Journal of Nursing, Social Studies, Public Health and Rehabilitation 3–4, 2020, pp. 107–115

LOW-CARBOHYDRATE DIET AND ITS INFLUENCE ON VISCERAL FAT AND OTHER SELECTED PHYSICAL PARAMETERS

Simona Šimková

University of South Bohemia in České Budějovice, Faculty of Health and Social Sciences, České Budějovice, Czech Republic

Submitted: 2020-10-01 **Accepted:** 2020-11-25 **Published online:** 2020-12-31

Abstract

Low-carbohydrate diets are often a controversial issue. They are not only currently a popular diet method, but also significantly beneficial for health. The influence on the reduction of the total body weight can be very significant, as can the amount of body fat or visceral fat – which is the main risk factor for developing cardiovascular and metabolic diseases. The research in this area is limited. Respondents often fail to finalize it and the studies often include few respondents and are short-term.

This article summarizes the published data that focus on the influence of low-carbohydrate diets on visceral fat in the human organism. The goal was to determine which physiological parameters were influenced by this type of diet and how low-carbohydrate diet influences the selected parameters.

The results of individual studies are often optimistic, but there are some references to a negative influence of low-carbohydrate diets. Regardless, mostly statistically significant changes in body weight drops have been observed (BMI drops as well), as well as total body fat drop, visceral fat drop, waist circumference drop, and the risk of cardiometabolic diseases. However, it is necessary to continue these studies and especially assess the long-term effect.

Keywords: *Anthropometric indicators; Carbohydrates; Cardiometabolic risk factors; Low-carbohydrate diet; Nutrition; Visceral fat*

Abbreviations:

BMI – Body Mass Index; DM – diabetes mellitus; HDL a LDL cholesterol – High density lipoprotein, Low density lipoprotein; CVD – cardiovascular disease; LC diet (VLC diet) – Low Carbohydrate Diet (Very Low Carbohydrate Diet); LF diet – Low Fat Diet; PAD – peroral antidiabetics; TAG – triacylglycerols; TNF-alpha – tumour necrosis factor alpha

REVIEW ARTICLE

INTRODUCTION

The global incidence of overweight and obesity is increasing. The WHO (WHO, 2020a) states that 1.9 billion adults were overweight in 2016, of which 650 million were obese. Overweight and obesity are risk factors for the incidence of other diseases, especially non-infectious chronic diseases. Although it is known that the increase of body weight, which is caused by the increased amount of adipose tissue, is preventable, we are unsuccessful in stopping the rising incidence of these diseases (WHO, 2020a).

One of the significant measures is the therapy by suitable diet and physical activity. Low-carbohydrate diets – and mainly their effect on health conditions – are a continuous research issue. Although

the points of view are controversial (Noto et al., 2013), it is assumed that such types of diet could positively affect the level of visceral fat, which is a significant risk factor of cardiometabolic diseases (Hu and Bazzano, 2014).

The incidence of cardiovascular diseases is globally rising and no country has succeeded in reversing this growing trend with preventive measures (Ng et al., 2014). It is one of the reasons why it is necessary to study other possibilities of changing our population's contemporary health conditions. A very-low-carbohydrate diet (VLC) or ketogenic diet seems effective in losing weight (Lim et al., 2010). VLC diet is positive for the reduction of weight, total fat, and the improvement of cardiometabolic risk parameters. There are also negative consequences, such as decreased muscular or bone mass (Tinsley and Willoughby, 2016). VLC diet, along with physical activity, positively affects the decrease of the muscular mass and, indirectly, bone mass. However, the total effect in obese individuals has been studied and the evidence is limited (Ding et al., 2019). There is also data focused on the effects of low-carbohydrate diets on intestinal microbiota. The research in this area is very limited. It points out the decrease in the variety of intestinal bacteria, as well as the increased number of proinflammatory bacteria (Paoli et al., 2020).

Low-carbohydrate diet is not a specific concept that clearly establishes the percentage of carbohydrates in food. Asian food contains a higher percentage of carbohydrates. The carbohydrate intake here is approximately 70% (Kwon et al., 2012). Low-carbohydrate diets (LC) have different levels of strictness regarding the decrease of carbohydrate intake, e.g., according to Oh et al. (2020):

1) very-low-carbohydrate diet (VLC): <10% of carbohydrates or 20–50 g/day;
2) low-carbohydrate diet (LC): <26% of carbohydrates or less than 130 g/day;
3) mild low-carbohydrate diet (MLC): 26–44% of carbohydrates;
4) high-carbohydrate diet (HC): >45% of carbohydrates.

These divisions are different as well, and it is always necessary to state a specific number of carbohydrates in a specific low-carbohydrate diet. LC diet is a tool whose popularity is growing for the reduction of adipose tissue, control of glycaemia, and the decrease of the risk of cardiovascular diseases. It is especially popular in patients who suffer from type 2 diabetes (Sasakabe et al., 2015).

Low-carbohydrate diets lead to ketosis. This is the condition when the organism consumes instant energy sources (glucose), and ketone production from fats in adipose tissue increases (Oh et al., 2020).

MATERIALS AND METHODS

We used the method of analysis of available resources in databases. We searched for relevant sources in scientific databases using EBSCO Discovery Service. The search was conducted with the keywords "low-carbohydrate diet", "low carbohydrate", "low carb diet" in combination with "visceral fat", "visceral adipose tissue", using the Boolean operator "AND". A significant criterion was the period of publication of the studies (2010–20) and their primary focus on the influence of low-carbohydrate diets on the changes of physiological parameters, especially visceral fat. We found 58 studies, and after result filtering, removing duplicates and those that did not deal with our issues in the required context, we were left with 11 full-text relevant studies in English. Data collection and result analysis were carried out between May and August 2020.

Our goal was to determine what physical parameters were affected by low-carbohydrate diets. Another goal was to determine what effect low-carbohydrate diets had on selected physical parameters, the respondent selection criteria, a control group, and all other included interventions except dietary ones. We included other criteria in the experiments, such as physical activity, etc.

RESULTS

Low-carbohydrate diets are popular for their relatively quick effect, especially regarding the reduction of body weight. Carbohydrate intake of most of the world's population is approximately 50% of the total energy intake. In Asian countries, the intake is higher (Kwon et al., 2012). Kwon et al. (2012) also stated that

the intake of carbohydrates, over 70% of the energy intake, is related to the incidence of the metabolic syndrome. Table 1 shows the summary of the main findings of the realized studies, including the basic information about the sample group or experiment. The data are later elaborated by the selected parameters.

Table 1 – Research results of the studies included in the analysis

Source	Findings	Other information
Goss et al. (2020)	↓ body weight, ↓ adipose tissue, ↓ visceral fat, ↓ total cholesterol, ↓ LDL cholesterol, ↓ TAG, increased HDL cholesterol	40 people, age 60–75 years, BMI 30–40 kg/m^2, 8 weeks
Sasakabe et al. (2011)	↓ BMI, ↓ LDL cholesterol in women, increased HDL cholesterol in men, ↓ visceral fat	People with DM type 2, 6 months
Sasakabe et al. (2015)	↓ adipose tissue, ↓ visceral fat, ↓ LDL cholesterol ↓ TAG, increased HDL cholesterol	76 people, 3 months, people with DM type 2, PAD treatment
Perissiou et al. (2020)	↓ adipose tissue, ↓ visceral fat, ↓ lean muscle mass	8 weeks, obese people, average age 35 years, average BMI 30.3 kg/m^2
Jang et al. (2018)	↓ body weight, ↓ waist circumference, ↓ BMI, ↓ systolic and diastolic blood pressure, ↓ LDL cholesterol, ↓ visceral fat	Patients with non-alcoholic fatty liver
Yu et al. (2014)	↓ body weight, ↓ visceral fat, ↓ adipose tissue, ↓ waist circumference	Patients with non-alcoholic fatty liver, 8 weeks
Miyashita et al. (2004)	↓ body weight, ↓ glycaemia, ↓ serum insulin, increased HDL cholesterol, ↓ total cholesterol and ↓ TAG, ↓ visceral fat	People with DM type 2, 4 weeks
Gu et al. (2013)	↓ body weight, ↓ BMI, ↓ waist circumference, ↓ adipose tissue and visceral fat	53 people, 8 weeks, obese patients, without DM
Kalam et al. (2019)	↓ body weight, ↓ adipose tissue, ↓ total cholesterol, ↓ LDL cholesterol, ↓ systolic blood pressure	6 months
Campanati et al. (2017)	↓ body weight, ↓ adipose tissue, ↓ waist circumference, ↓ visceral fat, ↓ total cholesterol and ↓ TAG	Patients with psoriasis, TNF-alpha inhibitory treatment
Kahleova et al. (2018)	↓ body weight, ↓ BMI, ↓ adipose tissue, ↓ visceral fat, ↓ insulin resistance	76 people, 16 weeks, vegetal diet

The influence of low-carbohydrate diets on body weight

A positive effect on body weight was observed in all mentioned studies. Goss et al. (2020) observed a decrease in body weight during a low-carbohydrate diet, although it was not the primary goal. These authors primarily wanted to observe the differences between low-carbohydrate and low-fat diets (LF), when the intake in both groups was set to maintain body weight. In low-carbohydrate diet, Goss et al. (2020) decreased the intake to max. 10% of energy intake and increased the fat intake to 65% of energy intake. The group with the low-fat diet had a decreased fat intake to 20% of energy intake, and carbohydrates were 55% of energy intake. All respondents reduced their body weight. The group with LC diet showed a more significant reduction ($p < 0{,}001$).

The participants in the study of Sasakabe et al. (2011) also experienced weight loss while being on a low-carbohydrate diet. These authors focused on people with type 2 diabetes mellitus. The intake of carbohydrates was not restricted as strictly (only 30–45% of energy intake). Sasakabe et al. (2011) first observed the influence of this diet after 6 months. They found out that body weight was significantly decreased, as well as BMI. The authors then studied changes in a shorter period – 3 months (Sasakabe et al., 2015). Again, they used a mild low-carbohydrate diet (30–45% of energy intake). All participants used peroral antidiabetics (PAD) and protein and fat intake was not restricted. The patients had an average BMI in the body weight range between normal and overweight, so the primary goal was not weight reduction. Despite that fact, the body weight and BMI of these patients decreased.

Perissiou et al. (2020) also monitored the effects of LC diet on patients with the average BMI of 30.3 kg/m². The maximum carbohydrate intake was set to 50 g of carbohydrates per day, but the energy intake was not restricted. The diet in this group was combined with physical activity (45 minutes, 4× a week). Perissiou et al. (2020) discovered that adipose tissue had decreased, which was undesirable. The decrease was more noticeable in patients with LC diet than in patients with a standard diet – both groups were physically active.

Hession et al. (2009) point out the positive influence of low-carbohydrate diet on weight loss in comparison to low-fat diet. Jang et al. (2018) also observed weight loss ($p < 0.001$) in the Asian population, who were indicated a low-carbohydrate diet (however, the intake of carbohydrates was between 50% and 60% of energy intake). Yu et al. (2014) also observed weight loss ($p = 0.001$) during an 8-week experiment. Here, the intake of patients with non-alcoholic fatty liver was only 800 kcal/day; the energy intake included less than 10% of carbohydrates, i.e. up to 20 g/day. The average weight loss was 6.8 kg, i.e., 7%.

The difference between a low-carbohydrate diet and a low-fat diet was also dealt with by Miyashita et al. (2004). They observed weight loss in both monitored groups after 4 weeks. At the same time, both monitored groups had the intake of 1,000 kcal with a different percentage of nutrients.

Gu et al. (2013) also used a low-carbohydrate diet in obese patients of Asian origin. This was an 8-week experiment, which included a significant restriction of energy intake – 800 kcal/day, max. 20 g of carbohydrates per day. After 8 weeks, they observed an average weight loss of 8.7 kg ($p < 0.0001$), which corresponds with a BMI decrease of approximately 3 kg/m².

Kalam et al. (2019) combined a low-carbohydrate diet with ad libitum (at will) food intake and alternate daily fasting. This study dealt with the restriction of intake to 600 kcal/day. The carbohydrate intake was restricted to 30% of energy intake. The first 3 months of this study were focused on reduction and the other 3 months were focused on the stabilization of parameters. During the first three months, the average weight loss was 5.5% ($p < 0.001$). In the second phase of the experiment, the weight remained relatively stable. The total weight loss during the 6-month period was 6.3%.

Campanati et al. (2017) observed patients with psoriasis, who were treated with TNF-alpha inhibitors. If these patients kept a low-carbohydrate diet (carbohydrate income between 30 and 100 g/day), they lost weight ($p < 0.0001$).

The influence of a low-carbohydrate diets on muscular tissue

An essential parameter is the influence of a low-carbohydrate diet on the muscular tissue. In their experiment, Perissiou et al. (2020) observed a decrease of the muscular tissue, which was undesirable. The decrease was observed in patients with a low-carbohydrate diet, when the intake of carbohydrates was restricted to max. 50 g of carbohydrates per day. On the contrary, Manninen (2006) states that ketogenic diets can have a protective effect on muscular mass if such diets include a sufficient protein amount. Paoli et al. (2019), who focused on the possible effect of ketogenic diets on muscular hypertrophy, stated that the effects of ketogenic diets on muscular hypertrophy during the physical training of muscles are insignificant or none. The authors also state that, during low-carbohydrate diets, ketogenic diets can have a protective effect against the decrease of muscular mass.

The influence of low-carbohydrate diets on the levels of blood fat

Another parameter with positive changes is blood fat, i.e., the level of cholesterol, the level of LDL or HDL cholesterol and the level of triacylglycerol (TAG). In LC diet, Goss et al. (2020) observed a significant increase of the level of HDL cholesterol (compared to LFD) and a decrease of the level of LDL cholesterol and triacylglycerol (TAG).

Sasakabe et al. (2011) stated that the assets of low-carbohydrate diets are the increase of the level of HDL cholesterol and the decrease of the level of triacylglycerol (TAG) in obese patients. The authors discovered that, after 6 months of keeping a low-carbohydrate diet, the level of HDL cholesterol in men increased ($p = 0.021$) and the level of LDL cholesterol in women decreased ($p = 0.001$). Sasakabe et al. (2015) also observed the decrease of TAG, LDL cholesterol and the increase of HDL cholesterol after three months of research, but the differences were not statistically significant.

Jang et al. (2018) observed the decrease of LDL cholesterol ($p < 0.001$). In low-fat diet, the authors did not observe the decrease of the level of total cholesterol.

Miyashita et al. (2004) also observed the increase of the level of HDL cholesterol in patients with a low-carbohydrate diet. The total level of cholesterol and TAG decreased in both monitored groups.

Kalam et al. (2019) observed the decrease of the level of total cholesterol and LDL cholesterol. They did not observe changes in HDL cholesterol or TAG.

The influence of low-carbohydrate diets on glycaemia and glycated haemoglobin

Sasakabe et al. (2011) found that, after 6 months of keeping to a low-carbohydrate diet, the level of glycated haemoglobin significantly decreased ($p = 0.05$). However, according to Yu et al. (2014), patients with non-alcoholic fatty liver did not show changes in glycaemia on an empty stomach or after the restriction of calories. After four weeks, Miyashita et al. (2004) observed weight loss and glycaemia decrease in both groups (patients with type 2 diabetes mellitus who kept low-carbohydrate and low-fat diets). The levels of serum insulin decreased in patients with a low-carbohydrate diet.

Kalam et al. (2019) also observed the decrease of insulin on an empty stomach after 6 months. The level of glucose on an empty stomach and glycated haemoglobin remained unchanged.

The influence of low-carbohydrate diets on adipose tissue and visceral fat

Goss et al. (2020) observed a significant reduction of adipose tissue in patients with a low-carbohydrate diet. Patients with VLC diet had 9.7% reduction, and patients with LFD showed the decrease of adipose tissue by 2%. Both values are statistically significant ($p < 0.001$). In particular, a large difference was observed in the values of visceral fat. Its decrease was statistically significant ($p < 0.01$) in patients with a low-carbohydrate diet. The values of visceral fat decreased on average by 22.8%. In low-fat diet, visceral fat decreased by 1%.

Sasakabe et al. (2011) also observed the decrease of visceral fat by 20 cm^2 (on average) in both genders ($p < 0.001$). Sasakabe et al. (2015) focused on the effect of a 3-month mild low-carbohydrate diet regarding the values of visceral fat as well as the total amount of fat in people with type 2 diabetes mellitus. The researchers started with the previous study and observed the decrease of visceral fat during a 6-month period. They assumed that it was possible to decrease the values of visceral fat faster and set the period for 3 months. After three months of a mild low-carbohydrate diet, the level of visceral fat significantly decreased, as well as subcutaneous fat ($p < 0.001$). The decrease of carbohydrate intake correlated with the decrease of visceral fat. A more significant decrease was observed in men. At the same time, men showed a significant loss of visceral fat during this 3-month period, regardless of the decrease of the total energy intake.

Perissiou et al. (2020) observed that the ketogenic condition caused a significant decrease ($p = 0.025$) of visceral fat and total fat, as well as muscular mass ($p = 0.042$). According to the authors, a short-term low-carbohydrate diet with physical activity decreases the risk of cardiovascular disease and improves the cardiometabolic profile. However, the sample group showed decreased muscular tissue when compared to the group with a standard diet and the same level of physical activity.

Haufe et al. (2011) also studied the effect of low-carbohydrate and low-fat diets and observed a positive effect on fat decrease in the liver. Jang et al. (2018) discovered that low-carbohydrate diet influenced the decrease of visceral fat ($p < 0.05$), but low-fat diet did not cause a significant difference.

After an 8-week experiment, Yu et al. (2014) discovered that weight loss was statistically significant. The change was caused by the decrease of visceral fat, which decreased by 1/3 ($p = 0.007$). Subcutaneous fat also decreased. On average, waist circumference decreased by 5 cm ($p = 0.04$). Patients with non-alcoholic fatty liver had their liver fat decreased by 2/3 ($p = 0.004$).

The decrease of visceral fat was also observed by Miyashita et al. (2004). The decrease was more considerable in the group with low-carbohydrate diet –40 cm² ($p < 0.05$) than the group with low-fat diet –10 cm². The results show that low-carbohydrate diets could be better for weight loss and the decrease of visceral fat in patients with diabetes mellitus type 2.

After 8 weeks of low-carbohydrate diet, Gu et al. (2013) observed an average waist circumference decrease of 5.9 cm ($p < 0.0001$). A statistically significant decrease was observed in the amount of subcutaneous fat and visceral fat by 66.5, i.e., 35.3 cm², as well as liver fat.

Kalam et al. (2019) carried out a 6-month experiment and observed a decrease in the total adipose tissue ($p < 0.01$), but the non-adipose tissue and visceral fat remained unchanged.

Campanati et al. (2017) based their research on the fact that visceral fat was related to a larger number of inflammatory and immunity cells, and a larger glucocorticoid expression and androgen receptors than subcutaneous fat. The rising level of visceral fat brings a greater risk of death, risk of hypertension, hyperlipidaemia, diabetes mellitus and other diseases. The research is based on the fact that the amount of fat is a better indicator of the risk of a disease than body weight or BMI. The research group of Campanati et al. (2017) showed a decrease of total fat ($p < 0.0001$) and visceral fat ($p < 0.0001$). The waist circumference decrease was also significant. Campanati et al. (2017) concluded that the TNF-alpha inhibitory treatment alone can cause weight increase, but it does not cause the increase of visceral fat. The combination of medical and dietary treatments appears good for the improvement of anthropometric indicators in patients with psoriasis.

Besides the mentioned parameters, the authors pointed out the changes in blood pressure. Jang et al. (2018) observed that the group with a low-carbohydrate diet had a decrease of systolic and diastolic blood pressure ($p < 0.001$). Kalam et al. (2019) also pointed out the decrease of systolic blood pressure.

DISCUSSION

Opinions are divided on low-carbohydrate diets. They are most frequently compared to low-fat diets. Although the significance of low-carbohydrate diets is related to weight loss and the increase of insulin sensitivity, their influence on other illnesses that are related to these risk factors is also studied.

The analysis carried out showed that most authors agreed that low-carbohydrate diets had a positive effect on weight loss (Goss et al., 2020; Gu et al., 2013; Jang et al., 2018; Miyashita et al., 2004). Low-carbohydrate diets also affected the increase of HDL cholesterol (Goss et al., 2020; Miyashita et al., 2004; Sasakabe et al., 2011; 2015). We found a decrease of energy intake of monitored participants in all studies (Kalam et al., 2019).

The influence of low-carbohydrate diets on the decrease of visceral fat seems very positive. Visceral fat is considered as one of the main risk factors for cardiometabolic diseases (Goss et al., 2020; Gu et al., 2013; Miyashita et al., 2004; Perissiou et al., 2020; Sasakabe et al., 2011; 2015;).

Perissiou et al. (2020) point out the negative effect, which is the decrease of muscular tissue and bone mass. Other studies did not find changes of HDL or LDL cholesterol (Yu et al., 2014). Glycaemia on an empty stomach also remained unchanged (Yu et al., 2014). Campanati et al. (2017) pointed out that, in patients with psoriasis, the level of visceral fat can decrease while keeping a low-carbohydrate diet; the patients' weight gain and other parameters are related to using medicaments.

In particular, the limitations of the studies include short monitoring periods and the participants keeping to a low-carbohydrate diet, small groups of respondents, or the presence/

absence of a control group. The studies are often combined with other, considerable parameters that can have a significant influence (e.g., physical activity, medical treatment, etc.). If a control group is present, there are indications regarding diet and there can be significant individual differences. Significant factors that influence food intake also include whether the participants had their daily diet adjusted in carbohydrates or substituted by dietary shakes.

CONCLUSIONS

Low-carbohydrate diets are often compared to diets that are based on low-fat intake. There are various assets as well as risks related to this type of diet. The goal of this article was to determine which physical parameters low-carbohydrate diets affect, and their influence on selected parameters. Low-carbohydrate diets affect basic physical parameters, which include physical weight, BMI, the amount of adipose tissue including visceral fat, the level of blood fat or blood pressure, glycaemia, or glycated haemoglobin.

The realized studies mostly agree on the positive influence on weight loss and the decrease of adipose tissue. Low-carbohydrate diets often lead to the decrease of visceral fat, which is a risk factor of cardiometabolic diseases. The decrease of total cholesterol is another benefit (LDL cholesterol, insulin on an empty stomach, maintenance or increase of HDL cholesterol, increase of insulin sensitivity). The realized studies almost always have limitations. Some studies use food supplements, which enables the participants to keep to the regime more easily, but, in the long run, the condition is mostly unsustainable. Also essential is whether the participants are willing to be included in the study; thus, the groups are often small and the experiments short. It is necessary for further research to be carried out that will assess the long-term influence of low-carbohydrate diets. It is necessary that the health benefits of low-carbohydrate diets be assessed.

Conflict of interests

The author has no conflict of interests to declare.

REFERENCES

1. Campanati A, Molinelli E, Ganzetti G, Guiliodori K, Minetti I, Taus M, et al. (2017). The effect of low-carbohydrates calorie-restricted diet on visceral adipose tissue and metabolic status in psoriasis patients receiving TNF-alpha inhibitors: results of an open label controlled, prospective, clinical study.: results of an open label controlled, prospective, clinical study. J Dermatolog Treat 28(3): 206–212. DOI: 10.1080/09546634.2016.1214666.
2. Ding J, Xu X, Wu X, Huang Z, Kong G, Liu J, et al. (2019). Bone loss and biomechanical reduction of appendicular and axial bones under ketogenic diet in rats. Exp Ther Med 17(4): 2503–2510. DOI: 10.3892/etm.2019.7241.
3. Goss AM, Gower B, Soleymani T, Stewart M, Pendergrass M, Lockhart M, et al. (2020). Effects of weight loss during a very low carbohydrate diet on specific adipose tissue depots and insulin sensitivity in older adults with obesity: a randomized clinical trial: a randomized clinical trial. Nutr Metab (Lond.) 17: 64. DOI: 10.1186/s12986-020-00481-9.
4. Gu Y, Yu H, Li Y, Ma X, Lu J, Yu W, et al. (2013). Beneficial Effects of an 8-Week, Very Low Carbohydrate Diet Intervention on Obese Subjects. Evid Based Complement Alternat Med 2013: 760804. DOI: 10.1155/2013/760804.
5. Haufe S, Engeli S, Kast P, Böhnke J, Utz W, Haas V, et al. (2011). Randomized comparison of reduced fat and reduced carbohydrate hypocaloric diets on intrahepatic fat in overweight and obese human subjects. Hepatology 53(5): 1504–1514. DOI: 10.1002/hep.24242.

6. Hession M, Rolland C, Kulkarni U, Wise A, Broom J (2009). Systematic review of randomized controlled trials of low-carbohydrate vs. low-fat/low-calorie diets in the management of obesity and its comorbidities. Obes Rev 10(1): 36–50. DOI: 10.1111/j.1467-789X.2008.00518.x.
7. Hu T, Bazzano LA (2014). The low-carbohydrate diet and cardiovascular risk factors: evidence from epidemiologic studies: evidence from epidemiologic studies. Nutr Metab Cardiovas Dis 24(4): 337–343. DOI: 10.1016/j.numecd.2013.12.008.
8. Jang ECH, Jun DW, Lee SM, Cho YK, Ahn SB (2018). Comparison of efficacy of low-carbohydrate and low-fat diet education programs in non-alcoholic fatty liver disease: A randomized controlled study. Hepatol Res 48(3): E22–E29. DOI: 10.1111/hepr.12918.
9. Kahleova H, Dort S, Holubkov R, Barnard ND (2018). A Plant-Based High-Carbohydrate, Low-Fat Diet in Overweight Individuals in a 16-Week Randomized Clinical Trial: The Role of Carbohydrates. Nutrients 10(9): 1302. DOI: 10.3390/nu10091302.
10. Kalam F, Gabel K, Cienfuegos S, Wiseman E, Ezpeleta M, Steward M, et al. (2019). Alternate day fasting combined with a low-carbohydrate diet for weight loss, weight maintenance, and metabolic disease risk reduction. Obesity Science and Practice 5(6): 531–539. DOI: 10.1002/osp4.367.
11. Kwon OW, Jun DW, Lee SM, Lee KN, Lee HL, Lee OY, et al. (2012). Carbohydrate but not fat is associated with elevated aminotransferases. Aliment Pharmacol Ther 35(9): 1064–1072. DOI: 10.1111/j.1365-2036.2012.05061.x.
12. Lim SS, Noakes M, Keogh JB, Clifton PM (2010). Long-term effects of a low carbohydrate, low fat or high unsaturated fat diet compared to a no-intervention control. Nutr Metab Cardiovas Dis 20(8): 599–607. DOI: 10.1016/j.numecd.2009.05.003.
13. Manninen AH (2006). Very-low-carbohydrate diets and preservation of muscle mass. Nutrition & Metabolism 3(1): 9. DOI: 10.1186/1743-7075-3-9.
14. Miyashita Y, Koide N, Ohtsuka M, Ozaki H, Itoh Y, Oyama T, et al. (2004). Beneficial effect of low carbohydrate in low calorie diets on visceral fat reduction in type 2 diabetic patients with obesity. Diabetes Res Clin Pract 65(3): 235–241. DOI: 10.1016/j.diabres.2004.01.008.
15. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono Ch, et al. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis. Lancet 384(9945): 766–781. DOI: 10.1016/S0140-6736(14)60460-8.
16. Noto H, Goto A, Tsujimoto T, Noda M (2013). Low-carbohydrate diets and all-cause mortality: a systematic review and meta-analysis of observational studies: a systematic review and meta-analysis of observational studies. PloS One 8(1): e55030. DOI: 10.1371/journal.pone.0055030.
17. Oh R, Gilani B, Uppaluri KR (2020). Low Carbohydrate Diet. StatPearls Publishing. [online] [cit. 2020-07-20]. Available at: https://www.ncbi.nlm.nih.gov/books/NBK537084/
18. Paoli A, Cancellara P, Pompei P, Moro T (2019). Ketogenic Diet and Skeletal Muscle Hypertrophy: A Frenemy Relationship?. J Hum Kinet 68: 233–247. DOI: 10.2478/hukin-2019-0071.
19. Paoli A, Mancin L, Giacona M, Bianco A, Caprio M (2020). Effects of a ketogenic diet in overweight women with polycystic ovary syndrome. Journal of Translational Medicine 18(1): 1–11. DOI: 10.1186/s12967-020-02277-0.
20. Perissiou M, Borkoles E, Kobayashi K, Polman R (2020). The Effect of an 8 Week Prescribed Exercise and Low-Carbohydrate Diet on Cardiorespiratory Fitness, Body Composition and Cardiometabolic Risk Factors in Obese Individuals: A Randomised Controlled Trial. Nutrients 12(2): 482. DOI: 10.3390/nu12020482.
21. Sasakabe T, Haimoto H, Umegaki H, Wakai K (2011). Effects of a moderate low-carbohydrate diet on preferential abdominal fat loss and cardiovascular risk factors in patients with type 2 diabetes. Diabetes Metab Syndr Obes 4: 167–174. DOI: 10.2147/DMSO.S19635.
22. Sasakabe T, Haimoto H, Umegaki H, Wakai K (2015). Association of decrease in carbohydrate intake with reduction in abdominal fat during 3-month moderate low-carbohydrate diet among non-obese Japanese patients with type 2 diabetes. Metabolism 64(5): 618–625. DOI: 10.1016/j.metabol.2015.01.012.
23. Tinsley GM, Willoughby DS (2016). Fat-Free Mass Changes During Ketogenic Diets and the Potential Role of Resistance Training. Int J Sport Nutr Exerc Metab 26(1): 78–92. DOI: 10.1123/ijsnem.2015-0070.
24. WHO (2020a). Obesity and overweight. [online] [cit. 2020-07-20]. Available at: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

25. WHO (2020b). Healthy diet. [online] [cit. 2020-07-03]. Available at: https://www.who.int/en/news-room/fact-sheets/detail/healthy-diet
26. Yu H, Jia W, Guo Z (2014). Reducing Liver Fat by Low Carbohydrate Caloric Restriction Targets Hepatic Glucose Production in Non-Diabetic Obese Adults with Non-Alcoholic Fatty Liver Disease. J Clin Med 3(3): 1050–1063. DOI: 10.3390/jcm3031050.

Contact:

Simona Šimková, University of South Bohemia in České Budějovice, Faculty of Health and Social Sciences, J. Boreckého 27, 370 11 České Budějovice, Czech Republic
Email: simkovas@zsf.jcu.cz