Original scientific paper
UDC 616.1-083.71

APPLICATION OF MULTIVARIATE TOOLS IN ESTABLISHING RELATIONS BETWEEN CARDIOVASCULAR HEALTH AND PHYSICAL ACTIVITY BASED ON A SURVEY

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Abstract

Proper diet that provides optimal ratio of nutrients, in particular fat and salt is one of the prerequisites for reducing the risk of cardiovascular diseases. The benefits of all forms of exercise are numerous and aerobic activities have a positive effect on the cardiovascular system. A pilot survey was conducted among the working populations of both genders to collect answers that could indicate their behavior regarding cardiovascular health. The aim of this study was to determine the attitudes of the respondents about the impact of proper nutrition and exercise on the cardiovascular system, and determine the level of awareness of respondents about potential links between the nutrition and cardiovascular health.

To determine the attitude of the respondents a validated questionnaire was used. In a large set of parameters that interact with each other, the multivariate analysis was applied. Principal component analysis was used to determine the similarities and differences of attitudes regarding the exercise and cardiovascular health.

The results are encouraging, showing that respondents are almost fully aware of the impact of proper nutrition (96%) and exercise (98%) on cardiovascular health. They point out the negative effect of fast food (86%), fat (34%), carbohydrates (24%) and salt (22%). According to the results of the research, physical activity can affect the good cholesterol and triglyceride levels (96% and 92%) and the blood pressure reduction (96%). The results show that those that are engaged in physical activity (at least moderately) have an attitude that aligns them to the critical population, because their eating knowledge or preferences are not in accordance with the food that should be consumed to prevent cardiovascular diseases. Therefore, they should be classified in a group that in the future could have a significantly higher risk of cardiovascular disease.

***Key words**: Cardiovascular health, Physical activity, Survey, Multivarate analysis.*

1. Introduction

Cardiovascular diseases (CVD) include: diseases of the heart, vascular diseases of the brain and diseases of blood vessels. According to the World Health Organisation [1], more than 17 million people in 2008 died from cardiovascular diseases. CVDs are the biggest cause of deaths in the world. In Croatia about 25,000 people dies each year from CVD [2]. According to the Croatian Ministry of Health [2] in the age group up to 65 years CVDs are the second cause of death and their share in the mortality rate is 25.8%. CVDs are cause of death for 54.3% women and 41.8% men. Croatia with standardized mortality rate of 342.1/100,000 belongs to European countries with medium high mortality rate.

Factors that promote the process of atherosclerosis are known as risk factors [3 - 6], and include: behavioural risk factors, metabolic risk factors and other risk factors. Behavioural risk factors are: tobacco use, physical inactivity, unhealthy diet (rich in salt, fat and calories), and harmful use of alcohol. Metabolic risk factors are divided into: raised blood pressure (hypertension), raised blood sugar (diabetes), raised blood lipids (e.g. cholesterol), overweight, and obesity. Other risk factors are: poverty and low educational status, advancing age, gender, inherited (genetic) disposition, psy-

chological factors (e.g. stress, depression) and other risk factors (e.g. excess homocysteine). There is strong scientific evidence that behavioural and metabolic risk factors play a key role in the aetiology of atherosclerosis [7]. Unhealthy behaviours lead to metabolic/physiological changes: raised blood pressure (hypertension); overweight/obesity; raised blood sugar (diabetes); and raised blood lipids (dyslipidaemia). Social relations are predictive of mortality and cardiovascular disease, and social relations play an equally protective role against both the incidence and progression of cardiovascular disease [8 - 10].

Insufficient physical activity can be defined as less than 5 times 30 minutes of moderate activity per week, or less than 3 times 20 minutes of vigorous activity per week, or equivalent, and it is the fourth leading risk factor for mortality [1]. People who are insufficiently physically active have a 20% to 30% increased risk of all-cause mortality compared to those who engage in at least 30 minutes of moderate intensity physical activity most days of the week [6]. Participation in 150 minutes of moderate physical activity by adults each week (or equivalent) is estimated to reduce the risk of ischemic heart disease by approximately 30% and the risk of diabetes by 27% [3]. Overwhelming evidence garnered from a number of sources, including epidemiological, prospective cohort and intervention studies indicating that CVD is largely a disease associated with physical inactivity and clinical benefits of exercise therapy in the prevention and treatment of CVD are encouraged [11 and 12]. Moreover, regular physical exercise training partially corrects endothelial dysfunction and leads to an economization of left ventricular function [13]. According to the Giada *et al.*, [14] physical exercise also seems to significantly reduce the risk of developing other chronic diseases such as: obesity, osteoporosis, diabetes, tumours and depression. According to Crisafulli *et al.*, [15] regular exercise is cardio-protective having beneficial impact on the cardiovascular system, both directly by improving endothelial function and indirectly by normalizing risk factors of atherosclerosis [16].

Substantial data have established that higher levels of physical activity participating in exercise training, and higher overall cardiorespiratory fitness provide considerable protection in the primary and secondary prevention of coronary heart disease [17, 18].

Nutrition has been largely recognized as an important risk protection factor for cardiovascular disease [19]. Fatty acids food composition has been strongly related to lipid metabolism and consequently to metabolic risk factors and the risk of cardiovascular disease [7]. Total and HDL cholesterol are major determinants of coronary heart disease. Saturated and trans-fatty acids have a total and LDL cholesterol elevating effect and unsaturated fatty acids a lowering effect. N-3 polyunsaturated fatty acids seem to have a protective effect on coronary heart disease occurrence independent of cholesterol [26]. More than a half century of evidence from epidemiologic, experimental and clinical trials pinpoints a positive correlation between lifestyle and dietary factors as they relate to blood lipids, blood pressure, and coronary heart disease risk and a number of evidence-based nutrition guidelines have emerged [8]. Broader adherence to recommendations for daily intake of: fruit, vegetables, fish and fatty acid composition may take away as much as 20 - 30% of the burden of cardiovascular disease [20]. However, diet may influence stroke risk via several mechanisms, but the optimal dietary habits for stroke prevention are not well established [21]. Nutritional intervention influences most important CV risk factors: cholesterol level, blood pressure (BP) and diabetes [22, 23]. Consumption of fruits and vegetables is associated with lower concentrations of total and low-density lipoprotein cholesterol [24]. Many nutrients and phytochemicals in fruits and vegetables, including: fibre, potassium, and folate, could be independently or jointly responsible for the apparent reduction in CVD risk [25]. The objectives of this study were: (i) to determine the attitudes of the respondents about the impact of proper nutrition and exercise on the cardiovascular system; and (ii) to determine the level of awareness of respondents about potential links between the nutrition and cardiovascular health.

2. Materials and Methods

2.1 Participants and questionnaire

The survey was conducted during the first half of 2016 in the Zagreb and Zagreb County area, Croatia. In the research a convenience sample was used, and data were collected using a self-administrated questionnaire on a sample aged over 18 years (N = 50). The questionnaire was distributed among respondents and participation was anonymous.

The questionnaire was designed to assess opinions and attitudes about the cardiovascular health and exercises, attitudes regarding proper nutrition as well as the socio-demographic variables (Table 1). It included 19 questions related to the nutrition and cardiovascular health. Open-ended questions were used in order to collect data about: (i) the respondents' opinion regarding food with negative impact on cardiovascular health, and (ii) respondents' knowledge of cardiovascular diseases. In order to measure attitudes of the respondents group of questions was rated on the five-point Likert scale as either positive or negative response to a given statement, using the following degrees: 1 = "strongly disagree", 2 = "disagree", 3 = "neither agree nor disagree", 4 = "agree" and 5 = "strongly agree".

Table 1. Socio-demographic characteristics of the data set

Characteristic	%
Gender	
Female	58
Male	42
Education level	
Elementary school	2
High school	24
University degree	60
Master's Degree/PhD	14
Income (€)	
< 470	10
471 - 670	16
671 – 1,000	26
1,001 – 1,350	18
> 10,000	30
Place of residence	
City	62
Village	38

2.2 Statistical analyses

To identify patterns in the experimental data and to express the data based on similarities and differences not detectable by use of descriptive statistical tools, we used the Principal components analysis (PCA). All analyses were performed using the program Statistica v. 10 [27].

3. Results and Discussion

The respondents were asked about their opinion regarding the influence of nutrition on their health and the importance of breakfast consumption (Figure 1 and Figure 2).

Significant majority is aware of the importance of the food quality and regularity of meal consumption related with the cardiovascular diseases. Although 86.7% of the respondents consider breakfast as an important meal (Figure 1), just 62% of them are having it every day (Figure 2).

The objective of the research was to identify CVDs which respondents perceived as a disease that potentially can be corrected with proper eating habits (Figure 3).

According to the Bergman Markovic *et al.*, [22], lower animal fat intake causes cardio vascular mortality (CVM) reduction by 12%, taking additional serving of fruit/day by 7% and vegetables by 4%. Restriction of dietary salt intake (3 g/day) lowers blood pressure by 2 - 8 mm Hg, and CVM by 16%. The respondents have also pointed out the hypertension (30% of them) as a CVD that can be partially controlled with an appropriate eating pattern.

Excessive sodium intake is a causal risk factor for hypertension, whereas a diet rich in fruit, vegetables, and low-fat dairy products, and low in sodium and saturated fat has been recommended to prevent and reduce hypertension on the basis of strong evidence [23]. Dietary and other lifestyle factors play a major role in the prevalence of hypertension [28] as confirmed according to the results presented in Figure 4.

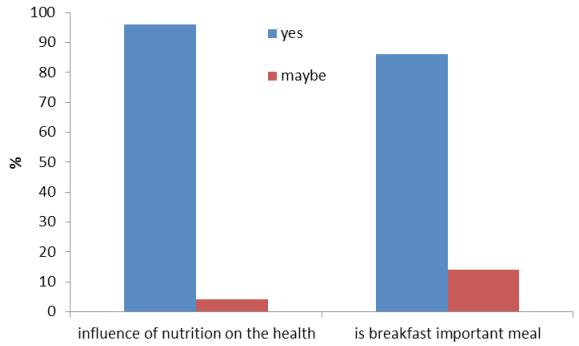

Figure 1. Opinion of the respondents regarding the influence of nutrition on their health and the importance of breakfast consumption

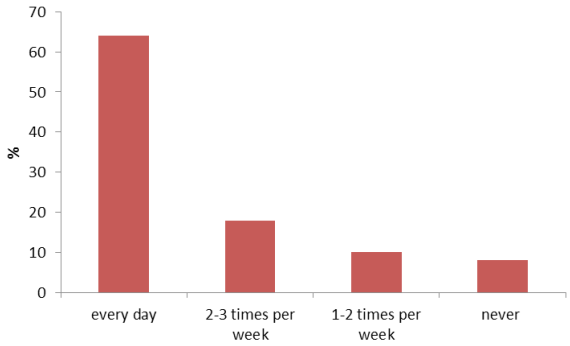

Figure 2. Regularity in breakfast consumption

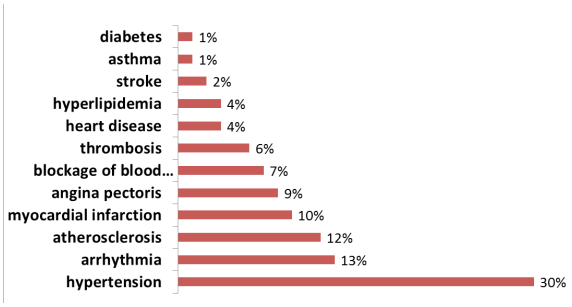

Figure 3. Cardiovascular diseases (CVD) related with the inadequate nutrition, according the opinion of the respondents

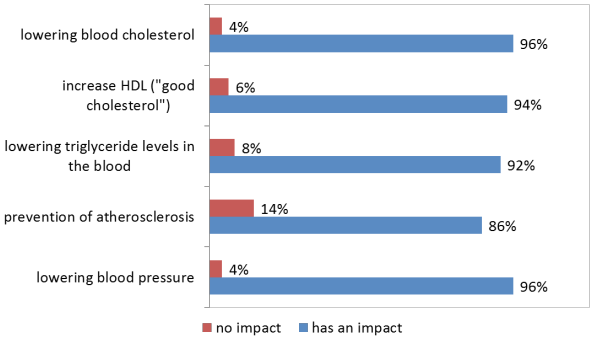

Figure 4. Impact of food on the cardiovascular health

Over 96% of respondents confirmed that the food intake has an impact on the blood pressure and that a specific diet can decreased it.

Studies show that the risk of CVD decreased whereas physical activity increased. Women and men who were physically active at least twice a week had a 41% lower risk of developing CVD than those who performed no physical activity (hazard ratio = 0.59, CI = 0.37 - 0.95), after adjustment for all the explanatory variables [17]. The results of this research confirm this as well (Table 2).

Table 2. What influences good health and the benefits of physical activity

	Has an impact (%)	No impact (%)
Good for health		
Physical activity	98	2
Increased physical activity	80	20
A varied diet	96	4
Regular consumption of a meal	82	18
The consumption of coffee	40	60
Regular consumption of fruits	80	20
Consumption of fish	82	18
Consumption of alcohol	42	58
The benefit of physical activity		
Lowering blood pressure	96	4
Prevention of atherosclerosis	86	14
Lowering triglyceride levels in the blood	92	8
Increase HDL ("good cholesterol")	94	6
Lowering blood cholesterol	96	4

98% of the participants agreed that the physical activity is important and has an impact on their good health pointing out the benefits like: lowering blood pressure (96%); prevention of atherosclerosis (86%); lowering triglyceride levels in the blood (92%); increase of HDL ("good cholesterol", 94%) and lowering blood cholesterol (96%).

When the idea is the observation and analysis of more than one statistical outcome variable at a time, than the multivariate analysis is involved. This technique is used to perform trade studies across multiple dimensions while taking into account the effects of all variables on the responses of interest. Biplot of the principal component analysis can be used to establish relationship between nutrition in different geographical regions [29, 30] as well as to evaluate potential dietary pattern [31] and the relation of fat intake and cardiovascular diseases [32, and 33]. Studies confirmed reduction of the number of CVD patients among the persons following the principles of the Mediterranean diet [34, 35]. The aim of the research was to establish the relationship of the physical activity and awareness of duly nutrition vs. expected cardiovascular diseases risk (Figure 5).

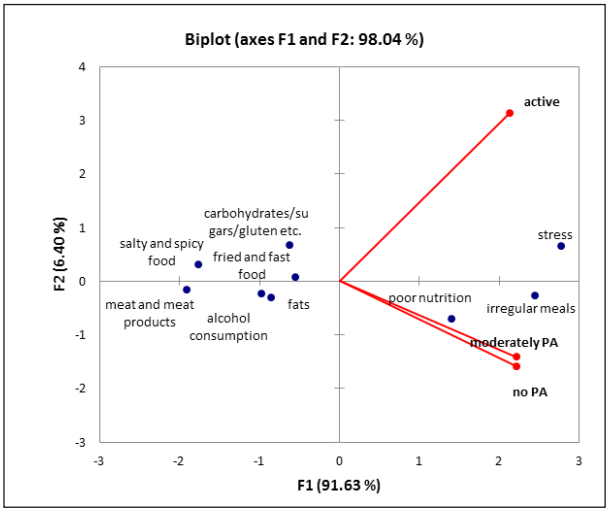

Figure 5. Biplot of the principal component analysis presenting as factors the food consumed and as components are presented the levels of physical activity

Those who are physically active indicate poor nutrition, irregular meals and stress as directly "responsible" for cardiovascular diseases (Figure 5).

Nola and co-workers presented in their study in 2010 [36], that eating habits are positively correlated with CDVs and their results reviled salty and spicy meals as an undesirable eating pattern what confirmed our findings. The efficiency of physical activity on the good health impact confirmed Völgyi *et al.*, [37]. Table 3 is presenting the component and factor scores coefficients in the observed data set.

Table 3. Component and factor score coefficients after Varimax rotation

Component and factor score		D1	D2
Physical activity	active	-0,96	1,66
	no	0,89	-0,51
	moderately	0,82	-0,43
Food habits	carbohydrates/ sugars/gluten etc.	-1,27	0,92
	fats	-0,11	-0,78
	meat and meat products	-0,63	-1,04
	fried and fast food	-0,35	-0,09
	salty and spicy food	-1,25	-0,16
	Stress	0,31	2,22
	poor nutrition	1,69	-0,69
	irregular meals	1,53	0,48
	alcohol consumption	0,07	-0,87

According the presented biplot - the two principal components explain over 98% of all variations in the data matrix and the majority appertain the first component, D1 (91.6%) in which are positioned the moderately and physically inactive respondents are positioned in diametrically opposed quadrants (Figure 5, 2nd and 4th quadrant), what confirm the values in Table 3. This means that two activity groups did not indicated food rich in carbohydrates/sugars/gluten, fried and fast food or salty and spicy food as food that should be reduced in the daily nourishment. The application of PCA allowed a characterization of different groups that differed based on their physical activity, what is again in accordance with findings of Waring and co-workers whose study in 2009 proved correlation of weight pattern during middle age, also related with the eating pattern [38].

4. Conclusions

- Presented results have confirmed the awareness of the respondents regarding the relationship of nutrition quality and physical activity as factors that can be helpful cardiovascular diseases prevention.

- The data obtained revealed significant differences regarding the activity level of the respondents. The use of principal component analysis helped to allocate the potential threats related to nutrition behaviour that could be related with developing cardiovascular disease depending on the physical activity of the respondents.

- The most problematic group is not the one consisting of persons not exercising but the group exercising moderately which seems to have irregular attitude about healthy diet.

- This study provides an update and useful information confirming the hypothesis that multivariate analysis provides an effective tool for data classification and extraction of important variables in an analysis of complex phenomena such as nutritional attitudes and physical activity.

5. References

[1] Mendis S., Puska P., and Norrving B. (Eds.). (2011). *Global atlas on cardiovascular disease prevention and control*. World Health Organisation, Geneva, Switzerland.

[2] Croatian Ministry of Health. (2015). *Action plan for prevention and control of chronic non-communicable diseases* (in Croatian). <URL:https://zdravlje.gov.hr/pristup-informacijama/savjetovanje-sa-zainteresiranom-javnoscu-1475/okoncana-savjetovanja/savjetovanja-u-2015-godini/akcijski-plan-za-prevenciju-i-kontrolu-kronicnih-nezaraznih-bolesti-2015-2020-1648/1648. Accessed 23 August 2016.

[3] World Health Organization. (2007). *Prevention of cardiovascular disease: Guidelines for assessment and management of cardiovascular risk*. <URL:http://www.who.int/cardiovascular_diseases/guidelines/Full%20text.pdf. Accessed 23 August 2016.

[4] World Health Organization. (2008). Resolution *WHA61.14. WHO 2008–2013. Action plan for the global strategy for prevention and control of non-communicable diseases*. <URL:http://www.who.int/nmh/publications/ncd_action_plan_en.pdf. Accessed 23 August 2016.

[5] World Health Organization. (2009). *Global health risks: Mortality and burden of disease attributable to selected major risks*. <URL:http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf. Accessed 23 August 2016.

[6] World Health Organization. (2010). *Global status report on non-communicable diseases*. <URL:http://www.who.int/nmh/publications/ncd_report2010/en/. Accessed 23 August 2016.

[7] Iacoviello L., Santimone I., Latella M.C., De Gaetano G., and Donati M. B. (2008). *Nutrigenomics: a case for the common soil between cardiovascular disease and cancer.* Genes and Nutrition, 3, (1), pp. 19-24.

[8] Retelny V. S., Neuendorf A., Roth J. L. (2008). *Nutrition protocols for the prevention of cardiovascular disease.* Nutrition in Clinical Practice, 23, (5), pp. 468-476.

[9] Tay L., Tan K., Diener E., Gonzalez E. (2013). *Social relations, health behaviors, and health outcomes: a survey and synthesis.* Applied Psychology: Health and Well-Being, 5, (1), pp. 28-78.

[10] Van Horn L., McCoin M., Kris-Etherton P. M., Burke F., Carson J. A., and Champagne C. M. (2008). *The evidence for dietary prevention and treatment of cardiovascular disease.* Journal of American Dietetic Association, 108, (2), pp. 287-331.

[11] Leung F. P., Yung L. M., Laher I., Yao X., Chen Z. Y., Huang Y. (2008). *Exercise, vascular wall and cardiovascular diseases: an update (Part 1).* Sports Medicine, 38, (12), pp. 1009-1024.

[12] Yung L. M., Laher I., Yao X., Chen Z. Y., Huang Y., and Leung F. P. (2009). *Exercise, vascular wall and cardiovascular diseases: an update (Part 2).* Sports Medicine, 39, (1), pp. 45-63.

[13] Wienbergen H., Hambrecht R. (2012). *Physical exercise training for cardiovascular diseases*. Herz Cardiovascular Diseases, 37, (5), pp. 486-492.

[14] Giada F., Biffi A., Agostoni P., Anedda A., Belardinelli R., Carlon R., Carù B., D'Andrea L., Delise P., De Francesco A., Fattirolli F., Guglielmi R., Guiducci U., Pelliccia A., Penco M., Perticone F., Thiene G., Vona M., Zeppilli P. (2008). *Exercise prescription for the prevention and treatment of cardiovascular diseases: Part II.* Journal of Cardiovascular Medicine, 9, (6), pp. 641-652.

[15] Crisafulli A., Pagliaro P., Cohen-Solal A., Coats J. A. (2015). *Effects of Physical Exercise on Cardiovascular Diseases: Biochemical, Cellular, and Organ Effects*. BioMed Research International, http://dx.doi.org/10.1155/2015/853632 853632. Accessed 25 August 2016.

[16] Mirat J. (2007). *Physical activity in the prevention and treatment of cardiovascular diseases.* Acta Medica Croatica, 61, Suppl 1, pp. 63-67.

[17] Sundquist K., Qvist J., Johansson S. E., and Sundquist J. (2005). *The long-term effect of physical activity on incidence of coronary heart disease: a 12-year follow-up study*. Preventive Medicine Journal, 41, (1), pp. 219-225.

[18] Swift D. L., Lavie C. J., Johannsen N. M., Arena R., Earnest C. P., O'Keefe J. H., Milani R. V., Blair S. N., Church T. S. (2013). *Physical activity, cardiorespiratory fitness, and exercise training in primary and secondary coronary prevention*. Circulation Journal, 77, (2), pp. 281-292.

[19] Srinath Reddy K., and Katan M.B. (2004). *Diet, nutrition and the prevention of hypertension and cardiovascular diseases*. Public Health Nutrition, 7, (1A), pp. 167-186.

[20] Engelfriet P., Hoekstra J., Hoogenveen R., Büchner F., van Rossum C., and Verschuren M. (2010). *Food and vessels: the importance of a healthy diet to prevent cardiovascular disease.* European Journal of Cardiovascular Prevention and Rehabilitation, 17, (1), pp. 50-55.

[21] Ding E. L., and Mozaffarian D. (2006). *Optimal dietary habits for the prevention of stroke*. Seminars in Neurolology Journal, 26, (1), pp. 11-23.

[22] Bergman Marković B., Katić M., Vrdoljak D., Kranjcević K., Jasna V., Ivezić Lalić D. (2010). *Diet as a cardiovascular risk factor in family medicine*. Acta Medica Croatica, 64, (2), pp. 115-122.

[23] Zhao D., Qi Y., Zheng Z., Wang Y., Zhang X. Y., Li H. J., Liu H. H., Zhang X. T., Du J., and Liu J. (2011). *Dietary factors associated with hypertension.* Nature Reviews Cardiology Journal, 8, (8), pp. 456-465.

[24] Mirmiran P., Noori N., Zavareh M. B., and Azizi F. (2009). *Fruit and vegetable consumption and risk factors for cardiovascular diseases.* Metabolism, 58, (4), pp. 460-468.

[25] Bazzano L. A., Serdula M. K., and Liu S. (2003). *Dietary intake of fruits and vegetables and risk of cardiovascular disease.* Current Atherosclerosis Reports, 5, (6), pp. 492-499.

[26] Kromhout D. (2001). *Diet and cardiovascular diseases.* Journal of Nutrition, Health and Aging, (3), pp. 144-149.

[27] Statistica. (2011). *StatSoft. Inc. version 10*. Available: <URL:http://www.statsoft.com. Accessed 27 August 2016.

[28] Beilin L. J. (1999). *Lifestyle and hypertension - an overview*. Clinical and Experimental Hypertension, 21, (5-6), pp. 49-62.

[29] Gajdoš Kljusurić J., Bosanac V, Šanko K, and Colić Barić I. (2016). *Establishing energy-nutritional variety of boarding school daily menus as a result of regional differences using multivariate analysis.* Journal of Food Composition and Analysis, 51, pp. 61-68.

[30] Gajdoš Kljusurić J., Čačić J., Misir A., and Čačić D. (2015). *Geographical region as a factor influencing consumers' perception of functional food - case of Croatia*. British Food Journal, 117, pp. 1017-1031.

[31] Lazarou C., Karaolis M., Matalas A. L., and Panagiotakos D. B. (2012). *Dietary patterns analysis using data mining method. An application to data from the CYKIDS study.* Computer Methods and Programs in Biomedicine, 108, pp. 706-714.

[32] Hayes K. C. (2002). *Dietary fat and heart health: in search of the ideal fat.* Asia Pacific Journal of Clinical Nutrition, 11, pp. S394-S400.

[33] Gillingham L. G., Harris-Janz S., Jones P. J. (2011). *Dietary monounsaturated fatty acids are protective against metabolic syndrome and cardiovascular disease risk factors*. Lipids, 46, pp. 209-228.

[34] Miller E. R., Erlinger T. P. (2008). *Epidemiological Studies on Atherosclerosis: The Role of the Mediterranean Diet in the Prevention of Cardiovascular Disease.* In: Holtzman, J. L. (Ed.), Atherosclerosis and Oxidant Stress, Springer, USA, pp. 11-24.

[35] Whitney E. N., and Rolfes S. R. (1999). *Understanding Nutrition* (8th ed.), West Wadsworth, London, UK.

[36] Nola I. A., Doko Jelinić J., Bergovec M., Ružić A., and Peršić V. (2010). *Dietary habits and cardiovascular diseases* (in Croatian). Acta Medica Croatica, 64, pp. 89-95.

[37] Völgyi E., Lyytikäinen A., Tylavsky F. A., Nicholson P. H. F., Suominen H., Alén M., and Cheng S. (2009). *Long-term leisure-time physical activity has a positive effect on bone mass gain in girls.* Journal of Bone and Mineral Research, 25, pp. 1034-1041.

[38] Waring M. E., Eaton C. B., Lasater T. M., and Lapane K. L. (2009). *Correlates of weight patterns during middle age characterized by functional principal components analysis.* Annals of Epidemiology, 20, pp. 201-209.