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Review Article

Ketogenics: Beneficial Impacts on Obesity and Metabolic Syndrome and Implementation in Clinical Practice and Biopsychosocial Considerations

Vasudeva Shaweta* and Pedroza Roseann

ShayTheCoach, USA

***Corresponding Author:** Vasudeva Shaweta, ShayTheCoach, USA.

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Abstract

This paper will review a brief history and definition of the ketogenic diet while describing its key components. While there have been several papers written and published on this topic, what separates this paper, is that it will specifically cover the beneficial impacts that a ketogenic diet has on obesity and metabolic syndrome [1-3]. We will discuss what metabolic syndrome is and its basic tenets as outlined by the American Heart Association [4] and how the ketogenic diet can positively impact metabolic syndrome. We will also discuss how to implement the ketogenic diet in clinical practice. We will discuss techniques on how to address the lifestyle of the ketogenic diet and how to help your clients or patients to utilize it in their day to day life [5-7]. We will discuss these considerations when using ketogenic diets in practice. This will include testing for ketones, food options, and the importance of supporting the diet to insure the body is receiving adequate nutrition [5].

Keywords: *Ketosis; Ketogenic Diet; Ketosis and Clinical Implementation; Ketosis and Metabolic Syndrome; Clinical Implementation and Ketogenic Diets; Obesity and Ketogenic Diets*

Abbreviations

CHO: Carbohydrates; BHB: Beta-Hydroxybutyrate; HDL: High Density Lipoprotein; LDL: Low Density Lipoprotein; SKD: Standard Ketogenic Diet; TKD: Targeted Ketogenic Diet; CKD: Cyclical Ketogenic Diet; MV: Multi Vitamin; MCT: Medium Chain Triglyceride; KA: Ketoacidosis

Brief Ketogenic Diet History

The ketogenic diet was founded in 1923 by Dr. Russell Wilder for the treatment of epilepsy [5,8,9]. Over time, research has started to indicate the use of ketogenic diets as a viable option for the treatment of other conditions such as Neuroinflammation, Psychological States (i.e.: depression), Metabolic Syndrome, Parkinson's Disease, ALS, Traumatic Brain Injury, Multiple Sclerosis, chronic headaches, cancer, diabetes (Type 1 and 2) [2,5,10].

What is the ketogenic diet?

The ketogenic diet is one in which the human body undergoes a metabolic change whereby it becomes fat-adopted [2,11,12]. In a fat-adapted body, the primary source of fuel becomes ketone bodies rather than carbohydrates (CHO). When this occurs, the body is said to be in a ketogenic state. Typically, this entails keeping daily CHO intake to 25 - 30 grams of net CHO which prevents the body from the need to release excess amounts of insulin, a glucose-regulating hormone that allows the body to use the glucose from the CHO as fuel. In a ketogenic state the main fuel is known as ketone bodies, which create a steady, constant blood glucose level in the body [13]. The typical

macronutrient breakdown for a ketogenic diet for adults is 70% - 80% from fat source, 20% - 25% from a protein source; and the last is 5% - 10% from CHO [5].

Once the body undergoes the metabolic switch and enters a state of ketosis, the body can convert ingested fat into its bi-products which are known as ketone bodies [1,2]. These ketones are called acetoacetate and acetone. The ketone body, acetoacetate, must be converted by the body to beta-hydroxybutyrate (BHB). BHB then serves as to fuel the body primarily versus glucose [14]. The ketone body, acetone, is created as a side product of acetoacetate via decarboxylation and the excreted through the urine [5,15].

Why does the body utilize ketones?

The body has always relied on ketones for energy when glucose source is depleted, and most babies are born in a state of ketosis [16]. However, with the abundant source of CHO available in the current market, adults are rarely in ketosis and in turn this metabolic pathway becomes dormant. Our bodies are amazing adapting to burning of ketones for fuel, as it is presumed that our ancestors had frequent periods of high carbohydrate food that were not available immediately.

Benefits of ketogenic diets on metabolic syndrome

Studies have shown that being in a ketogenic state assists in sports performance, weight loss, epileptic seizures in children, systemic inflammation, and in depression along others [1,2,10]. There is documented evidence that the ketogenic diet is beneficial to metabolic syndrome [1,2,17]. Metabolic syndrome is characterized by the following risk factors [4]:

- High blood glucose (sugar)
- Low levels of HDL ("good") cholesterol in the blood
- High levels of triglycerides in the blood
- Large waist circumference or "apple-shaped" body
- High blood pressure.

Metabolic syndrome often shows up in individuals deemed "morbidly obese" "obese" or "clinically obese" or as a precursor there of [4]. In these cases, ketogenic states can be beneficial [1,2]. There's also evidence that a ketogenic diet can benefit neuroinflammation and psychological states such as depression [10].

High blood glucose

When the human body is not ingesting a diet based on ketogenic macronutrient ratios, the CHO intake is up to 45% - 65% which is 225 to 325 grams a day [18]. So, in turn when the body is in a ketogenic state, the significantly lower intake of 25 - 30 grams of CHO results in decrease of amount of released insulin [13]. This hormone is released to allow the body to use glucose from CHO as fuel, in result creates a steadier constant blood glucose level in the body [13].

Low levels of HDL

Regular levels of HDL range from 40 to 50 milligrams per deciliter (mg/dl) or higher [18]. As for low density lipoprotein (LDL), normal ranges are below 100 mg/dl [18]. When in a ketogenic state, research has been shown to improve and increase HDL levels [13]. This is attributed to the fact that HDL's role is to help transport LDL from cells and tissue back to the liver, transporting the excess cholesterol from the cells and blood preventing the blockage of veins and arteries [13].

Managed triglyceride levels

Triglycerides are an ester formed from glycerol and three fatty acid groups. Triglycerides are the main constituents of natural fats and oils, and high concentrations in the blood indicate an elevated risk of stroke [18]. In a ketogenic stage, due to the low level of CHO present

in the body, the blood glucose levels and cholesterol levels remain steady [14]. High triglycerides levels have been associated as contributors to heart disease, heart attacks, and stroke, especially in people with low levels of "good" HDL cholesterol and in those with type 2 diabetes [18]. In a ketogenic state, through the process of lipogenesis and subsequent triglycerides synthesis, the body no longer needs to convert and store excess glucose in the form of triglycerides [14].

Lowered waist circumference

Individuals who have higher body fat levels store excess glucose in a form of visceral fat in the abdominal region which is associated with elevated blood glucose levels due to insulin resistance [18]. So, a large waist circumference from visceral fat is often attributed due to insulin resistance. When the body becomes insulin resistant, hormone is unable to remove the excess glucose out the bloodstream in the human body and this in turn, may lead to and individual developing diabetes [18].

Volek and colleagues [14] studied two groups over a twelve-week period, whereby a group of forty men and women were placed into two groups. One group was placed on a high fat diet and the second group was placed a low-fat diet. The study found that the high fat diet group resulted in a greater decrease in blood lipid levels which also influenced their triglyceride levels. This was attributed to improved glycemic control and insulin sensitivity.

The ketogenic diet in clinical practice

In clinical practice, there are confounding variables that need to be accounted for when it comes to the implementation of the ketogenic diet. As with any specific diet, there are side effects and risks. These can be mitigated through proper clinical testing and by working with an experienced and credentialed professional who is versed in being aware of signs and symptoms that the human body is deficient or requiring specific nutritional supplementation. One common symptom is stomach or gastric pain, which is a sign that the body needs to be adequately hydrated. This can be remedied by adding electrolytes to the client's nutritional program [15]. Other symptoms are low energy, brain fog, and mental rationalization those can be fixed by adjusting the client's macronutrients or consuming more fats [5].

Ketogenic diet variations

There are several types of ketogenic diets, that range from the

- Standard Ketogenic Diet (SKD)
- Targeted Ketogenic Diet (TKD)
- Cyclical Ketogenic Diet (CKD).

These variations can be used by an experienced and qualified professional to induce ketosis and accommodate physiological, athletic, and lifestyle goals because on size doesn't fit all.

SKD is the major type of ketogenic diet that has recently been prevalent in social media and main stream marketing. Yet, it is important to note per discussion in this paper, it has been in use for 100 plus years for treatment of various medical disorders. Typically, 75 - 80% of the SKD diet comes from fats, 20 - 25% from protein, and 5 - 10% from Carbohydrates. Typically, it amounts to eating about 20 - 30 grams net CHO per day. TKD is sometimes utilized by athletes because the number of net CHO ingested can be increased based on the athlete's activity level. CKD is similar to SKD. The major difference is that in CKD, there is cycling of CHO intake. Individuals on CKD would have a period of low CHO intake followed by a period of eating a higher number of CHO. The cycle can be repeated based on the individual's needs [6,7].

Ensuring adequate nutrition in ketosis

As with many dietary specific lifestyles, it is important to work with a qualified professional to ensure the human body's dietary needs are being met. In a ketogenic diet, sometimes it is necessary to have supplementation with micronutrients such as multi-vitamins (MV) and minerals. It can also be beneficial to utilize exogenous ketones, Medium Chain Triglyceride (MCT) oils, and collagen protein [6].

Due to the educational nature of this paper, precise dosages and timings will not be discussed here. At the risk of sounding redundant, it is important to consult a qualified professional in order to obtain these. The professional can order medical and laboratory testing as necessary and can track an individual's results to ensure proper levels are being maintained within the body.

Ketogenic testing methodologies

The testing of ketone levels in the body is a key clinical indicator to assess whether a client is in a truly adequate ketogenic state to obtain optimal results. Simply consuming ketogenic foods would not automatically ensure the body is in a ketogenic state and has become fat adapted. While this diet entails consuming large amounts of the fat and low amounts of CHO, excess intake of protein prevent ketosis through a process called protein deamination. In this process, excess proteins can be converted into glucose [6]. As such, it is important to track macronutrients on a regular basis either through a database or macronutrient tracker.

It is also important to measure ketone bodies. There is a period of time once the ketogenic diet is started whereby the human body needs to become fat adapted. This is a process and is often referred to as the "keto flu." Due to the non-diagnostic nature of this paper and that the manifestation of the keto flu varies in individuals, the specific length of time to become fat adapted will not be discussed here. This paper will, however, discuss three methods in which testing ketone bodies can be done: urine, blood, and breath. This becomes vital to ensure the body has entered a ketogenic state and is maintaining it [5,6,19].

Urine ketone body testing

Urine tests show the excess number of ketones that are excreted (acetone), those tests can be done at home and are not completely reliable but can be cost-effective [6]. In order to mitigate the reliability factor, it is best to utilize this method of testing at a consistent time and on a daily basis.

Blood ketone body testing

Blood tests can be done via a medical lab and through utilizing an experienced and qualified practitioner who can order and monitor the labs. There are at-home- blood ketone test methods as well. It is important to include your practitioner in discussion when deciding the best testing methodology with regards to blood ketone testing. A barrier to this type of testing is that it can become rather pricey [6].

Breathe ketone body testing

The final testing methodology to be discussed in the contents of this paper is breath ketone body testing. This test measures the amount of acetone in the breath and is not as reliable as laboratory blood ketone testing. A positive is that it tends to be less of a financial commitment than blood ketone body testing [6].

It is important to note that ketone body levels should be tested on a regular basis due to risks of the human body entering a metabolic state called Ketoacidosis (KA). This is when extremely elevated levels of ketones can exist in the blood which can be dangerous because it can create a situation in the human body whereby the blood becomes acidic [20]. Risks of this can be offset by measuring ketone bodies carefully and moderated using proper laboratory testing by a qualified professional who can prescribe methods to bring the blood within the human body into its normal alkaline state of 7.365 [20].

Examples of ketogenic diet foods

The following is a list of commonly ingested ketogenic diet foods [5,6,7]:

Food	Example
Meats	Fatty cuts of grass-fed beef, chicken and other poultry, pork, lamb, goat, turkey, veal, bison, and fish sources like salmon, sardines, catfish, mahi, etc.
Oils	Olive oil, avocado oil, coconut oil, ghee, grass-fed butter, and nuts and seeds (whole or as butters)
Whole Eggs	Preferably organic, free-range. yolks preferred as they contain all of the fat content.
Dairy	Full-fat cheeses, sour cream, full-fat (unsweetened) yogurt, and heavy creams.
Seeds	Flax, hemp, sunflower, pumpkin, and chia seeds
Nuts	Macadamia nuts, pecans, and hazelnuts
Low-glycemic index vegetables and fruits	Spinach, kale, broccoli, cauliflower, asparagus and other leafy greens. Small quantities of blueberries, strawberries, raspberries, and avocados.

Conclusion

In conclusion, this paper provided an operational definition of ketogenic diets, a brief history of ketogenic diets, its beneficial impacts on obesity and metabolic syndrome, and ketogenic diet clinical implementation considerations. The ketogenic diet has a long-standing history dating back to the 1920's and has been utilized to treat the medical condition of epilepsy. The diet has also shown promise in the management of other brain-based disorders such as Parkinson's disease, ALS, Traumatic Brain Injury, Multiple Sclerosis, and chronic headaches, as well as in metabolic disorders like obesity, cancer, and type 2 diabetes [10].

Due to the scope of this article, the authors acknowledge there is further discussion on ketogenic diets that can be done around psychosocial considerations. In many countries, including the US, there is tremendous stigma surrounding high fat diets and the nutritional benefits of fat consumption. As more evidence-based research on this subject is being done and released, this has the potential to shift. Also, it is important to consider an individuals' lifestyle, athletic and sports activity, financial resources, availability to medical facilities and qualified practitioners, and availability of ketogenic foods [19].

This paper addressed these topics in brief, yet there is room to be expounded upon them. There are methods that are specific to tailoring the ketogenic diet to the needs of individuals in special circumstances. Yet this paper has covered several key components of ketogenic diets. It is a solid review of the types of ketogenic diets and how the diet can impact and individual's life with regards to obesity and metabolic syndrome.

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Conflict of Interest

N/A.

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