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THE INFLUENCE OF GLUTEN-FREE BAKERY PRODUCTS CONSUMPTION ON SELECTED ANTHROPOMETRIC PARAMETERS

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ABSTRACT

The aim of the study was to evaluate the effect of a short-term consumption (six weeks) of gluten-free bakery products on the anthropometric parameters. The study group was composed of volunteers from the general population and consisted of 30 healthy adults. The amount of bakery product was determined as follows: women consumed 150 – 200 grams per day; men 200 – 250 grams per day. Anthropometric measurements were made by using InBody 720, we received data such as body weight, Body Mass Index (BMI) and Waist-to-Hip Ratio (WHR), which we evaluated the presence of overweight and obesity in the monitored groups. We also observed visceral fat area (VFA). We found out that the 6-week consumption of gluten-free bread and bakery products showed a significant reduction in body weight and BMI (p <0.01), but also to a significant increase in VFA (p <0.05). By the impact of consumption we recorded the increase of body weight and BMI in 70% of participants (in 30% there was slight increase), decrease of WHR in 33% (increase in 43%) and decrease of VFA in 43% (increase in 57%). For other participants, the values remained unchanged. Two months after the termination of the consumption of gluten-free products we found out the increase of body weight and BMI, WHR remained unchanged, however in the case of VFA showed significant increase of values. We can summarize that dietary habits play a crucial role in the development of overweight and obesity and the consumption of bread and bakery products can also affect it. However, the overall effect of bread and bakery consumption on the development of overweight depends on many factors, such as the composition of the bread and bakery products and the presence of gluten.

Keywords: gluten, bakery products, body mass index, waist-to-hip ratio, visceral fat area

INTRODUCTION

Obesity is health problem affecting more than a million adults worldwide **(WHO, 2008)**. Health professionals recommend the exclusion of some foods in weight loss diets **(Layman et al., 2003; Luscombe et al., 2003; Yancy et al., 2004; Noakes et al., 2005)**. Restricting the consumption of carbohydrates, especially bread, is a frequent practice since these foods are considered as inappropriate and are included in the list of forbidden foods by those trying to lose weight **(Malinauskas et al., 2006; López Sobaler et al., 2007)**. High carbohydrate content in cereals is considered as one of the factors contributing to the obesity epidemic **(Hoffmanová and Sánchez, 2015)**.

Bread is one of the most popular staple foods in the world and its consumption provides energy, proteins, dietary fiber, minerals and vitamins intake **(Nanditha and Prabhasankar, 2009)**. Bread and bakery products are usually produced from wheat and rye containing gluten. Prolamins such as gliadins of wheat, hordeins of barley, secalins of rye and avenins of oats cause health problems to people with disorders such as coeliac disease, allergy and non-celiac gluten sensitivity **(Hamer, 2005)**.

The prevalence of celiac disease is high, ranging from 0.5 – 1% in Europe and America, a similar prevalence is also estimated in Australia, the Middle East, North Africa and probably also in northern China. In Slovakia, the incidence of celiac disease is 1:250. Prevalence is more pronounced in women with a ratio of 2:1 to 3:1 **(Suchá et al., 2015)**. Celiac disease also known as celiac sprue or gluthene enterotherapy is a digestive and autoimmune disorder resulting in damage to the small intestine mucosa caused by eating foods containing gluten **(Bansal, Gupta and Bansal, 2017)**. Recognition of symptoms, as well as a responsible approach to disease therapy and nutrition counseling is very important for the patient's prognosis **(Haas et al., 2014)**. At present, the only affordable and acceptable treatment for celiac disease is a strict gluten-free diet, which in practice means excluding all foods containing rye, wheat and barley. The inclusion of oats in the diet is still under discussion. At present, we are still working on the development and validation of new

methods for determining the presence of gliadins, secalins and hordeins in plant material and on the possibilities of using various alternative plants and pseudocereals in nutrition of celiatics **(Socha, Raždíková and Urminská, 2010; Chňapek et al., 2014)**.

Dietary measures usually lead to normalization of clinical, laboratory and enterobioptic findings at a different time from the introduction of a gluten-free diet **(Suchá et al., 2015)**. The content of some vitamins (B_1, B_2, B_{12}, D), minerals (iron, calcium, zinc, magnesium) and dietary fiber in the gluten-free diet may be lower than recommended for a sufficient intake **(Frič and Keil, 2011)**. In the western civilization, daily consumption of gluten is very high, on average 20-50 g **(Hoffmanová and Sánchez, 2015)**.

Recently, gluten-free products are very popular among consumers without diagnosed celiac disease, which has caused an exponential increase in gluten-free product sales. This report was updated by NHANES (National Health and Nutrition Examination Survey) from 2009 – 2012. From all of study participants (14,701 participants), 0.9% of them adhered to a gluten-free diet even though they had no diagnosed celiac disease **(Missbach et al., 2015)**. A gluten-free diet is necessary for patients with any form of gluten sensitivity. However, today many healthy people adhere to a gluten-free diet, although this is not necessary (**Kolesárová et al., 2017)**. This is a trend promoting gluten-free diet as a healthier diet. According to the survey, up to 30% of Americans are adhering to this diet. After removing gluten from the diet, these people feel less tired and, above all, do not have a weight problem. In fact, gluten-free foods are known to have an increased amount of fat, in some cases they contain up to 5 times more fat than gluten-containing products, so it is difficult to lose weight with this diet **(Kutner, 2014)**. According to **Penagini et al. (2013)** gluten-free products contain more carbohydrates and lipids compared to the gluten products and have a high glycemic index (estimated glycemic index of gluten-free products is ranged between 83.3 – 96.1 vs. 71 for white bread). In 2015, a study involving 30,000 respondents from 60 countries worldwide was carried out. It was found that 21% of respondents rated gluten-free products as an important attribute when they purchased food. The older generation is less affected by the gluten-free industry, despite the reports of an increased incidence of hypersensitivity to gluten in the elderly. According to the study, 37% of respondents under the age of 20 and 31% aged 21 – 34 were willing to pay higher prices for gluten-free products and only 22% of respondents aged 50 – 64 years and 12% aged 65 and over were also willing to invest in gluten-free products **(Reilly, 2016)**.

At present, the results of scientific studies have been gathered to find out the impact (also negative impact) of gluten-free foods on a healthy consumer. Some commonly used gluten-free foods contain more fat and carbohydrates and have a lower protein, iron and folic acid content compared to the conventional products **(Kulai and Rashid, 2014)**. For a healthy consumer, gluten-free foods do not provide additional health benefits from a nutritional point of view, so it is not appropriate to replace products containing gluten by gluten-free foods that are considerably more expensive **(Missbach et al., 2015)**. Our study was mainly focused on the effect of six weeks consumption of gluten-free bread and bakery products on changes in selected anthropometric parameters. Simultaneously, we assessed other changes of selected parameters two months after the termination of consumption of gluten-free bakery products.

Scientific hypothesis

Six weeks consumption of gluten-free bread and bakery products have effect on changes in selected anthropometric parameters.

MATERIAL AND METHODOLOGY

The trial was approved by the Ethic Committee at the Specialized Hospital St. Zoerardus Zobor, n.o. Nitra, Slovakia (protocol no. 012911/2016). The requirement for participation in the research was informed consent of volunteers with all the study and measurement conditions which they will have to complete during the research. All participants signed written informed consent to participate in the study. The participant group was composed of volunteers from the general population and consisted of 30 healthy adults (3 men and 27 women), who during 6-week period consumed gluten-free bread and gluten-free bakery products, however the participant of the study were not allowed total gluten-free diet. Participants with the present severe disease or with recommended special dietary regimen were excluded from the study group. The amount of bread and bakery products was determined according to the recommended consumption of food for the Slovak population as follows: women consumed 150-200 grams per day; men 200 – 250 grams per day. All participants were asked not to change their eating habits and also not to change their habits related to the physical activity.

Probands had a total of 3 anthropometric measurements (first measurement before consumption of gluten-free bakery products, second measurement after the 6-week consumption of gluten-free bread and bakery products, and the third measurement 2 months after end of consuming gluten-free bakery products).

The anthropometric measurements were made by using InBody 720 (Biospace Co. Ltd., Seoul, Republic of Korea). Each of the participants was informed with the measurement procedure, explained the possible risks of measuring in the case of pregnancy or having an artificial pacemaker at the heart. Before the measurement, participants were asked to excrete and refrain from drinking excessive amounts of water **(Wiklund et al., 2014)**. At the same time each participant signed informed consent for the measurement procedure and also agreed to the processing of personal data. We used the Lookin'Body 3.0 software to process the results. Through the Inbody 720 we received data such as weight, Body Mass Index (BMI) and Waist-to-Hip Ratio (WHR), which we evaluated the presence of overweight and obesity in the monitored groups. We also observed visceral fat area (VFA). Its excessive amount causes the metabolic and cardiovascular diseases. In the examination, the visceral fat area is defined as the cross-sectional area of visceral fat found in the abdomen.

Statistical analysis

We evaluated the collected data from the anthropometric measurements statistically and graphically in Microsoft Office Excel 2010 (Los Angeles, CA, USA). The changes in different groups were performed using Pared Student *t*-test and the data were presented as mean ± standard deviation (SD). The levels of statistical significance were set at $p < 0.05$ (*), $p < 0.01$ (**), $p < 0.001$ (***).

RESULTS AND DISCUSSION

Figures 1 – 4 and Table 1 show the changes of selected monitored parameters of participants throughout the survey.

Body weight

Bread is one of the most restricted foods in hypocaloric and reduced diets. **Loria-Kohen et al. (2012)** found that the results obtained after the completion of a hypocaloric diet intervention in overweight and obese patients are not related to the presence or absence of bread in the diet. There were no significant differences between bread or no-bread groups, both groups significantly reduced their body weight. Study of **Lean et al. (1997)** showed that a greater intake of bread is associated with less weight loss in postmenopausal women; however, **Aston, Stokes and Jebb (2008)** reported that the presence of bread was associated with greater weight loss.

At the beginning of the study during the first measurement was the average body weight of probands 65.32 ±12.60 kg. The value of maximal body weight was 101.40 kg and the lowest value of body weight was 48.50 kg. 20% of the participants exceeded their maximum recommended weight (Figure 1, Table 1). One proband was below the recommended minimum, other participants ranged within recommended values. After 6-week consumption of gluten-free bakery products, the average body weight of participants significantly decreased to 65.08 ±12.54 kg ($p < 0.01$). The value of maximal body weight was 100.50 kg and the lowest value of body weight was 48.10 kg. The exceeding of the recommended body weight was again recorded in 20% probands and same as below the recommended minimum value (1 participant). In one analytic study, in whose participated total 37 patients, were collected data about the patients with celiac disease, where after the year of the consumption of the gluten free diet the authors recorded significant increase of the body weight. The value of BMI remained within the normal range (**Quero et al., 2015**). After 2 months since the termination of the consumption of gluten free bakery products, we did not record any significant changes, despite the fact that the average weight was increased to 65.88 ±12.78 kg, the maximum to 102.7 kg and the minimum to 50 kg. The exceeding of the recommended body weight was recorded in 20% probands, the rest of the participants were within the range of the recommended values.

Figure 1 compares the results of all 3 measurements with respect to the specified individual weight standard of each proband. During all 3 measurements, the variability of the body weight of our participants was as follows: in the second measurement (due to the consumption of bakery products), 9 participants (30%) changed its weight, which had an increase in body weight relative to the first measurement. The greatest deviation was shown in the weight gain by 2.59% and the lowest by 0.34%. 70% of the participants reduced their weight, the greatest weight loss was by 1.96% and the lowest weight loss was by 0.18%. According to **Diamanti et al. (2014)** the occurrence of overweight in patients with celiac disease is in the range from 8.8% to 20.8%. The overweight/obesity is more common in newly diagnoses patients with celiac disease. It is possible that disinclination to food is led to the preference of food with high content of fat and proteins and high caloric food. However, the occurrence of obesity is possible to explain as a global trend of the overweight/obesity in people, including celiatics. During the third measurement (two months after the end of the consumption of gluten-free bread and bakery products) 20 participants (67%) increased their body weight, while the greatest recorded increase of body weight was by 2.46%. The rest 10 probands (33%) reduced their body weight with the greatest deviation in the increase of body weight

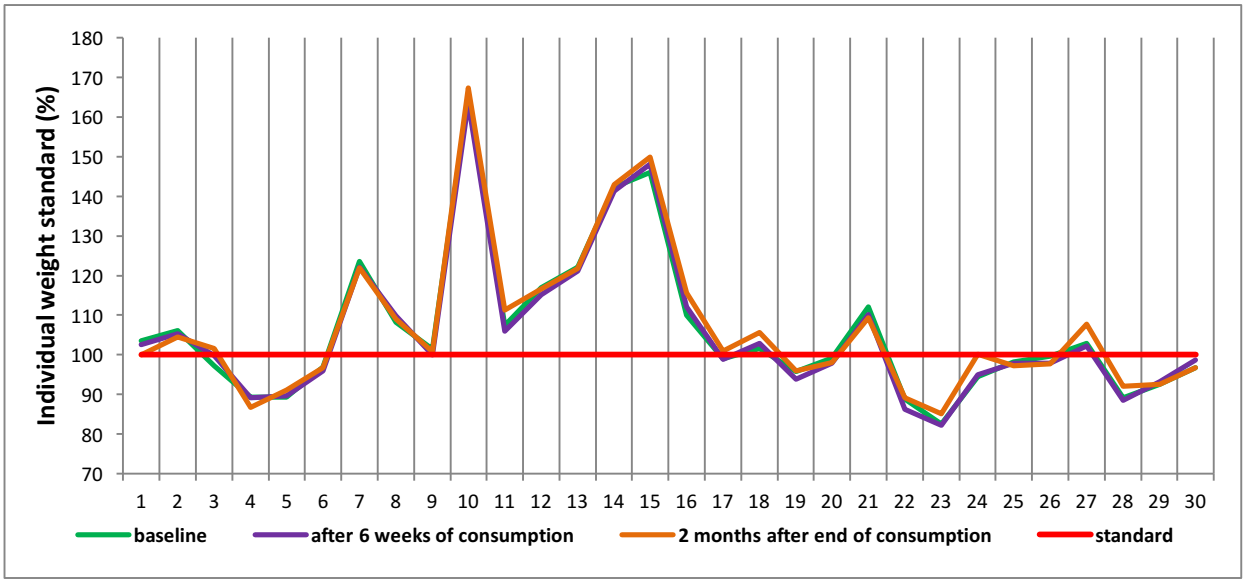

Figure 1 Changes of body weight compared to the individual weight standard in percent during the study.

by 5.35% and the lowest body weight decrease was by 0.15%. We found out that while at the beginning of the study 50% of the participants exceeded the ideal body weight, by the influence of the consumption of gluten-free bakery products the ideal body weight was exceeded in less probands (47%), but when comparing the number of subjects who exceeded the normalized body weight at the start and at the end of the study it was found the worsening, because up to 60% of the participants exceeded the normalized body weight limit in the conclusion of the study. Compared with the initial values, the body weight increased in 53% of participants, decreased in 40%, and 7% of the participants had the same body weight values between the first and last measurements. These changes were not significant.

Body Mass Index

The body mass index is used to determine the approximate degree of obesity. The BMI method is widely used in the general medicine, dietary and sport medicine as the main means for the evaluation of degree of obesity. The disadvantage of this method is that it can not be applied to adults with a high degree of muscle mass, to children and persons over 65 years or to pregnant women. The body mass index does not capture the changes in the nutritional status in the presence of overweight or obesity, because malnutrition can be present and masked by the abnormal amount of fat. Prior to the commencement of the consumption, a group with a normal weight was consisted of 23 participants, three probands had the overweight, two probands suffered from the first degree of obesity and the second degree of obesity was occurred in one participant (Figure 2, Table 1).

The average value of BMI was 22.83 ±3.95 kg.m^{-2}, while the values were in the range from 17.75 kg.m^{-2} to 35.5 kg.m^{-2}. After the 6-week consumption of gluten-free bakery products we recorded significant decrease of this index (p <0.01), while the average value of BMI was 22.75 ±3.95 kg.m^{-2} (Max value was 35.19 kg.m^{-2} and Min value was 17.68 kg.m^{-2}). After the last measurement we observed the increase of the average value of BMI to 23.03 ±4.02 kg.m^{-2}, it was also increased Max value of BMI to 35.96 kg.m^{-2} and Min value to 18.3 kg.m^{-2}. Increase or decrease of BMI values in the dynamics of the study directly correlate with the changes in the body weight values. As it is shown in the Figure 2, nine participants (30%) increased their values of BMI in the range from 0.04 to 0.54 kg.m^{-2}, on the contrary, decreasing of BMI were observed in 21 participants (70%) in the range of 0.04 – 0.54 kg.m^{-2}. During the third measurement since 2 months after the consumption of gluten-free bakery products we observed further increase of BMI values in 20 probands (67%) in the range from 0.03 to 1.17 kg.m^{-2}, decreasing was found in 10 probands (33%) in the range of 0.03-0.05 kg.m^{-2}. During the study, BMI values over 25 kg.m^{-2} had 20% of the participants, under 19 kg.m^{-2} at the beginning 3%, after consumption since the end of the study 7% of participants. **Ukkola et al. (2012)** monitored the influence of the year consumption of gluten-free diet to the body mass index in the celiatics. The values of BMI at the determination of the diagnosis and after a year on the gluten-free diet were assessed and compared with the data of general population. At the beginning of the diagnosis of the disease were underweight 4% of monitored probands, 57% of probands had values in the normal range, 28% were overweight and 11% were obese. After a one year consumption of gluten-free diet, 69% of underweight participants increased their body weight, and 18% overweight and 42% obese participants lost weight. BMI values of other subjects remained unchanged. The celiac group showed more favorable BMI results than the normal population.

In Italy, a study was conducted to compare BMI between 150 patients with celiac disease and 288 healthy subjects. At the diagnosis of celiac disease the median value of BMI was significantly lower as in the healthy subjects; patients usually did not suffer from overweight or obesity. During gluten-free diet, there was a significant decrease in the number of underweight patients (13 vs. 27) and a minimal increase in the number of overweight patients (9 vs. 6).

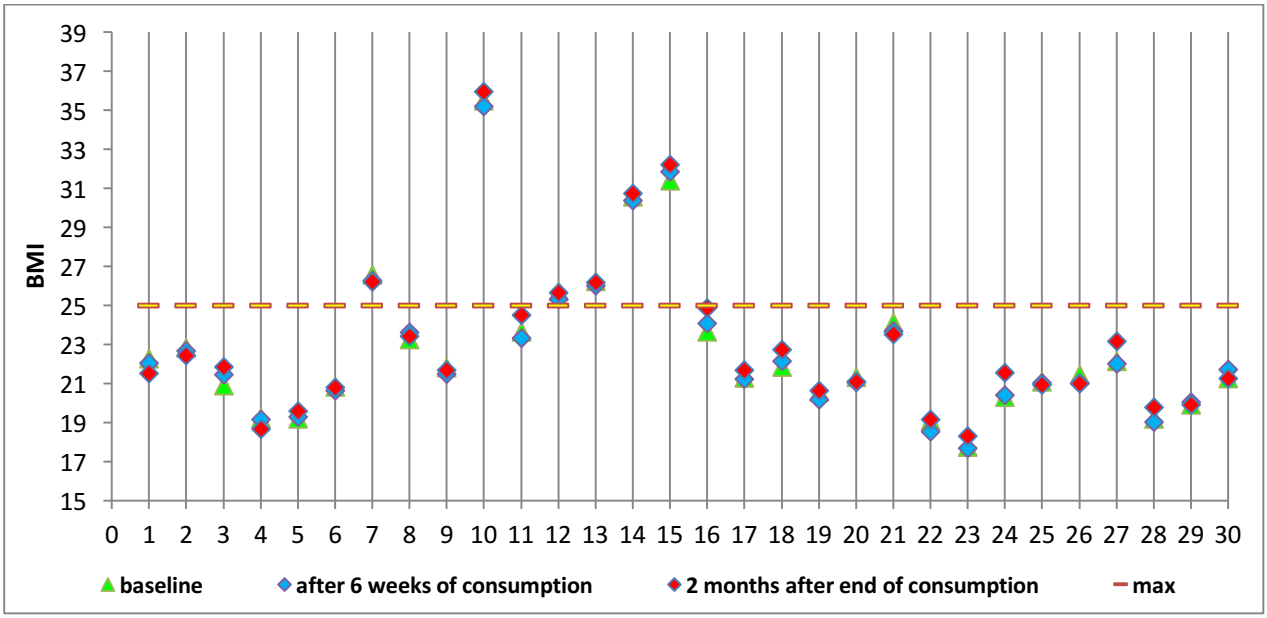

Figure 2 Changes of Body Mass Index during the study.

Table 1 Changes of body weight, BMI, WHR and VFA during the study.

	body weight (kg)			VFA (cm^2)		
	baseline	**after 6 weeks of consumption**	**2 months after end of consumption**	**baseline**	**after 6 weeks of consumption**	**2 months after end of consumption**
mean	65.32	65.08	65.88	72.70	73.26	75.65
±SD	12.60	12.54	12.78	29.18	30.32	29.01
Max	101.40	100.50	102.70	153.94	167.22	157.86
Min	48.50	48.10	50.00	37.80	41.07	41.50
Med	62.95	62.20	62.95	67.36	66.60	66.62
p	0.1576	0.0041[a]	0.0587	0.4175	0.0244[a]	0.0111[b]
significance		**			*	*
	BMI ($kg.m^{-2}$)			**WHR**		
	baseline	**after 6 weeks of consumption**	**2 months after end of consumption**	**baseline**	**after 6 weeks of consumption**	**2 months after end of consumption**
mean	22.83	22.75	23.03	0.87	0.87	0.87
±SD	3.95	3.95	4.02	0.06	0.06	0.06
Max	35.50	35.19	35.96	1.00	1.01	1.02
Min	17.75	17.68	18.30	0.78	0.80	0.79
Med	21.62	21.61	21.69	0.85	0.86	0.86
p	0.1637	0.0033[a]	0.0597	0.2550	0.5725	0.1110
significance		**				

Note: ±SD – standard deviation; Max – maximum value; Min – minimum value; Med – the median value of a range of values; VFA – visceral fat area, [cm^2]; the levels of statistical significance chosen for the comparisons were p <0.05 (*), p <0.01 (**), p <0.001 (***); [a] – intra-group differences after 6-weeks consumption of gluten-free bakery products; [b] – differences between baseline data and post-intervention data.

The high frequency of overweight patients in determining the diagnosis confirms the need for individual nutritional care **(Brambilla et al., 2013)**. **Loria-Kohen et al. (2012)** recorded a significant reduction in BMI in both groups when comparing two groups with and without of bread consumption. **Dickey and Kearney (2006)** and **Capristo et al. (2009)** reported the increase of BMI during gluten-free diet. **Zanini et al. (2013)** found that during gluten-free diet the mean value of BMI increased significantly. The large majority of the patients remained in the same category as at baseline and 9% of patients moved from the underweight to the normal weight category. However, 8% of patients moved from normal to overweight/obese group.

Waist-to-hip ratio

Among the indices reflecting visceral fat accumulation, waist circumference or waist-to-hip ratio have been used for convenience. However, waist circumference includes both visceral and sucutaneous fat **(Kuk et al., 2005)**. Waist-to-hip ratio (a trait of the criteria for metabolic syndrome) is more strongly related to the cardiovascular disease than BMI **(St-Onge, Janssen and Heymsfield, 2004)**. Subjects with the WHR value 0.9 and higher are considered as the subjects suffer from abdominal obesity.

At the beginning of the study we found values higher than 0.9 in 23% of participants in the range of 0.91 – 1, the average value of the group was 0.87 ±0.06 (Figure 3, Table. 1).

During the study the WHR values did not significantly change, the mean WHR values were between 0.87 ±0.06. The Max and Min values of the observed parameter varied in the dynamics of the study by a more rising trend from 1.00 at the beginning of the study to 1.01 when the consumption of gluten-free bakery products was over, up to 1.02 at the end of the study (Min 0.78/0.8/0.79). Due to the consumption of gluten-free bakery products, the number of participants with abdominal obesity (23%) did not increase and two months after the end of the consumption the number of participants with WHR greater than 0.9 even decreased (20%). As shown in the Figure 3, during the consumption of gluten-free bakery products WHR increased in 43% of probands, decreased in 33% and in 23% of participants WHR did not change. Two months after the end of consumption, a further increase in WHR values occurred in 47% of participants and a decrease in 37% of participants. We compared the values of the observed parameter at the beginning and the end of the study and we found that 30% of the participants reduced their WHR values, 50% of participants increased their WHR values, and in 20% of probands the values remained unchanged.

Visceral fat area

The visceral fat area is defined as the cross-sectional area of the internal fat found in the abdomen. If VFA is greater than 100 cm^2 we talk about abdominal obesity

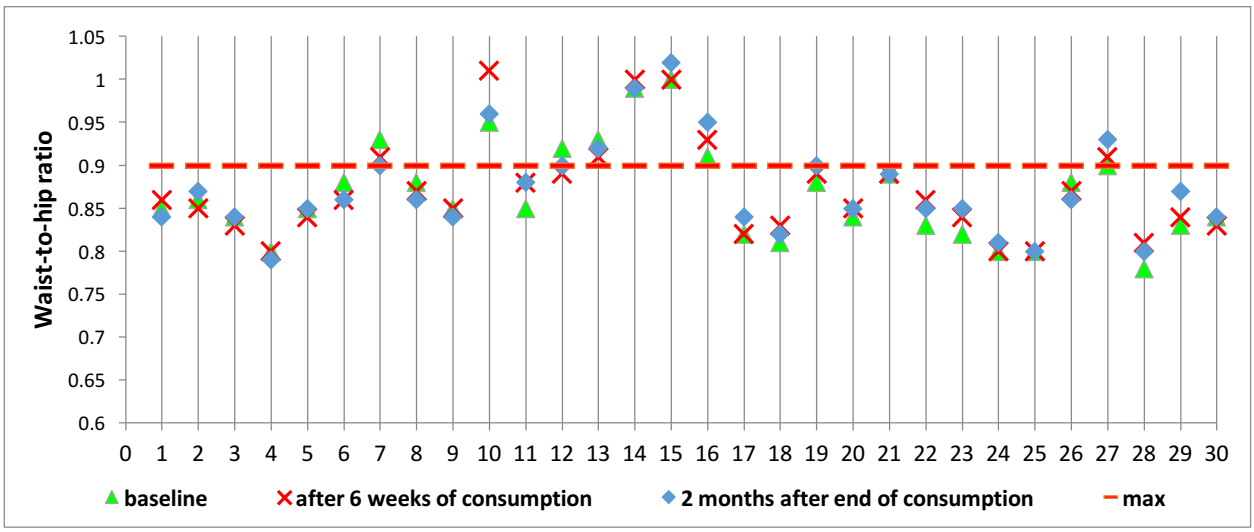

Figure 3 Changes of WHR during the study.

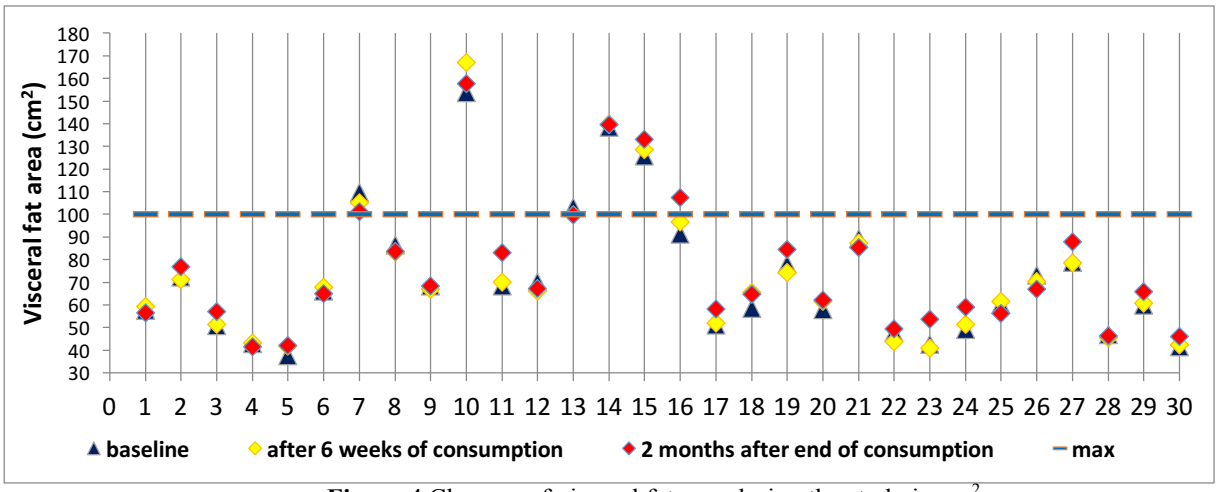

Figure 4 Changes of visceral fat area during the study in cm^2.

(Biospace, 2017). The visceral fat is deposited between the organs in the abdominal cavity where it is not normally present. In the case that this kind of fat is present in a higher amount, it is very dangerous and there is a risk of cardiovascular diseases, diabetes and the risk of the metabolic syndrome. Measurement of visceral fat area is also reported to be useful for predicting atherosclerosis **(Fox et al., 2007)**. From the point of the risk assessment it is more important where the fat is stored and not its amount. Many studies have shown that the fat stored in the waist area represents a higher risk than the fat stored in the thighs, buttocks and loins. The visceral fat is hidden and therefore healthy and slim persons can suffer from it. It does not need to be produced only by increased energy intake, but paradoxically even at very low intake or even the energy intake is lower than the basal metabolic need.

Before the consumption of bread and bakery products five probands (17%) suffered from the abdominal obesity, their values were higher than 100 cm^2 (Figure 4, Table 1). The average value of the visceral fat area of all participants was 72.7 ±29.18 cm^2 (the lowest value was 37,8 cm^2 and the highest value 153,94 cm^2). At the same time we found value of VFA lower than 40 cm^2 which is undesirable from the endocrine side. It occurred only in one proband and only at the beginning of the study. After 6-weeks of gluten-free bread and bakery products consumption we found that VFA values above 100 cm^2 had four participants, the increase in VFA values was observed in 57% of participants and decrease in 43% of participants.

Compared to the baseline values at the beginning of the study there was a statistically significant increase in VFA (p <0.05), the mean value of the group increased to 73.26 ±30.32 cm^2 (also the Max value to 167.22 cm^2, Min value to 41.07 cm^2). The consumption of gluten-free bread and pastries may increase the area of visceral fat. Two months after the end of the gluten-free pastries consumption, the number of participants with abdominal obesity returned to the initial number (five participants). The mean value of the visceral fat area was 75.65 ±29.01 cm^2 at the end of the study (Max VFA was significantly reduced to 157.86 cm^2 compared to the previous measurement, the Min VFA was 41.5 cm^2). When comparing the initial and final values of VFA we found a significant increase (p <0.05). Figure 4 shows changes in the visceral fat area throughout the study. During the consumption of gluten-free bread and bakery products the increase of visceral fat area was observed in 57% of participants in the range from 0.28 to 13.28 cm^2 and decrease in 43% of participants in the range of 0.28 – 4.39 cm^2. After releasing gluten-free bakery products we found in many participants a further increase in visceral fat area values (up to 67% of them) in the range of 0.12 – 12.85 cm^2. Two months after the end of the

consumption we recorded a reduction in visceral fat area in 33% of participants in the range of 0.12 – 9.36 cm^2. Compared with the baseline values at the end of the study we found a decrease in VFA in 37% of participants and an increase in 63% of them. According to **Vici et al. (2015)** with the consumption of gluten-free pastries is associated a higher risk of obesity due to the high glycemic index of gluten-free foods and also the high content of saturated fat. During the gluten-free diet, in many studies it was confirmed the inadequacies in the intake of some macronutrients and trace elements, mainly fiber, vitamin B_{12}, vitamin D, calcium, iron, zinc and magnesium. **Bautista-Castaño et al. (2013)** found that the different compositions of whole-grain and white bread have different influences on body weight and abdominal fat. This may be caused by factors such as postprandial insulin responses, gastric emptying after consuming a meal with high glycemic index and others **(Juntunen et al., 2002)**. **Romaguera et al. (2011)** reported a direct association between the increase in white bread consumption and annual visceral adiposity gain, independent from BMI. Similar results were found in our survey, where we observed a higher increase in VFA values then BMI. Study results of authors **Bautista-Castaño et al. (2013)** suggest that reducing white bread, but not whole-grain bread consumption is associated with the lower gains in weight and abdominal fat. **Fuente-Arrillaga et al. (2014)** in their study found that participants in the highest category of white bread consumption (≥6 slices per day) showed a significantly increased risk of becoming overweight or obese and that a higher consumption of whole-grain bread was inversely associated with the risk of overweight and obesity althought without statistically significant. Finally, it is important that the consumption of bread has continued to fall in the world over the past decades but world epidemic of obesity has been increasing **(WHO, 2000; Serra-Majem and Quintana, 2010)**.

CONCLUSION

In our study we found that the 6-week consumption of gluten-free bread and bakery products had a significant reduction in the body weight and BMI (p <0.01), but also had a significant increase in VFA (p <0.05). WHR remained unchanged. Many people perceive benefit from the gluten-free products and diet often without a clear scientific explanation. There is no evidence that processed gluten-free foods are healthier than their gluten-containing counterparts.

REFERENCES

Aston, L. M., Stokes, C. S., Jebb, S. A. 2008. No effect of a diet with a reduced glycaemic index on satiety, energy intake and body weight in overweight and obese women. *Int. J. Obes.*, vol. 32, p. 160-165. https://doi.org/10.1038/sj.ijo.0803717 PMid:17923862

Bansal, M., Gupta, R., Bansal, J. 2017. Celiac Disease: A Scientometric Analysis of World Publication Output, 2005-2014. *OGH Reports*, vol. 6, no. 1, p. 8-15. https://doi.org/10.5530/ogh.2017.6.1.2

Bautista-Castaño, I., Sánchez-Villegas, A., Estruch, R., Martínez-González, M. A., Corella, D., Salas-Salvadó, J., Covas, M. I., Schroder, H., Alvarez-Pérez, J., Quilez, J., Lamuela-Raventós, R. M., Ros, E., Arós, F., Fiol, M., Lapetra, J., Muñoz, M. A., Gómez-Gracia, E., Tur, J., Pintó, X., Ruiz-Gutierrez, V., Portillo-Baquedano, M. P., Serra-Majem, L. 2013. Changes in bread consumption and 4-year changes in adiposity in Spanish subjects at high cardiovascular risk. *Br. J. Nutr.*, vol. 110, no. 2, p. 337-346. https://doi.org/10.1017/S000711451200476X PMid:23199451

Biospace. 2017. Available on: <www.biospace.cz>

Brambilla, P., Picca, M., Dilillo, D., Meneghin, F., Cravidi, C., Tischer, M. C., Vivaldo, T., Bedogni, G., Zuccotti, G. V. 2013. Changes of body mass index in celiac children on a gluten-free diet. *Nutrition Metabolism and Cardiovascular Diseases*, vol. 23, no. 3, p. 177-182. http://dx.doi.org/10.1016/j.numecd.2011.10.002

Capristo, E., Malandrino, N., Farnetti, S., Mingrone, G., Leggio, L., Addolorato, G., Gasbarrini, G. 2009. Increased serum high-density lipoprotein-cholesterol concentration in coeliac disease after gluten-free diet treatment correlates with body fat stores. *Journal of Clinical Gastroenterology*, vol. 43, no. 10, p. 946-949. https://doi.org/10.1097/MCG.0b013e3181978e4d

de la Fuente-Arrillaga, C., Martinez-Gonzalez, M. A., Zazpe, I., Vazquez-Ruiz, Z., Benito-Corchon, S., Bes-Rastrollo, M. 2014. Glycemic load, glycemic index, bread and incidence of overweight/obesity in a Mediterranean cohort: the SUN project. *BMC Public Health*, vol. 14, no. 1091. https://doi.org/10.1186/1471-2458-14-1091

Diamanti, A., Capriati, T., Basso, M. S., Panetta, F., Di Ciommo Laurora, V. M., Bellucci, F., Cristofori, F., Francavilla, R. 2014. Celiac Disease and Overweight in Children: An Update. *Nutrients*, vol. 6, no. 1, p. 207-220. https://doi.org/10.3390/nu6010207

Dickey, W., Kearney, N. 2006. Overweight in coeliac disease: prevalence, clinical characteristics, and effect of a gluten-free diet. *American Journal of Gastroenterology*, vol. 101, p. 2356-2359. https://doi.org/10.1111/j.1572-0241.2006.00750.x PMid:17032202

Fox, C. S., Massaro, J. M., Hoffmann, U., Pou, K. M., Maurovich-Horvat, P., Liu, C. Y., Vasan, R. S., Murabito, J. M., Meigs, J. B., Cupples, L. A., D'Agostino, R. B. Sr, O'Donnell, C. J. 2007. Abdominal visceral and subcutaneous adipose tissue compartments: Association with metabolic risk factors in the Framingham Heart Study. *Circulation*, vol. 116, no. 1, p. 39-48. https://doi.org/10.1161/CIRCULATIONAHA.106.675355

Frič, P., Keil, R. 2011. Celiakie pro praxi. Med. Praxi (Celiac disease for practice. Med. practice), vol. 8, no. 9, p. 354-359. (In Czech).

Haas, S. V. The value of the banana in the treatment of coeliac disease. *American Journal of Diseased Child*, vol. 1924, no. 24, p. 421-437.

Hamer, R. J. 2005. Coeliac disease: Background and biochemical aspects. *Biotechnology Advances*, vol. 23, no. 6, p. 401-408. https://doi.org/10.1016/j.biotechadv.2005.05.005 PMid:16006084

Hoffmanová, I., Sánchez, D. 2015. Neceliakálna gluténová senzitivita (Nonceliac glutene sensitivity). *Vnit. Lék.*, vol. 61, no. 3, p. 219-227. (In Czech)

Chňapek, M., Tomka, M., Balážová, Ž., Gálová, Z. 2014. Protein complex of wheat, buckwheat and maize in relation to celiac disease. *J. M. B. F. S.*, vol. 3 (special issue 2), p. 88-92.

Juntunen, K. S., Niskanen, L. K., Liukkonen, K. H., Poutanen, K. S., Holst, J. J., Mykkänen, H. M. 2002. Postprandial glucose, insulin, and incretin responses, grain products in healthy subjects. *Am. J. Clin. Nutr.*, vol. 75, no. 2, p. 254-262.

Kolesárová, A., Zeleňáková, L., Gažarová, M., Cesneková, S. 2017. Konzumácia pekárskych výrobkov. (Consumption of bakery products. Hygiene and Food Technology) In: Proceeding of: Hygiena a technologie potravin – XLVII. Lenfeldovy a Höklovy dny: sborník přednášek a posterů, Veterinární a farmaceutická univerzita Brno, 18.-19.10.2017. p. 165-170. ISBN 978-80-7305-793-0. (In Slovak)

Kuk, J. L., Lee, S., Heymsfield, S. B., Ross, R. 2005. Waist circumference and abdominal adipose tissue distribution: Influence of age and sex. *The American Journal of Clinical Nutrition*, vol. 81, no. 6, p. 1330-1334.

Kulai, T., Rashid, M. 2014. Assessment of Nutritional Adequacy of Packaged Gluten-free Food Products. *Can. J. Diet. Pract. Res.*, vol. 75, no. 4, p. 186-190. https://doi.org/10.3148/cjdpr-2014-022

Layman, D. K., Boileau, R. A., Erickson, D. J., Painter, J. E., Shiue, H., Sather, C., Christou, D. D. 2003. A reduced ratio of dietary carbohydrate to protein improves body composition and blood lipid profiles during weight loss in adult women. *J. Nutr.,* vol. 133, p. 411-417.

Lean, M. E., Han, T. S., Prvan, T., Richmond, P. R., Avenell, A. 1997. Weight loss with high and low carbohydrate 1200 kcal diets in free living women. *Eur. J. Clin. Nutr*., vol. 51, p. 243-248. https://doi.org/10.1038/sj.ejcn.1600391
PMid:9104574

Loria-Kohen, V., Gomez-Candela, C., Fernandez-Fernandez, C., Perez-Torres, A., Garcia-Puig, J., Bermejo, L. M. 2012. Evaluation of the usefulness of a low-calorie diet with or without bread in the treatment of overweight/obesity. *Clinical Nutrition*, vol. 31, no. 4, p. 455-461. https://doi.org/10.1016/j.clnu.2011.12.002

López Sobaler, A. M., Ortega, R. M., Aparicio, A., Bermejo, L. M., Rodríguez Rodríguez, E. 2007. Concerns about body weight. National study on related mistakes and habits. In: R. M. Ortega (Ed.) *Nutrition in the females population*. Madrid, Spain : Ergón, p. 39-50.

Luscombe, N. D., Clifton, P. M., Noakes, M., Farnsworth, E., Wittert, G. 2003. Effect of a high protein, energy restricted diet on weight loss and energy expenditure after weight stabilization in hyperinsulinemic subjects. *Int J Obes*., vol. 27, no. 582-590.

Malinauskas, B. M., Raedeke, T. D., Aeby, V. G., Smith, J. L., Dallas, M. B. 2006. Dieting practices, weight perceptions, and body composition: a comparison of normal weight, overweight, and obese college females. *Nutr. J.,* vol. 5, 11. https://doi.org/10.1186/1475-2891-5-11
PMid:16579846

Missbach, B., Schwingshackl, L., Billmann, A., Mystek, A., Hickelsberger, M., Bauer, G., Konig, J. 2015. Gluten-free food database: the nutritional quality and cost of packaged gluten-free foods. *Peer J.*, vol. 3, 1337. https://doi.org/10.7717/peerj.1337

Nanditha, B., Prabhasankar, P. 2009. Antioxidants in bakery products: A review. *Critical Reviews in Food Science and Nutrition*, vol. 49, no. 1, p. 1-27. https://doi.org/10.1080/10408390701764104
PMid:18949596

Noakes, M., Keogh, J. B., Foster, P. R., Clifton, P. M. 2005. Effect of an energy-restricted, high-protein, low-fat diet relative to a conventional high-carbohydrate, low-fat diet on weight loss, body composition, nutritional status, and markers of cardiovascular health in obese women. *Am. J. Clin. Nutr*., vol. 81, no. 6, p. 1298-1306. PMid:15941879

Penagini, F., Dilillo, D., Meneghin, F., Mameli, C., Fabiano, V., Zuccotti, G. V. 2013. Gluten-free diet in children: an approach to a nutritionally adequate and balanced diet. *Forum Nutr.*, vol. 5, no. 11, p. 4553-4565. https://doi.org/10.3390/nu5114553

Reilly, N. 2016. The Gluten-Free Diet: Recognizing Fact, Fiction, and Fad. *Journal of Pediatrics*, vol. 175, p. 206-210. http://dx.doi.org/10.1016/j.jpeds.2016.04.014

Romaguera, D., Ängquist, L., Du., H., Jakobsen, M. U., Forouhi, N. G., Halkjær, J., Feskens, E. J., van der A, D. L., Masala, G., Steffen, A., Palli, D., Wareham, N. J., Overvad, K., Tjønneland, A., Boeing, H., Riboli, E., Sørensen, T. I. 2011. Food composition of the diet in relation, changes in waist circumference adjusted for body mass index. *PLoS One*, vol. 6, no. 8, p. e23384. https://doi.org/10.1371/journal.pone.0023384

Salazar Quero, J. C., Espín Jaime, B., Rodríguez Martínez, A., Argüelles Martín, F., García Jiménez, R., Rubio Murillo, M., Pizarro Martín, A. 2015. Nutritonal assessment of gluten-free diet. Is gluten-free diet in some nutrient. *An. Pediatr. (Barc.)*, vol. 83, no. 1, p. 33-39. https://doi.org/10.1016/j.anpedi.2014.08.011

Serra-Majem, L., Raido Quintana, B. 2010. Consumo de pan en el mundo y en España (Bread consumption in the world and in Spain). In Gil, A., Serra-Majem, L. *Libro Blanco del Pan (Bread's White Book)*, pp. 63-77. Madrid, Spain : Ed Med Panamericana. (In Spain)

Socha, P., Ražďíková, A., Urminská, D. 2010. Optimalizácia stanovenia celiakálne aktívnych bielkovín v cereáliách a pseudocereáliách (optimization of celiatic disease active proteins estimation in cereals and pseudocereals). *Potravinarstvo*, vol. 4 (special issue February 2010), p. 497-508. (In Slovak) Available at: https://www.potravinarstvo.com/dokumenty/mc_februar_2010/pdf/5/Socha.pdf

St-Onge, M. P., Janssen, I., Heymsfield, S. B. 2004. Metabolic syndrome in normalweight Americans: new definition of the metabolically obese, normalweight individual. Diabetes Care, vol. 27, no. 9, p. 2222-2228. https://doi.org/10.2337/diacare.27.9.2222
PMid:15333488

Suchá, V., Jurgoš, Ľ., Dostálová, K., Móricová, Š. 2015. Aktuálny pohľad na Celiakiu. *Via pract*., vol. 12, no. 1, p. 22-28.

Ukkola, A., Mäki, M., Kurppa, K., Collin, P., Huhtala, H., Kekkonen, L., Kaukinen, K. 2012. Changes in body mass index on a gluten-free diet in coeliac disease: a nationwide study. *Eur. J. Intern. Med.,* vol. 23, no. 4, p. 384-388. https://doi.org/10.1016/j.ejim.2011.12.012

Vici, G., Belli, L., Biondi, M., Polzonetti, V. 2016. Gluten free diet and nutient deficiencies: A review. *Clin. Nutr*., vol. 35, no. 6, p. 1236-1241. https://doi.org/10.1016/j.clnu.2016.05.002

Wiklund, P., Alen, M., Munukka, E., Cheng, S. M., Yu, B., Pekkala, S., Cheng, S. 2014. Metabolic response to 6-week aerobic exercise training and dieting in previously sedentary overweight and obese pre-menopausal women: A randomized trial. *Journal of Sport and Health Science*, vol. 3, no. 3 p. 217-224. http://dx.doi.org/10.1016/j.jshs.2014.03.013

World Health Organization. 2000. *Obesity: Preventing and Managing the Global Epidemic*. Report of a WHO Consultation. WHO Technical Report Series no. 894. Geneva, Switzerland : WHO.

World Health Organization. 2008. *Obesity and overweight*. Geneva, Switzerland : WHO. Available at:

Yancy, W. S. Jr., Olsen, M. K., Guyton, J. R., Bakst, R. P., Westman, E. C. 2004. A low-carbohydrate, ketogenic diet versus a low-fat diet to treat obesity and hyperlipidemia. *Ann. Intern. Med*., vol. 140, no. 10, p. 769-777.

Zanini, B., Mazzoncini, E., Lanzarotto, F., Ricci, C., Cesana, B. M., Villanacci, V., Lanzini, A. 2013. Impact of gluten-free diet on cardiovascular risk factors. A retrospective analysis in a large cohort of coeliac patients. *Dig. Liver Dis*., vol. 45, no. 10, p. 810-815. https://doi.org/10.1016/j.dld.2013.04.001

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