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Implications of the Ketogenic Diet on Metabolic Syndrome

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Abstract

Metabolic syndrome (MetS) is a condition defined as a clustering of risk factors that is strongly associated with obesity, heart disease, and diabetes (Kahn, Buse, Ferrannini, & Stern, 2005). The prevalence of MetS has reached epidemic levels globally. It is estimated that 20% to 25% of the adult global population has MetS (Alic, 2018). MetS is diagnosed when three of the five risk factors are present. The risk factors are a large waistline (abdominal obesity), high triglyceride level, low HDL cholesterol, high blood pressure, and high fasting blood sugar. The standard and most effective treatment for MetS has been lifestyle interventions, with dietary interventions being one of the major effective lifestyle interventions utilized to treat MetS (Grundy et al., 2005; Samson & Garber, 2014). The Ketogenic Diet (KD) is one dietary intervention that may have the potential to improve MetS risk factors. One of the primary uses of the KD has been to treat epilepsy however, there is substantial evidence that it may help improve other conditions and illnesses, such as MetS (Mobbs, Mastaitis, Isoda, & Poplawski, 2013; Westman et al., 2007; Paoli, 2014). Despite this potential, certain dietary misconceptions may have prevented or slowed further research and use of the KD, particularly the national dietary guidelines that have promoted a low-fat, high-carbohydrate diet for several decades (Hite et al., 2010; Woolf, & Nestle, 2008; Woolston, 2015). The purpose of this paper is to conduct a review of the literature regarding MetS, the KD, and the implications of the KD as a treatment for MetS. Existing research is systematically reviewed regarding the KD's potential to address MetS and MetS risk factors. The results of the review indicate the validity and the need for further research on the KD and its potential to address MetS and MetS risk factors.

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Introduction

The prevalence of Metabolic Syndrome (MetS) has become a global epidemic that can be closely associated with the global obesity epidemic. MetS has been defined as a clustering of risk factors that can indicate a significant increase in the risk of developing dangerous conditions and chronic diseases; such as obesity, heart disease, and diabetes (Grundy et al., 2005). Treatment for MetS generally consists of lifestyle and pharmacological intervention however, lifestyle intervention has proven to be the most preferred and effective (NHLBI, n.d.). Dietary interventions are one of the lifestyle interventions that have been used to effectively treat MetS. The ketogenic diet (KD) is one such diet that may hold significant promise in treating MetS (Volek et al., 2008). Therefore, the purpose of this paper is to conduct a review of the literature regarding MetS, the KD, and the implications of the KD as a treatment for MetS.

Metabolic Syndrome: Definition, Epidemiology, Implications, Causes, and Treatment

Three of the five risk factors must be present for a diagnosis of MetS however, the more risk factors that are present the greater the risk of the associated conditions and diseases (Kahn et al., 2005). Having a diagnosis of MetS signifies a higher disease risk than when the risk factor components are analyzed individually (NHLBI, n.d.). The risk factors, which can be viewed on table 1, include having a large waistline (abdominal obesity), high triglyceride level, low HDL cholesterol, high blood pressure, and high fasting blood sugar. MetS has been labeled many different names throughout the years. It has been referred to as insulin resistance syndrome, dysmetabolic syndrome, hypertriglyceridemic waist, obesity syndrome, and syndrome X (Alic, 2018).

There has been wide disagreement on the correct diagnoses criteria for MetS, particularly for the adolescent population. Indeed, the clinical usefulness of MetS as a diagnosis has been stifled by the multiple definitions of the syndrome. In 2009, a harmonized criterion for MetS was established, which can be viewed in table 1 (Samson, & Garber, 2014). Despite this harmonization, Vanlancker et al. (2017) states that the adult definition for MetS should not be used for children. With children and adolescents, growth interferes with the variables used to define MetS. Factors such as puberty induces physiological changes in adiposity and insulin sensitivity, which likely decreases the validity of normal risk factor measures. Age dependent cut-off points have yet to be formally established and there currently seems to be no consensus on the definition of MetS in children and adolescents (Vanlancker et al., 2017; Bass III, 2017).

Globally, the incidence and prevalence of MetS, alongside obesity, has reached epidemic proportions. Generally, it is estimated that 20% to 25% of the adult global population qualifies as having MetS (Alic, 2018). It is estimated that 30% of the world's population is either overweight or obese, with the U.S. having the highest proportion of obese people (13%). Obesity has been attributed to nearly one-half of the diabetes burden and one-quarter of the heart disease burden. (Ross, 2017). In the U.S., MetS has seen increases from about 32% of the adult population in 2000, to about 34%-35% in 2017 and for populations in the U.S. with previous health problems the rates are above 35% (Alic, 2018).

The prevalence varies greatly by geographic region, age, sex, race, and ethnicity, as well as by definition of the syndrome. Some estimates of MetS prevalence range from below 10% to as high as 84% depending on the population (Alic, 2018). There is substantial evidence that the prevalence of MetS increases with age (Aguilar et al., 2015; Alic, 2018; Samson, & Garber,

2014). Individuals age 20 to 39 had a prevalence of 18.3%, while the prevalence increased to 46.7% for those aged 60 or older (Aguilar et al., 2015).

There are many factors that influence the incidence and prevalence of MetS. The risk of being diagnosed with MetS is closely associated with being overweight or obese, which is also closely associated with decreased insulin sensitivity. A decrease in insulin sensitivity, also known as insulin resistance, has been proposed as the primary underlying causal factor of MetS (Vanlancker et al., 2017). Both, genetic and environmental factors play a part in driving the pathophysiology of MetS. Ethnicity and family history can play a role in having the condition. For example, being predisposed to insulin resistance can be a condition that is inherited through genetics. Environmental factors can include leading a sedentary lifestyle, consuming calorie-dense food, stress, and smoking (NHLBI, n.d.; Hoffman, VonWald, & Hansen, 2015).

Insulin resistance and a pro-inflammatory/pro-oxidative state are shown to be major drivers for the risk factors that comprise MetS. Insulin resistance generally indicates defects in insulin action of insulin sensitive organs such as adipose tissue, skeletal/cardiac muscle, and liver. A pathophysiological condition occurs in which the normal insulin concentration does not produce the normal insulin response in the target tissue. Insulin resistance over time leads to the inability to produce sufficient insulin which leads to impaired fasting glucose, impaired glucose tolerance and eventually, type II diabetes. Insulin resistance often occurs along with abdominal obesity, which is one of the major risk factors for MetS (Lim, & Eckel, 2014; Martin, Mani, & Mani, 2015). The pro-inflammatory/pro-oxidative state is most accurately measured by the inflammatory marker high-sensitivity C-reactive protein (hsCRP). HsCRP is a good predictor of MetS, strongly associated with abdominal obesity, and can predict cardiovascular events and atherosclerotic disease. Having a large amount of adipose tissue tends to induce systemic

inflammation, which is further exacerbated by high plasma triglycerides and low HDL-C levels creating a vicious cycle that drives MetS risk factors to further undesirable levels (Acevedo et al., 2015; Lim, & Eckel, 2014).

There is no pharmacological agent that treats the overall syndrome therefor, it is the components or risk factors of MetS that must be treated individually. Lifestyle intervention primarily includes changes in diet and physical activity but may also include stress management and smoking prevention. Dietary intervention has been shown to be effective in improving many of the risk factor components of MetS however, the greatest improvement seems to occur when multiple lifestyle interventions are employed (NIH, n.d.; Alic, 2018; Joaquín, & Andrés, 2011). A systematic review of 11 randomized controlled studies of lifestyle interventions with a median length of one year found that the proportion of patients with resolution of MetS was approximately 2-fold over controls (Samson, & Garber, 2014). Managing stress and quitting smoking were other lifestyle changes that have been recommended to treat MetS. Research has been conducted indicating that certain diet interventions can be successful for preventing, treating, and even reversing MetS (Alic, 2018; Joaquín, & Andrés, 2011).

Dietary Interventions and Controversy

Dietary interventions are a large part of the lifestyle changes that can be recommended to prevent, manage, and potentially reverse MetS. Despite the relevance of using dietary interventions to address a wide range of health issues, including MetS, there remains to be a great deal of controversy regarding what a healthy diet should consist of. The national dietary guidelines were first introduced in 1977 with the goal of reducing dietary fat consumption. Since then the dietary guidelines have largely favored a low-fat, high carbohydrate diet (Elliot, 2014).

There has been a great deal of concern, supported by research, that those guidelines have been based on poor science and that there is little evidence supporting their effectiveness (Hite et al., 2010; Woolf, & Nestle, 2008; Woolston, 2015).

Archer, Pavela, & Lavie, (2015) investigated the memory-based dietary assessment methods (MB-M; e.g., interviews, surveys) that were primarily utilized to inform the dietary guidelines. The study highlighted that MB-M data has been considered valid and valuable, yet there is no empirical support regarding the validity of human memory and retrospective recall in dietary assessment. Harcombe et al. (2015) studied more effective methods of research, randomized controlled trials, and found no supporting evidence for the low-fat, concomitantly high carbohydrate recommendations. Further, there is mounting evidence that the genesis of the vilification of fat and its continued promulgation has been based on poor and misguided science (Elliott, 2014; Taubes, 2001; Mozaffarian, & Ludwig, 2015). The increased prevalence of overweight/obesity and diabetes seems to indicate that the dietary guidelines recommending a low-fat, high carbohydrate diet are failing. The dietary recommendations have placed a great deal of stigma on dietary fat that has created substantial barriers for dietary interventions, such as the ketogenic diet, that may have the potential to address a number of health issues, including MetS.

The Ketogenic Diet

The KD is generally defined as a high-fat, low-carbohydrate, moderate protein diet, of which the aim is to switch the primary fuel source for the body from utilizing glucose to utilizing fat and ketones. This results in a metabolic state that is very similar to starvation or fasting. Since ancient times, fasting has been used to treat a number of health problems, such as obesity,

diabetes mellitus, and epilepsy (Mobbs, Mastaitis, Isoda, & Poplawski, 2013; Roehl, & Sewak, 2017; Wheless, 2008). It is put forward that the KD may have the potential, when formulated properly, to allow for the consumption of adequate nutrient intake, thus avoiding the malnutrition that can be associated with prolonged starvation and fasting, while still producing the same therapeutic benefits (Roehl, & Sewak, 2017).

The modern-day, or classic KD was first conceptualized by two independent groups in 1921. Woodyatt of Rush Medical College in Chicago proposed that components of the KD, known as ketones, were formed through a diet low in carbohydrates and high in fat. Wilder, from the Mayo Clinic in Rochester, Minnesota, found the KD could be used as an effective treatment for seizures (Roehl, & Sewak, 2017). Although the KD was used primarily for children with epilepsy, other research indicates that it was also effective in treating adults with epilepsy (Kohli, & Samour, 2013). The KD fell out of prominence until the mid-1990's, when a resurgence of the KD occurred largely due to a popular, highly publicized, documented case in which a young epileptic patient became seizure-free by implementing the diet. Since then, the KD has remained relatively prominent, which may be in part due to the public's growing disdain for prescription medications and preference for more natural-based cures (Wheless, 2008). Contributing to the KD resurgence may also be its potential to address a number of other health issues (Mobbs, Mastaitis, Isoda, & Poplawski, 2013; Westman et al., 2007; Paoli, 2014).

Ketosis and Ketones

The KD initiates the process of ketosis primarily through the restriction of carbohydrates, usually to less than 50 grams a day. When this carbohydrate restriction is followed for approximately three days, a shift in the body's metabolic state occurs. The body's glucose reserves become exhausted, requiring the central nervous system to shift fuel sources from a

"glucocentric" (glucose) to "adepocentric" (ketone bodies, fatty acids) metabolism (Gildea, 2017). The lack of glucose leads to an over-production of acetyl coenzyme A (CoA), which is used to produce the three ketone bodies (KB), beta-hydroxybutyrate (BHB), acetoacetate, and acetone, in the mitochondria of the liver (Luat, Coyle, & Kamat, 2016).

KB are an excellent source of fuel. Although the prevailing idea is that glucose is the body's preferred fuel source, the body's physiology is more appropriately designed for fatty acid metabolism. Fatty acid metabolism yields more energy than glucose metabolism, considering that 100 grams of glucose generates 8.7 grams of ATP, while 100 grams of BHB (KB) can generate 10.5 grams of ATP (Gildea, 2017).

Implications of the Ketogenic Diet on Metabolic Syndrome

There was little research to be found that has been conducted specifically focusing on the KD as a way of treating MetS. Volek et al. (2008) conducted a randomized, controlled, dietary intervention trial that proposed carbohydrate restriction (CR) may have a more favorable effect on MetS than a Low-Fat diet (LFD). When the search field is widened to the KD as treatment for the diseases and conditions strongly associated with MetS, there is more research to be found. Studies have been conducted investigating the KD and its utility in treating obesity, type II diabetes mellitus, and risk factors for heart disease (Moreno et al., 2014; Hussain et al., 2012; Sharman et al., 2002). Several of the risk factors for these conditions are also risk factors for MetS. Further insight may be gained by considering the implications of the ketogenic diet on the five risk factors that make up MetS.

Abdominal Obesity

The presence of abdominal obesity is associated with the risk of developing disorders such as diabetes, hypertension, and cardiovascular disease (Koran, Bolatke, Can, Acara, & Harmankaya, 2017). It is closely associated with insulin resistance. Despite these associations the differences between risks associated with general obesity and abdominal obesity is not well understood. Koran, Bolatkale, Can, Acara, & Harmankaya (2017) compared the cardiovascular risk profile of individuals with obesity and abdominal obesity finding that the only significant difference was that obese individuals had higher inflammatory parameters of fibrinogen and CRP. Therefore, research available on the KD and general obesity was considered relevant and utilized for review of this MetS risk factor. The KD has been well researched as a means of losing weight however, the mechanisms causing the weight loss is still a subject of debate. Some hypothesized mechanisms include: reduction in appetite, reduction in lipogenesis and increased lipolysis, greater metabolic efficiency in consuming fat, and increased metabolic costs of gluconeogenesis (Paoli, 2014).

Moreno et al. (2014) compared a very low-calorie ketogenic diet (VLCK) with a standard low-calorie diet (LC) for the treatment of obesity, finding that the VLCK diet was significantly more effective than a standard LC diet. Gibson et al. (2015) found that a clinical benefit of a KD is in the suppression of appetite, despite weight loss, and a more lasting feeling of satiety. Sumithran et al. (2013) showed that the hormones that regulate appetite were altered on a KD in a way that reduced appetite. The levels of cholecystokinin (CCK), a hormone which increases satiety, increased on a KD, while the circulating levels of ghrelin, an appetite stimulating hormone, were reduced.

Primary characteristics of insulin resistance is a reduced ability of muscle cells to take up circulating glucose and the reduced ability to slow down hepatic glucose output. The ability to metabolize carbohydrates becomes problematic under these circumstances leading to a greater proportion of glucose from the dietary carbohydrates being converted to fat (lipogenesis), rather than being oxidized for energy in skeletal muscle (Paoli, 2014). When glucose reserves become exhausted on a KD the body requires a different fuel source, thus shifting to a state of ketosis. It is during this state that a mobilization of fatty acids from adipose tissue is accelerated and the liver begins producing ketone bodies (Gildea, 2017). Alessandro et al. (2015) observed an increased level of fat oxidation from adipose tissue on a KD and a greater amount of fat loss compared to a Mediterranean diet. During the first few days on a KD, glucose is derived from the process of gluconeogenesis from amino acids, which can be an energy demanding process calculated at approximately 400-600 Kcal/day (Feinman, & Fine, 2007). As time passes on a KD more of the necessary glucose is derived from the glycerol from circulating fatty acids (Paoli, 2014). The mechanisms responsible for weight loss on a KD should be a focus of research in the future however, despite this need, strong evidence exists for the effectiveness of the KD to treat obesity (Hussain et al., 2012; Rabast, Schönborn, & Kasper, 1979; Westman, Yancy, Edman, Tomlin, and Perkins, 2002; Yancy, Olsen, Guyton, Bakst, and Westman, 2004).

High Triglyceride Level and Low HDL Cholesterol

High triglyceride levels and Low HDL Cholesterol are strongly associated with one another and have been strongly associated with insulin resistance. Insulin plays an important role in the regulation of lipid homeostasis. When a diet of excess carbohydrates is consumed the insulin blocks lipolysis. The chronic presence of glucose and insulin interrupts the appropriate

synthesis of triglycerides (Pérez -Guisado. 2006). It has been put forward that high triglyceride levels are an independent risk factor for cardiovascular disease (Harchaoui, Visser, Kastelein, Stroes, & Dallinga-Thie, 2009). One study evaluating the association of all 5 MetS components with cardiovascular risk found the strongest association with triglycerides (Miller et al., 2011). HDL cholesterol has also been considered a significant predictor of major cardiovascular events, even after all other baseline risk factors. In fact, one analysis determined that each increase of 1 mg per deciliter in HDL cholesterol is associated with a decrease of 2 to 3% in the risk of future coronary heart disease (Barter et al., 2007).

The majority of the previously cited studies regarding the KD's effectiveness in treating obesity also reported significant decreases in triglyceride levels and increases in HDL (Hussain et al., 2012; Moreno et al., 2014; Volek et al., 2009; Yancy et al., 2004; Westman et al., 2002). Sharman et al. (2002) conducted a 6-week study where 12 men consumed a KD and 8 controls consumed their habitual diet. Serum triglyceride levels were significantly reduced at 3 weeks (-30.9%) and 6 weeks (-33%). The authors proposed that the significant reduction in triglycerides was likely due to a combination of a reduced VLDL production rate and an increase in triglyceride removal considering that high-fat diets increase postheparin plasma lipase activity and skeletal muscle postheparin plasma lipase activity in humans. HDL significantly increased from week 0 to week 3 and overall, there was an increase in HDL of 10% (Sharman et al., 2002).

High Blood Pressure

Considering the effects of the KD on blood pressure, there is further evidence that insulin resistance drives obesity and MetS. Fasting serum insulin is higher in an insulin resistant state. Lucas, Estigarribia, Darga, & Reaven, (1985) found that both systolic and diastolic blood

pressure were found to be significantly associated with serum insulin level indicating that insulin may play a major role in blood pressure regulation in obesity. Volek et al. (2008) conducted a study where a carbohydrate-restricted diet group had 50% reduction in insulin concentrations. A study comparing a low-carbohydrate, ketogenic diet (LCKD) with the drug orlistat plus a low-fat diet (O + LFD) for weight loss found that, although glucose, insulin, and hemoglobin A(1c) levels improved for the LCKD over the O + LFD group, the only parameter that significantly improved was systolic and diastolic blood pressure (Yancy et al., 2010). Hession et al. (2009) conducted a systematic review of randomized controlled trials of low-carbohydrate, ketogenic like diets vs. low-fat/low-calorie diets for the management of obesity and its comorbidities, where the results showed a trend towards improvement in diastolic and systolic blood pressure at 6, 12, and 17 months for the low-carbohydrate diet. The difference was significant at 12 months. However, Bravata et al. (2003) and Nordmann et al. (2006) were studies that were reviewed by Hession et al. (2009) that found no difference in blood pressure at any point for the low- and very-low-carbohydrate diets.

High Fasting Blood Sugar (Glucose)

The state of insulin resistance is very strongly associated with how efficiently glucose is utilized in the body and thus, it is also strongly associated with higher fasting blood sugar levels. Under normal dietary consumption circumstances, when larger amounts of carbohydrate are consumed, insulin and glucose are more often elevated, which is thought to lead to a reduction in insulin sensitivity of the cells (Paoli et al., 2013). As previously discussed, the KD has been found to have beneficial effects on fasting and postprandial insulin responses, which could likely

be attributed to a greater reliance on fat oxidation for fuel and subsequent reduced requirement for insulin to assist in glucose uptake (Sharman et al., 2002).

The systematic review by Hession et al. (2009) found an overall trend towards improvement in fasting plasma glucose. Volek et al. (2008) found a significant average reduction of 12% in fasting glucose and subsequently, found significant improvements in glycemic and insulin control. Yancy et al. (2010) reported improved glucose, insulin, and hemoglobin A(1c) levels in a low-carbohydrate KD group. One study looking at the effects of a KD on diabetic obese patients over a 56-week period included two groups in the study; group I consisted of obese subjects with high blood glucose levels and group II consisted of subjects with normal blood glucose levels. The results revealed that both groups experienced significant reduction in blood glucose levels that occurred from the beginning through week 56 (Dashti et al., 2007). Considering these findings, the KD has the ability to reduce blood glucose to lower than normal levels and to reduce glucose metabolism. This certainly indicates the potential to reduce fasting glucose to safe levels for individuals who have this MetS risk factor, but also to reverse complications from high fasting glucose, which does not occur if blood glucose is only normalized (Mobbs et al., 2013).

Potential Adverse Effects of the Ketogenic Diet

There are a number of potential adverse effects that have been associated with the KD. Some appear to be relevant, while others seem to be based on misconceptions surrounding the KD. As discussed previously, there is a still prominent belief that dietary fat, particularly saturated fat is a leading cause of heart disease. Due to this persistent idea, the high fat content of the KD raises concerns however, there is little evidence supporting this theory (Elliott, 2014;

Taubes, 2001; Mozaffarian, & Ludwig, 2015). Despite little evidence for this concern, Kapetanakis, Liuba, Odermarsky, Lundgren, & Hallböök (2014) looked at the long-term effects of vascular function on children being treated for epilepsy with the KD. They found that there were adverse alterations in lipids, apoB, and arterial function observed at three and 12 months however, at 24 months the alterations appeared to return to baseline. Another often described adverse effect of the KD is that it can cause kidney and liver problems due to the high protein intake. This misconception can be clarified by emphasizing that the KD is not considered a high protein diet (Pérez -Guisado, 2006; Westman et al., 2007).

Some research indicates that the KD may affect growth in children when used long-term (Vining et al., 2002). Various nutrient deficiencies have been observed in some studies, such as selenium, calcium, and vitamin D, which has often resulted in the recommendation of supplementation when on the KD (Kohli, & Samour, 2013). Dehydration has been observed in KD protocols that involve initial periods of fasting. Due to the potential conjunction of hypercalciuria, acid urine, and low urinary citrate excretion with low fluid intake there is a risk for kidney stones, thus fluid intake should be optimized while on the KD (Pérez -Guisado, 2006). Gastrointestinal problems have also been reported, including vomiting, diarrhea, and constipation. Many of these side effects have been attributed to the higher ratio (4:1) KD, which is more restrictive and includes a higher fat content (Luat, Coyle, & Kamat, 2016).

Conclusion

The increasing prevalence of MetS has reached global epidemic proportions that are in line with the increasing prevalence of obesity, diabetes, and heart disease (Kahn et al., 2005). The strong association MetS has with these diseases and conditions can highlight the level of

beneficial impact that an effective treatment for MetS could have for healthcare. The standard and most effective treatment for MetS has been lifestyle interventions, with dietary interventions being one of the major effective lifestyle interventions used (Grundy et al., 2005). The KD has been one of those dietary interventions that has been shown to have significant potential for treating MetS however, certain dietary misconceptions could be a major barrier to the recommended use of the KD (Volek et al., 2008). In particular, the national dietary guidelines, that have promoted a low-fat, high-carbohydrate diet for several decades, may have hindered the furthering of research on the KD (Hite et al., 2010; Woolf, & Nestle, 2008; Woolston, 2015). Despite these circumstances, the research discussed in this paper highlights the potential utility of the KD to treat MetS and should hopefully prompt further research on this topic.

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Table 1. – Harmonized Criteria for Metabolic Syndrome		
Risk Factors		**Defining Level**
Large Waistline (abdominal obesity)	**Men**	**WC ≥ 94 cm**
(Primarily geographic and ethnic Specific)	**Women**	**WC ≥ 80 cm**
High triglyceride level		**≥ 150 mg/dL**
		or treated
Low HDL cholesterol	**Men**	**≤ 40 mg/dL**
	Women	**≤ 50 mg/dL**
High blood pressure		**SBP ≥ 130**
		DBP ≥ 85
		or treated
High fasting blood sugar		**≥ 100 mg/dL**
		or treated
Abbreviations: WC - Waist Circumference, SBP - Systolic Blood Pressure, DBP – Diastolic Blood Pressure		
(Samson, & Garber, 2014).		

Table 2. Comparison of Ketogenic Diet Variations and 2015 -2020 Dietary Guidelines for Americans			
(ratios and daily macronutrient percentages) (Roehl, & Sewak, 2017).			
Diet	**Fat**	**Carbohydrate**	**Protein**
	<----------range (%)---------->		
2015-2020 Dietary Guidelines for Americans	20 - 35	45 - 65	10-35
Classic Ketogenic diet ratios			
4:1	90	2-4	6-8
3:1	85 - 90	2-5	8-12
2:1	80 - 85	5-10	10-15
Modified Atkins diet (1:1 ratio)	60 - 65	5-10	25-35
Low glycemic index treatment (1:1 ratio)	60 - 70	20 - 30	10-20
Medium-chain triglyceride diet (1:1 ratio)	60 - 70	20 - 30	10