/L in men. The values of CRP >3 mg/L indicate an increased risk of cardiovascular disease.

The study was conducted on a sample of 60 female respondents, who were between 20-60 years old. The initial measurement of the lipid status, BMI, and CRP was done, and the study was performed for two months. After the DASH diet and exercise program, the average value of BMI M = 27.02 was established. Analyzing the values of the CASTELLI 1 index in 95.9% of respondents, high values of M = 5.3 were observed, which indicates a high risk of CVD. The study results indicate that the average value of cholesterol, triglycerides, LDL-C significantly reduced after two months of adherence to the DASH diet and exercise. With the help of Spearman’s rank, the correlation coefficient indicated the existence of a positive relationship between the CASTELLI 1 index and total cholesterol, triglycerides and HDL-C. In the initial analysis, CRP had a high value (M = 10 mg/L). In contrast, after the program, the CRP value decreased to (M = 4 mg/L), and a significant negative correlation (p <0.01) was observed between CRP and HDL-C, indicating that HDL-C value as a protective lipoprotein for blood vessels increased. CRP decreased after two months of DASH diet and exercise. Conclusion: With this research, we aim to draw attention to the importance of promoting healthy lifestyles and creating adequate risk assessment models with a well-developed strategy that will include anthropometric, laboratory and other multidisciplinary aspects to combat cardiovascular disease.

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lipoprotein) ≤ 3.0 mmol/L, triglycerides ≤ 1.7 mmol/L.[6] The Promac Heart study found that the most serious risk factor was an LDL value of 5 mmol/L and that triglyceride levels greater than 3 mmol/L increased the incidence of myocardial infarction.[7] The same study also pointed to the importance of total cholesterol levels greater than 5.3 mmol/L with increased triglyceride levels in women indicating a threefold higher risk of developing CVD.[7,8] It has also been proven that the atherogenic index parameter is used in the risk assessment for CVD development, the calculation of which has predictive significance. According to frequency, atherogenic risk factors leading to cardiovascular disease can be classified into frequent and uncommon factors.[8,9] Common risk factors include increased levels of total cholesterol, LDL, triglycerides, decreased HDL density lipoprotein, improper diet and consumption of atherogenic foods, physical inactivity, hyperglycemia, gender, age, smoking, and genetic predisposition. On the other hand, uncommon risk factors relate to the composition and size of lipoproteins and other parameter values (glucose, inflammatory markers, homocysteine, etc.). It is estimated that about 60% of the coronary circulation is covered with atherosclerotic plaques in most people, providing that other risk factors such as hypertension, smoking, obesity, and genetic predisposition are not present during life.[10] Obesity strongly impacts lipoprotein metabolism, regardless of ethnic group. Increased BMI is considered a determinant of higher triglyceride and LDL-C concentrations and decreased HDL-C concentrations.

In all countries of the European Union, there are national programs for the prevention of cardiovascular diseases, and they include various programs of physical activity, regulation of diet, prevention and treatment of hyperlipidemia and hypertension.[11] The objectives of our study were to examine the values of lipid status, CRP and BMI before and after the application of the DASH diet and five-day exercise.

Methods
The study was designed as a prospective longitudinal study, which lasted from March to November 2018. The research was designed to assess the risk of cardiovascular disease, which included initial measurement of lipid status, CRP and BMI, and then repeated measurement after DASH diet and exercise. Laboratory analysis of lipid status and CRP was performed using spectrophotometry and immunochemical methods. The risk is estimated empirically, using the CASTELLI 1 value of the risk index, which was obtained through the formulas:

\[ \text{CASTELLI 1 risk index} = \frac{\text{total cholesterol}}{\text{HDL-C}} \]

Recommended values are <4.5.

In order to detect the degree of nutrition, we calculated BMI. After measuring body height and body weight, we obtained the BMI value via the WHO formula: BMI = kg/cm^2. After the initial measurement, we recommended to all subjects a two-month application of the DASH diet and daily exercise, which consisted of breathing exercises (abdominal and thoracic), coordination, equilibrium and balance exercises, exercises to improve circulation, strengthen the upper and lower extremities (stretching), exercises for fine and gross motor skills. In addition, all respondents were educated about the benefits, the principle of keeping a diet diary (https://www.nhlbi.nih.gov/files/docs/public/heart/dash_brief.pdf), and the needs of the body for a healthy diet and exercise.

Responders
The research was conducted on a sample of 60 female respondents who are beneficiaries of the health program of the Center for Health Promotion and Improvement "Generation" Stari Grad. Consent for the research was obtained from the Center and all respondents involved in the study. The study included subjects who did not suffer from cardiovascular disease, did not use therapy to regulate lipid status and had blood pressure values> 140/90 mmHg. We excluded persons who suffered from cardiovascular diseases, who use therapy to regulate lipid status, and subjects who had blood pressure values <140/90 mmHg from the study.

Statistical analysis
Data were collected and entered into the database in the IBM SPSS Statistical program. Data analysis was performed in the mentioned program using the Kolmogorov-Smirnov test Shapiro Wilk test for testing the normality of distribution. In addition, nonparametric tests were used, the Spearman test was used to prove the correlation, and the Wilcoxon test was used to examine the differences between the parameters. Statistical significance was proved at the level of accuracy 95%, and this is for the value of p <0.05.

Results
According to the criteria, the research included 60 female respondents who joined the survey. The analysis of the data established that the respondents were aged 50–65 years. During the initial anthropometric measurement, the average height of the subjects was x = 163.7 cm, and the average body weight was x = 76.6 kg. The median value of BMI in the subject was M = 28, which indicates overweight. Following the WHO (World Health Organization) categorization of BMI, the study found that 62% of respondents were overweight, 26% were obese, and only 12% of respondents had ideal body weight. After the DASH diet and exercise program, the median value of BMI M = 27 was established. The Wilcoxon test revealed a statistically significant difference p <0.05 between the first and two months of measured BMI. (Graph 1)

![Graph 1. Measurement of BMI before and after two months of DASH diet and exercise.](image)

By analyzing and categorizing the values of the CASTELLI 1 index, high values of M = 5 were observed in 95.9% of respondents, which indicates a high risk of developing cardiovascular diseases. The maximum value of the CASTELLI 1 index in the study is 10. (Table 1) The study results indicate that the average value of cholesterol, after two months of adherence to the DASH program of diet and exercise, decreased significantly compared to the initial measurement and was M = 4 mmol/L. Using a nonparametric Wilcoxon test, a statistically significant difference between the two measurements was confirmed at the level of p <0.01. After two months of adherence to the program, triglyceride values were significantly lower than the initial value and amounted to M = 1.5 mmol/L. Using a nonparametric Wilcoxon test, a statistically significant difference between the two measurements was confirmed at the level of p <0.01. The effectiveness of the DASH diet and exercise is also indicated by the fact that the value of HDL-C increased after two months of application of the program, and whose median was M = 2 mmol/L. (Graph 2) LDL-C in the initial analysis was M = 6 mmol/L, while after two months of the DASH diet and exercise, it was M = 1.5 mmol/L.

Using the Spearman correlation coefficient, positive correlations were found between the initial values of total cholesterol and CASTELLI 1 index (r = 0.29; p <0.05), triglycerides and CASTELLI 1 index (r = 0.59; p <0.01), HDL-C and triglycerides (r = 0.56; p <0.01), HDL-C and CASTELLI 1 index (r = 0.76, p <0.01). (Table 2) Negative correlations were observed between the initial value of total cholesterol and the cholesterol value after two months of DASH diet and exercise (r = -0.53, p <0.01). (Table 3)
Table 1 CASTELLI 1 index value.

| Median CASTELLI 1 index | Maximum value obtained | Upper reference limit |
|-------------------------|------------------------|-----------------------|
| 5                       | 10                     | <4,5                  |

Table 2 Spearman correlation coefficient.

| Parameter      | CASTELLI 1 index | Triglycerides |
|----------------|------------------|---------------|
| total cholesterol | r = 0,29*         | r = 0,31*     |
| triglycerides   | r = 0,59**        | r = 1         |
| HDL-C           | r = 0,79**        | r = 0,56**    |

*p < 0.05  
** p < 0.01

Table 3 Spearman’s correlation coefficient of total cholesterol.

| Parameter                        | Cholesterol after two months of DASH diet and exercise |
|----------------------------------|--------------------------------------------------------|
| initial value of total cholesterol | r = - 0,53**                                             |

** p < 0.01

Table 4 Spearman’s triglyceride value correlation coefficient.

| Parameter           | Triglyceride after two months |
|---------------------|-------------------------------|
| initial triglyceride value | r = - 0,69**                 |

** p < 0.01

Table 5 Spearman correlation coefficient of CRP and HDL-C parameters.

| Parameter | HDL-C after two months |
|-----------|------------------------|
| CRP       | r = - 0,42**           |

** p < 0.01
There was a negative correlation with other triglyceride values after two months of DASH diet and exercise \((r = -0.69; p < 0.01)\). (Table 4) A negative correlation was shown with the second CRP value after two months of DASH diet and exercise \((r = -0.42; p < 0.01)\). (Table 5)

### Discussion

According to the 2016 report of the FBiH Institute of Public Health on the population’s health status, the leading morbidities in women are cardiovascular diseases, which are ultimately the cause and the leading cause of mortality.[2] According to the inclusion criteria, this research included 60 female respondents who joined the survey. In a study by Dekker and associates on metabolic syndrome and the ten-year risk of CVD, the age group of respondents ranged from 50–75 years.[12] This study is not correlated with our study due to the presence of metabolic syndrome in this age group.

In the work of Anderson and associates, high blood pressure is present in 52% of respondents around the age of 73, and 72% of respondents have blood pressure values higher than the above reference value.[13] This work is correlated with our study, which included subjects with blood pressure values > 140/90 mmHg.

The impact of the two-month DASH diet and exercise program on BMI is evident. The significance of lowering the endpoint BMI relative to baseline was statistically significant, \(p < 0.05\), as confirmed by the Wilcoxon test. By categorizing the BMI values in this paper, it was found that 62% of respondents were overweight, 26% of respondents were obese, and only 12% of respondents had an ideal body weight. The authors of the study Estruch and associates, in their study, proved that 45% of respondents are overweight (BMI> 25) and that 47% of respondents are obese (BMI> 30).[14] Given the percentage of overweight respondents, this paper correlates with our work in terms of increased representation of overweight people while not correlated with the number of respondents, which is higher in this study compared to our study. Obesity is closely linked to cardiovascular risk, as confirmed by a study establishing a link between anthropometric measurements and the risk of cardiovascular disease.[15,16]

In the study by Blumethal and associates, the effects of dietary regimen (DASH) and aerobic exercise on changes in insulin and lipid levels were investigated. Subjects who combined the DASH diet with aerobic exercise lost weight and reported lower total cholesterol and triglycerides than the control group.[17]

Considering the values of lipid status, in this study, CASTELLI I index in 95.9% of respondents indicated the presence of a risk of cardiovascular disease (M = 5). The maximum value in work reached a degree with a very high risk of cardiovascular disease (M = 10). Spearman correlation coefficient indicated the existence of a positive relationship between CASTELLI I index and total cholesterol \((r = 0.29; p < 0.05)\), CASTELLI I index and triglycerides \((r = 0.59; p < 0.01)\), CASTELLI I index and HDL-C \((r = 0.79; p < 0.01)\). This means that the increase in the value of one parameter is followed by the increase in the value of another parameter. In their paper, Bhardwaj S and associates cite the importance of the CASTELLI I index in the prediction of cardiovascular disease and the direct impact of the CASTELLI I index with cholesterol and triglyceride values on cardiovascular disease.[18]

In the work of the author Andić, cholesterol values were \((x = 3.86 \text{ mmol/L})\), triglycerides \((x = 1.64 \text{ mmol/L})\), glucose \((x = 5.44)\), but these values cannot be correlated with our work because the sample is respondents with an already established diagnosis of CVD.[19] In terms of lipid status, in this research, the initial cholesterol measurement showed increased values \((M = 7 \text{ mmol/L})\), while after the second month of DASH diet and exercise, cholesterol decreased \((M = 4 \text{ mmol/L})\). The significance of lowering the cholesterol value in relation to the initial value was statistically significant, \(p < 0.01\) (difference in cholesterol values), confirmed by the Wilcoxon test. The Spearman correlation coefficient indicated a negative relationship between the initial cholesterol values and the cholesterol value after two months of applying for the above program \((r = -0.53; p < 0.01)\). A negative correlation between the parameters indicates that high baseline cholesterol values were accompanied by a decrease after two months of DASH diet and exercise.

A retrospective study by Wilson and associates demonstrated high triglyceride levels in 48% of subjects \((x = 3.32 \text{ mmol/L})\).[20] The mentioned research cannot be correlated with our research because it refers to a follow-up period of 12 years. The value of the initial measurement of triglycerides in this study indicated increased values of \(M = 2 \text{ mmol/L}\). In comparison, the values of triglycerides after two months of application of the program were lower \(M = 1.5 \text{ mmol/L}\). The significance of the decrease in triglyceride values compared to the initial value was statistically significant, \(p < 0.01\), which was confirmed by the Wilcoxon test. Spearman’s correlation coefficient indicated a negative relationship between the initial triglyceride values and the triglyceride value after two months of program application \((r = -0.69; p < 0.01)\). A negative correlation between the parameters indicates that high initial triglyceride values are accompanied by a decrease in values after applying the DASH diet and exercise program.

According to Ridker P. and associates, the ratio of total cholesterol to HDL-C was a good predictor of cardiovascular disease.[21] In addition to the parameters for determining obesity, blood pressure, and lipids, the authors cite the parameter of high-sensitivity CRP, which also provided prognostic information. While the measurement of total cholesterol, low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C) is recommended in most modern cardiovascular screening algorithms, CRP has been further proven to be a predictive parameter in all groups.[21] In our study, CRP had a high value in the initial analysis \((M = 10 \text{ mg/L})\), while after the implementation of the entire program, the CRP value decreased to \((M = 4 \text{ mg/L})\), and a significant negative correlation \((p < 0.01)\) we observed between the values of CRP and HDL-C, which indicates that the value of HDL-C as a protective lipoprotein for blood vessels increased. CRP decreased after two months of DASH diet and exercise.

### Conclusion

Based on the study, we concluded that, when examining lipid status, the initial value before two months of the program is high. The value after two months of DASH diet and exercise decreased significantly; thus, the values returned within the reference intervals. By examining BMI values, baseline values before applying the program indicated overweight. A significant reduction in BMI was found after two months of DASH diet and exercise. The Castelli I index, as a useful parameter for predicting the risk of cardiovascular diseases, showed the presence of risk in the subjects, which decreased when it was determined afterwards. In addition to the above, the inflammatory marker CRP after the program’s application decreased to reference values and is considered a useful screening parameter in risk assessment. With this research, we want to draw attention to the importance of creating adequate risk assessment models with a well-developed strategy that will include anthropometric, laboratory and other multidisciplinary aspects in order to combat cardiovascular disease. Also, our research points to the significant role of creating guidelines and programs, which will reduce the values of lipid status and BMI and promote healthy lifestyles as indispensable programs in the fight against cardiovascular disease. Further research is recommended to expand the laboratory panel of parameters and non-laboratory aspects of risk assessment to a larger number of respondents.

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**Graph 2.** Initial values of cholesterol, triglycerides and HDL-C in relation to the values after the application of DASH diet and exercise.
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Conflict of Interest
There are no conflicts of interest to declare by any of the authors of this study.

References
1. Sadeghi M, Haghdoost AA, Bahrampour A, Dehghani M. Modeling the burden of cardiovascular diseases in Iran from 2005 to 2025: the impact of demographic changes. Iran J Public Health. 2017;46(4):506.

2. Zdravstveno stanje stanovništva i zdravstvena zaštita u Federaciji Bosne i Hercegovine 2016. Zavod za javno zdravstvo FBiH, 2017. Dostupno na: http://www.fmoh.gov.ba/images/federalno_ministarstvo_zdravstva/preporucujemo/istrazivanja/Zdravstveno-stanje-stanovnistva-2016.pdf

3. Prabawati D, Lorica J. Cardiovascular disease risk assessment based on laboratory versus non-laboratory tests: A systematic review.

4. Dhana K, Ikram MA, Hofman A, Franco OH, Kavousi M. Anthropometric measures in cardiovascular disease prediction: comparison of laboratory-based versus non-laboratory-based model. Heart. 2015 Mar 1;101(5):377-83.

5. Parhofer KG. Interaction between Glucose and Lipid Metabolism. Pubmed 2015. Dostupno na: https://www.ncbi.nlm.nih.gov/pubmed/26566492

6. Žaljko Reiner, Alberico L, Catapano, Guy De Backer, Ian Graham, Marja-RiittaTaskinen, OlovWiklund, i sar. ESC/EAS Guidelines for the management of dyslipidemias. EuroHeart J 2011; 32(14): 1769-1818.

7. Assman G, Schulte H. The Prospective Cardiovascular Münster (PROCAM) study. Pubmed; 1988 Dec;116(6 Pt 2):1713-24.

8. Stone NJ, Robinson J, Lichtenstein AH, i sar. Guideline on the Treatment of Blood Cholesterol to Reduce Atherosclerotic Cardiovascular Risk in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol 2013.

9. Dekker J.M, Girman C, Rhodes T. Metabolic Syndrome and 10-Year Cardiovascular Disease Risk. Circulation. American Heart Association. 2005;112:666-673.

10. Petrović D, Mitić V. Rehabilitacija starijih osoba sa kardiovaskularnim oboljenjima. Balneoclimatologija 2007; 31(suppl 1): 315-23.

11. Ilić S, Deljanin-Ilić M, Nikolić A. Acute coronary syndromes. Second part: prognosis, treatmentand secondary prevention. Acta Medica Medianae 2004; 43 (3): 37-44.

12. Dekker J.M, Girman C, Rhodes T. Metabolic Syndrome and 10-Year Cardiovascular Disease Risk. Circulation. American Heart Association. 2005;112:666-673.

13. Anderson KM, Wilson P, Odell, et al. An updated coronary risk profile. A statement for health professionals. Circulation 1991; 83:357-63.

14. Estruch R, Ros E, Salas-Salvado J. Primary Prevention of Cardiovascular Disease with Mediterranean Diet. The New England Journal of Medicine. Vol.368. No 14, 2013.

15. Yusuf S, Hawken S, Ôunpuu S, et al. Učinak potencijalno primjenjivih čimbenika rizika povezanih s infarktom miokarda u 52 zemlj (studija INTERHEART); studija slučaj-kontrola. Orv Hetil. 2004;147(15):675;

16. Wang, F., Chen, Y., Chang, Y. et al. New anthropometric indices or old ones: which perform better in estimating cardiovascular risks in Chinese adults. BMC Cardiovasc Disord 18, 14 (2018). https://doi.org/10.1186/s12872-018-0754-z

17. Blumenthal JA, Babyak MA, Sherwood A, Craighead L, Lin PH, Johnson J, Watkins LL, Wang JT, Kuhn C, Feinglos M, Hinderliter A. Effects of the dietary approaches to stop hypertension diet alone and in combination with exercise and caloric restriction on insulin sensitivity and lipids. Hypertension. 2010 May 1;55(5):1199-205.

18. Bhardwaj S, Bhattacharjee J, Bhatnagar MK, Tyagi S. Atherogenic plasma index, Castelli risk index and atherogenic coefficient - new parameters in cardiovascular risk assessment. Int J PharmBio Sci. 2013; 3: 359–64.

19. Andić M. Efekti fizičkog treninga u kardiopulmonalnoj rehabilitaciji posle infarkta miokarda. Univerzitet u Beogradu Medicinski fakultet. Doktorska disertacija. 2016.

20. Wilson P, Agostino R, Levy D et al. Prediction of Coronary Heart Disease Using Risk Factor Categories. Circulationaha. American Heart Association. 1998; 97:1837-1847.

21. Ridker PM, Rifai N, Cook NR, Bradwin G, Buring JE. Non–HDL Cholesterol, Apolipoproteins A-I and B100, Standard Lipid Measures, Lipid Ratios, and CRP as Risk Factors for Cardiovascular Disease in Women. JAMA. 2005;294(3):326–333. doi:10.1001/jama.294.3.326.