ATTITUDES, BELIEFS, AND PRACTICES OF REGISTERED DIETITIANS IN INDIANA REGARDING NUTRITIONAL KETOSIS AS A DIETARY TREATMENT FOR TYPE 2 DIABETES

A THESIS
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Type 2 diabetes mellitus (T2DM), with its rapidly increasing incidence, is a significant contributor to morbidity, mortality and rising healthcare costs in the United States. The registered dietitian plays an important role in providing accurate, evidence-based dietary strategies to treat and manage diabetes. Recent research indicates that diets resulting in nutritional ketosis are as effective at reducing weight, and more effective at maintaining glycemic control, than traditionally recommended low-fat, low-calorie or low-glycemic index diets. It is not known, however, if registered dietitians recommend diets that results in nutritional ketosis to manage T2DM. Thus, the purpose of this study was to examine the attitudes, beliefs, and practices of registered dietitians who are members of the Indiana Academy of Nutrition and Dietetics regarding dietary treatments for type 2 diabetes mellitus (T2DM). An anonymous online survey was used to investigate these trends, with the results compared by frequency of patient counseling and level of education. Results indicated that registered dietitians in Indiana (n=199) do not recommend ketogenic diets for the treatment of T2DM, with most (92.8%) having never recommended a ketogenic diet for T2DM. More than half (63%) indicated they do not believe they will ever recommend nutritional ketosis to a client with diabetes. While most dietitians reported being only moderately or slightly familiar with diets that induce nutritional
ketosis, more than half indicated they believe that evidence to support the use of a ketogenic diet for the treatment of T2DM is inconclusive or weak. The majority of dietitians reported having negative attitudes toward ketogenic diets, with nearly a half indicating they would be judged negatively by their peers or colleagues if they were to recommend a ketogenic diet for the treatment of T2DM. No differences were found among any of these constructs when compared by educational level or frequency of counseling individuals with T2DM. However, dietitians who counsel individuals with T2DM frequently were significantly ($\chi^2=4.839$, $p=0.028$) more likely to report that concerns regarding side effects of ketosis would prevent them from recommending a ketogenic diet for the treatment of T2DM. Additionally, dietitians who held post-graduate degrees were significantly ($\chi^2= 3.953$, $p=0.047$) more likely to report that long-term dietary adherence would prevent them from recommending a ketogenic diet for the treatment of T2DM, compared to those who held an undergraduate degree. Overall, the results of this study aid in the understanding of the attitudes and beliefs of registered dietitians regarding diets that cause nutritional ketosis, while also shedding light on the dietary macronutrient compositions most frequently recommended by registered dietitians for the treatment of type 2 diabetes.
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CHAPTER 1

INTRODUCTION

Diabetes Mellitus (DM) refers to a metabolic disorder characterized by hyperglycemia due to faulty insulin secretion, faulty insulin action, or both (Goldenberg & Punthakee, 2013). Diabetes is a significant contributor to morbidity, mortality and rapidly rising healthcare costs (American Diabetes Association, 2017). The estimated global prevalence of diabetes has risen from 108 million in 1980 to 422 million in 2014 (Zhou et al., 2016). Type 1 diabetes (T1DM) currently accounts for only 5.8% of all diabetes cases in the United States; in contrast, type 2 diabetes (T2DM) accounts for 90.8% of the cases, with the remaining 3.3% of cases classified as “other” types of diabetes (Bullard et al., 2018). It is estimated that in the United States, diabetes (both type 1 and type 2) prevalence will increase by 54%, effecting more than 54.9 million Americans between 2015 and 2030. Diabetes attributed deaths are expected to climb by 38% annually to 385,800 with total medical and societal costs increasing 53% to $622 billion by 2030 (Rowley, Bezold, Arikan, Byrne & Krohe, 2017). The diagnosis of any type of diabetes is based upon a fasting plasma glucose (FPG) value, a 2-hour plasma glucose (2-h PG) value during a 75g oral glucose tolerance test (OGTT), or via hemoglobin A1c criteria (American Diabetes Association, 2018).

Medical nutrition therapy (MNT) provided by a registered dietitian (RD) is crucial for the management and treatment of diabetes (Morris & Wylie-Rosett, 2010). The goal of nutrition
therapy in the treatment of T2DM is to reach and maintain healthy body weight, body mass index, and HbA1c, while stabilizing blood glucose values to avoid hyperglycemia or hypoglycemia (Chamberlain, Rhinehart, Shaefer, & Neuman, 2016). Currently, the Academy of Nutrition and Dietetics (Academy) practice guidelines for the treatment of diabetes do not support the use of a specific diet, but rather state that registered dietitians should use evidence-based practice to choose the most effective dietary strategy for each patient. Diet preference and adherence should be considered for each patient, as a variety of eating patterns may be effective in the management of diabetes (Franz et al., 2017).

The Academy of Nutrition and Dietetics Nutrition Care Manual (NCM, 2018) describes a 4:1 ratio classic ketogenic diet as a diet where 90% of the calories come from fat. The 4:1 ratio refers to four grams of dietary fat for each combined gram of dietary protein and carbohydrate. A ketogenic diet (KD) requires the body to use fat, rather than carbohydrate, as its primary fuel substrate. When metabolized, the dietary fat produces three primary metabolic products (i.e., acetoacetate, beta-hydroxybutyrate and acetone), each of which is a ketone. As the ketone bodies accumulate, ketosis results (Stubbs et al., 2017).

Ketosis is considered a normal metabolic process that occurs during periods of fasting or limited carbohydrate availability, during which the body burns fat rather than carbohydrate from food for the cells’ energy (Paoli, Bosco, Camporesi, & Mangar, 2015). Under conditions of dietary carbohydrate restriction, a shift from a “glucocentric” (reliant upon glucose), to an “adipocentric” (reliant on ketones and fatty acids) metabolism occurs, and fatty acids (from dietary sources and adipose tissue) become the body’s main fuel source (Westman et al., 2007). Nutritional ketosis refers to a physiological state, induced by the consumption of a very-low carbohydrate (typically less than 50grams/day), moderate protein (commonly 1.5g/kg idea body...
weight), high-fat diet, which leads to a therapeutic rage of circulating ketone bodies. Nutritional ketosis is confirmed through urine measurements of acetoacetate or blood measurements of beta-hydroxybutyrate, which is considered optimal when in the range of 0.5-3 Mmol/L (Miller, Villamena & Volek, 2018). The amount of circulating ketones present in nutritional ketosis is much lower than the 6-7.5Mmol/L commonly seen in in prolonged fasting, and a fraction of the dangerous amount of ketones (up to 25 Mmol/L) associated with ketoacidosis in uncontrolled diabetes (Kanikarla-Marie & Jain, 2016). Ketogenic diets (i.e., diets that result in nutritional ketosis) have been used since the early 1900s to treat epilepsy as well as diabetes before the discovery of insulin (Wheless, 2008). Emerging research indicates that this eating pattern may be effective in the treatment of T2DM (Goday et al., 2016; Saslow et al., 2017; Hallberg et al. (2018).

In short-term trials, ketogenic diets have led to more effective weight loss and greater improvements in fasting plasma glucose, HbA1c, serum triglycerides, and HDL cholesterol when compared to calorie restricted diets (Goday et al., 2016; Houssain et al., 2012). When compared to a low-glycemic index diet, an ad libitum ketogenic diet produced greater improvements in HbA1c, body weight, and HDL cholesterol (Westman, Yancy, Mavropoulos, Marquart, & McDuffie, 2008). Additionally, after 24 weeks of diet intervention, 95% of study participants in the ketogenic diet group reduced or eliminated the need for diabetes medication, compared to only 62% in the low-glycemic index group (Westman et al., 2008).

Tay et al. (2015) conducted a clinical trial to compare the long-term effects of a ketogenic diet high in unsaturated fat with a high-carbohydrate, low-fat diet on obese adults with T2DM. Results indicated that weight loss and reductions in HbA1c were similar among both groups after 52-weeks of dietary intervention. However, significantly greater improvements in serum
triglycerides, HDL cholesterol and blood glucose stability, as well as a greater mean reduction in diabetes medication use were achieved in the ketogenic diet group.

Hallberg et al. (2018) recently published the first year of findings from an ongoing trial that is investigating the effectiveness and safety of a ketogenic diet for the treatment of T2DM. These researchers reported significant benefit and no serious adverse effects related to the ketogenic diet. Most importantly, results indicated a drastic decline in the use of T2DM prescription medications, other than Metformin, among study participants after 1 year of intervention. Among those prescribed exogenous insulin, 40% discontinued insulin therapy and 60% reduced their daily dosage of insulin from 105 units per day to 54 units per day on average. Additionally, the use of Sulfonylureas was completely eliminated among those in the ketogenic treatment group.

Lastly, in addition to producing weight loss and superior glycemic control with less prescription medication use, Volek, Sharman, & Forsythe (2005) have reported that the ketogenic diet improves the lipoprotein profile, a risk factor for cardiovascular disease, independent of weight loss. Recent evidence suggests that HDL cholesterol and triglycerides (TG) are also very important cardiovascular risk factors to consider, especially for individuals with T2DM. Carbohydrate restricted diets have been shown in numerous clinical studies to effectively reduce triglyceride levels while increasing HDL cholesterol, and therefore lowering the HDL/TG ratio (Hu et al., 2012; Foster et al., 2013; Bueno et al., 2013).

Despite the body of evidence suggesting that a ketogenic diet (i.e., any diet that results in nutritional ketosis) is at least as effective, if not more effective, than a conventional low-fat, moderate carbohydrate diet for the treatment of T2DM, as well as for reducing weight, achieving glycemic control, reducing or eliminating prescription medication use, and improving the
lipoprotein profile among individuals with T2DM (Goday et al., 2016; Houssain et al., 2012; Westman et al., 2008; Tay et al., 2015; Hallberg et al., 2018; Volek, Sharman, & Forsythe, 2005), carbohydrate recommendations for this population remain controversial among registered dietitians (McArdle, Greenfield, Avery, Adams & Gill, 2016). An extensive review of the literature found no previous studies that have investigated the commonly recommended macronutrient ratio by registered dietitians for the treatment of T2DM. For this reason, investigating the macronutrient ratios being prescribed by registered dietitians for T2DM treatment, as well as their attitudes, beliefs and current practices regarding recommending a diet that results in nutritional ketosis for the treatment and management of T2DM, was warranted.

**Problem Statement**

Diabetes is a significant contributor to morbidity and mortality, leading to rapidly increasing healthcare costs (American Diabetes Association, 2017). The estimated global prevalence of diabetes has risen from 108 million in 1980 to 422 million in 2014 (Zhou et al., 2016). Medical nutrition therapy (MNT) provided by registered dietitians is crucial for the effective management of T2DM (Morris & Wylie-Rosett, 2010). Medical nutrition therapy treatment goals for T2DM focus on achieving and maintaining a healthy body weight, stabilizing blood glucose and reducing HbA1c values, while avoiding episodes of hyperglycemia or hypoglycemia (Chamberlain et al., 2016). The American Diabetes Association no longer promotes a specific diet for the treatment of T2DM, and now asserts that many dietary patterns, including a low-carbohydrate or very-low-carbohydrate diet, may be successful in the treatment of T2DM (Evert et al., 2019). The lack of specific MNT guidelines for the treatment of T2DM make it reliant upon the dietitian to use evidence-based practice when providing nutrition
prescriptions (Franz et al., 2017). Evidence suggests that a ketogenic diet improves weight, glycemic control, and HbA1c values, which are the very outcomes targeted by diabetes MNT (Goday et al., 2016; Saslow et al., 2017). However, it is unknown how many registered dietitians choose to use this high-fat, low-carbohydrate approach to treat patients with type 2 diabetes. Due to the lack of research in this area, this study investigated the attitudes, beliefs, and practices of registered dietitians regarding dietary treatments for type 2 diabetes mellitus.

**Purpose**

The purpose of this study was to examine the attitudes, beliefs, and practices of registered dietitians who are members of the Indiana Academy of Nutrition and Dietetics regarding dietary treatment recommendations for type 2 diabetes mellitus (T2DM).

**Research Questions**

The following research questions will be examined in this study:

RQ#1. What method(s) do registered dietitians recommend to help clients with T2DM manage their blood glucose levels?

RQ#2. What macronutrient distributions do registered dietitians recommend for the dietary management of T2DM?

RQ#3. What macronutrient distributions do registered dietitians associate with nutritional ketosis?

RQ#4. What are the attitudes of registered dietitians toward recommending a diet that results in nutritional ketosis to treat T2DM?
RQ#5. What are the beliefs of registered dietitians about recommending a diet that results in nutritional ketosis to treat T2DM?

RQ#6. What concerns prevent registered dietitians from recommending a diet that results in nutritional ketosis to treat T2DM?

RQ#7. Are there differences in attitudes, beliefs or practices among registered dietitians regarding recommending a diet that results in nutrition ketosis to treat T2DM based on the following respondent characteristics?
   a) Level of education.
   b) Frequency of counseling clients with T2DM.

**Rationale**

The registered dietitian plays an important role in providing dietary advice to help patients with diabetes maintain a healthy body weight and achieve tight glycemic control. Research indicates that a ketogenic diet is as effective as-- or more effective than -- a traditional moderate-carbohydrate, low-fat diet for the treatment of T2DM (Tay et al., 2015; Saslow et al., 2017). Because registered dietitians are the foremost experts on nutrition who must use evidence-based practice guidelines and clinical judgment when selecting a dietary strategy for disease management, it is crucial that they are aware of current research regarding all effective dietary treatments for T2DM. Presently, there is a lack of research indicating the beliefs and attitudes of RDs about the efficacy and safety of nutritional ketosis for the treatment of T2DM, or how many dietitians choose to recommend this dietary pattern. For this reason, this study investigating the macronutrient recommendations of registered dietitians for the treatment of T2DM, as well as their attitudes, beliefs, and current practices regarding nutritional ketosis, was warranted.
Assumptions

The researcher makes the following assumptions in the implementation of the study and in the interpretation of the data:

1. The instrument used to collect this data is valid and reliable.
2. The data gathered is an appropriate measure of attitudes, beliefs and current practices of registered dietitians.
3. The respondents to the survey provided answers that were truthful.
4. The results from this study can be generalized to dietitians who practice outside of the state of Indiana.

Definitions

For the purpose of this study, the following definitions will be used:

1. Diabetes Mellitus (DM): Diabetes Mellitus refers to a metabolic disorder characterized by hyperglycemia caused by faulty insulin secretion, faulty insulin action or both (Goldenberg & Punthakee, 2013).

2. Type 2 Diabetes (T2DM): The classification of T2DM may range from predominantly an issue of insulin resistance with little insulin deficiency to a predominant defect in insulin secretion with concurrent insulin resistance (Goldenberg & Punthakee, 2013).

3. Ketogenic diet (KD): A diet comprised of 90% dietary energy from fat, also referred to as a 4:1 ratio Ketogenic diet. The 4:1 ratio refers to 4 grams of dietary fat for 1 combined gram of protein and carbohydrate in the diet (Academy of Nutrition and Dietetics Nutrition Care Manual, 2018).
4. **Registered Dietitian (RD):** A person who is trained in the science of nutrition and dietetics who has successfully completed the registration examination for dietitians and remitted the annual registration fee (Academy of Nutrition and Dietetics, 2017).

5. **Medical nutrition therapy (MNT):** Nutritional diagnostic, therapy and counseling services for the purpose of disease management which is furnished by a registered dietitian or nutrition professional (Academy of Nutrition and Dietetics, 2006).

6. **Hemoglobin A1c (HbA1c):** A measure of glycated hemoglobin in the blood which indicates blood glucose values over a 3-month period (National Institute of Diabetes and Digestive and Kidney Diseases, 2018).

7. **Blood glucose (BG):** A measure of glucose in the blood (mg/dL), also called blood sugar (American Diabetes Association, 2018).

8. **Evidence-based practice guidelines:** Practice guidelines based on evidence or expert consensus (Academy of Nutrition and Dietetics, 2017).

9. **Nutritional ketosis:** Nutritional ketosis refers to a physiological state, induced by the consumption of a very-low carbohydrate (typically less than 50grams/day), moderate protein (commonly 1.5g/kg ideal body weight), high-fat diet, which leads to a therapeutic range of circulating ketone bodies. Nutritional ketosis is confirmed through urine measurements of acetoacetate or blood measurements of beta-hydroxybutyrate, which is considered optimal when in the range of 0.5-3 Mmol/L (Miller, Villamena & Volek, 2018).
Summary

The prevalence of T2DM is increasing, both in the United States and throughout the world. Medical nutrition therapy provided by a registered dietitian is key for the prevention and treatment of T2DM. The goal of medical nutrition therapy for the treatment of T2DM is to achieve a healthy body weight, reduce HbA1c and improve glycemic control. Several eating patterns with varying macronutrient compositions may be effective in achieving this goal. For this reason, registered dietitians must use evidence-based practice guidelines to determine which diet will be the most effective in producing these results for each individual patient. However, with T2DM steadily on the rise, there is reason to question the efficacy of current diet recommendations for the prevention and treatment of T2DM. Recent evidence suggests that ketogenic diets readily produce weight loss and improve blood glucose control while reducing the need for T2DM prescription medications. Because the popular use of ketogenic diets as nutrition therapy began with the treatment of neurological conditions such as epilepsy, not T2DM, the number of registered dietitians in the U.S. who utilize this dietary strategy to treat patients with T2DM remains unknown. This study sheds light on the attitudes, beliefs and current practices of registered dietitians concerning the use of a ketogenic diet for the treatment of T2DM.
CHAPTER 2

REVIEW OF LITERATURE

The purpose of this study was to examine the attitudes, beliefs, and practices of registered dietitians who are members of the Indiana Academy of Nutrition and Dietetics regarding dietary treatments for type 2 diabetes mellitus (T2DM). This chapter will present a review of the literature that defines T2DM, describes current medical nutrition therapy recommendations for T2DM, reviews the history and current uses of the ketogenic diet, and defines the role of a registered dietitian in the treatment and prevention of T2DM.

Diabetes

Definition and Types of Diabetes

Diabetes Mellitus (DM) refers to a set of metabolic disorders characterized by hyperglycemia caused by faulty insulin secretion, faulty insulin action or both (Goldenberg & Punthakee, 2013). There are at least 3 distinct classifications of diabetes, including Type 1 diabetes mellitus (T1DM), Type 2 diabetes mellitus (T2DM) and gestational diabetes mellitus (GDM). Type 1 diabetes mellitus refers to a condition caused by the destruction of pancreatic beta cells, most often due to autoimmune dysfunction, although there are cases in which the etiology of the beta cell destruction remains unknown (Skyler et al., 2017). The classification of T2DM ranges from issues of insulin resistance with little insulin deficiency to a defect in insulin
secretion with concurrent insulin resistance. In contrast, gestational diabetes refers to glucose intolerance which first appears or is recognized during pregnancy (Goldenberg & Punthakee, 2013). Chronic hyperglycemia, associated with all classifications of diabetes, can lead to specific long-term microvascular complications effecting the kidneys, eyes, and nerves while also increasing the risk of cardiovascular disease (Skyler et al., 2017). Understanding the classifications of diabetes is important to determine the most appropriate therapy.

**Diagnosis of Diabetes**

The diagnosis of diabetes can be made using plasma glucose criteria based on one of these three methods: 1) a fasting plasma glucose (FPG) value, 2) a 2-hour plasma glucose (2-h PG) value during a 75g oral glucose tolerance test (OGTT), or 3) via HbA1c criteria (American Diabetes Association, 2018). Typically, the FPG, 2-h PG during 75g OGTT or HbA1c are equally appropriate diagnostic criteria for diabetes, though the 2-h PG during 75g OGTT is said to more frequently diagnose people with diabetes (American Diabetes Association, 2018). A fasting (defined as no caloric intake for more than 8 hours) plasma glucose value of 126mg/dL (7.0 mmol/L) or higher, a 2-h PG during 75g OGTT value of 200 mg/dL (11.1 mmol/L) or higher, or a HbA1c value of 6.5% (48 mmol/mol) or higher is indicative of diabetes. In the absence of obvious hyperglycemic symptoms, results should be confirmed by repeat testing (American Diabetes Association, 2018).

**Etiology of Diabetes**

In both T1DM and T2DM, a combination of genetic and environmental factors leads to a decrease in pancreatic beta cell mass and/or function leading to the clinical manifestation of
hyperglycemia (American Diabetes Association, 2018). The pathogenesis of T2DM primarily begins with the insufficiency of pancreatic beta islet cells to respond to a chronic fuel surplus, leading to insulin resistance and obesity (Pandey et al., 2015). Characterization of the underlying pathophysiology of diabetes is more developed in T1DM than in T2DM, and it is now clear that the persistent presence of two or more autoantibodies is an almost certain predictor of clinical hyperglycemia and T1DM (American Diabetes Association, 2018). Individuals with T1DM (previously called “juvenile onset diabetes”) require daily insulin injections to regulate blood glucose in the absence of an endogenous insulin supply.

Type 2 diabetes, previously referred to as “non-insulin dependent” or “adult-onset” diabetes, is a heterogeneous disorder caused by a combination of genetic factors related to insulin resistance, impaired insulin secretion and environmental factors such as obesity, lack of exercise, stress and aging (Ozougwu, Obima, Belonwu & Unakalamba, 2013). The specific etiology of T2DM is unknown, but it is characterized by the presence of insulin resistance as well as disruption in functional beta-cell insulin signaling. Genetic predisposition and environmental factors are believed to play important roles in the development of the disease (Alonso-Magdalena, Quesada, & Nadal, 2011). Most, but not all, people with T2DM are obese or overweight (American Diabetes Association, 2018).

Symptoms of undiagnosed T1DM and T2DM include increased urination, thirst and hunger, fatigue, blurred vision or weight loss despite increased food intake (American Diabetes Association, 2018). Clinical manifestations of T1DM and T2DM have some similarities but diabetic ketoacidosis, defined as hyperglycemia in the presence of elevated blood ketones, is a common condition seen in the presentation of T1DM that is rare in T2DM. Type 2 diabetes may remain undiagnosed for several years because hyperglycemia occurs gradually and during the
initial stage may not present the classic diabetes symptoms (American Diabetes Association, 2018).

**Prevalence of Diabetes**

Diabetes is a significant contributor to morbidity, mortality and healthcare costs throughout the world. The estimated global prevalence of diabetes was 422 million in 2014, four times higher than the 108 million individuals affected in 1980. From 1980 to 2014, the world-wide prevalence of diabetes increased from 4.3% to 9.0% among men and rose from 5.0% to 7.9% among women (Zhou et al., 2016). Currently, T1DM accounts for an estimated 5.8% of all the cases of diabetes in the United States, with T2DM accounting for 90.8%. The remaining 3.3% of cases were other types of diabetes, including gestational diabetes (Bullard et al., 2018). It is estimated that in the United States, diabetes (both type 1 and type 2) prevalence will increase by 54%, affecting more than 54.9 million Americans between 2015 and 2030. Diabetes attributed deaths are expected to climb by 38% annually to 385,800 with total medical and societal costs increasing 53% to $622 billion by 2030 (Rowley et al. 2017).

The prevalence of obesity, which is strongly associated with the development of T2DM, was estimated to be 39.8% among adults, and 18.5% among adolescents, in the United States in 2016 (Hales et al., 2017). The prevalence of obesity among Hispanic (47.0%) and non-Hispanic black (46.8%) adults in the United States was higher than in non-Hispanic white (37.9%) adults. Middle aged Americans between 40 and 59 years of age had the highest prevalence of obesity at 42.8%. From 1999-2000 through 2015-2016 the prevalence of obesity among American adults rose from 30.5% to 39.8%, and from 13.9% to 18.5% among American children (Hales et al., 2017).
**Summary**

In summary, the three distinct types of diabetes include type 1 diabetes, type 2 diabetes and gestational diabetes. Type 1 diabetes, caused by autoimmune mediated destruction of insulin secreting pancreatic beta islet cells, accounts for about 5% of diabetes cases in the United States. Gestational diabetes refers to hyperglycemia which presents or is first diagnosed during pregnancy. Type 2 diabetes, accounting for more than 90% of all diabetes cases in the United States, is largely preventable and strongly linked to obesity and lifestyle factors. All types of diabetes are on the rise, in the United States and across the world. Modifiable lifestyle factors such as diet and exercise play a large role in the development and progression of T2DM.

**The Ketogenic Diet**

**History**

The therapeutic history of ketogenic diets, in our modern age, began as a treatment for epilepsy. Before the use of the ketogenic diet to treat epilepsy, it was reported that periods of starvation or fasting could reduce the frequency and severity of epileptic seizures (Wheless, 2008). According to Gano, Patel & Rho (2014), in 1921, Dr. R. T. Woodyatt at Rush Medical College discovered that during periods of fasting, the liver produces ketone bodies (acetoacetate, acetone and beta-hydroxybutyrate). The term “ketogenic diet” was first used in 1922 by Dr. Wilder, a physician at the Mayo Clinic, who coined the term while working with diabetic patients. Dr. Wilder suggested that a diet comprised of less than 60g of carbohydrate per day should ensure that all dietary carbohydrate would be metabolized and ketogenesis achieved (Wilder & Winter, 1922). Subsequent studies indicated a ketogenic diet was able to successfully control epileptic seizures (Peterman., 1924; Peterman, 1925; Talbot, Metcalf & Moriarty, 1926).
Consequently, the ketogenic diet became popular for the treatment of epilepsy in the early half of the 20th century (Barborka et al., 1928; Lennox & Cobb, 1928).

The therapeutic use of the ketogenic diet decreased greatly with the advent of new pharmaceutical treatments for epilepsy (Wheless, 2008). Interest in the diet gained popularity again in the 1990s when pharmaceutical treatments failed to work for certain types of epilepsy and often caused severe side effects. Kinsman et al. (1992) were among the first to reevaluate the efficacy and tolerability of the ketogenic diet for epileptic patients. These authors found that seizure control improved in 75% of epileptic patients treated with the ketogenic diet for 18 months (Kinsman et al., 1992). The ketogenic diet was further popularized for the treatment of epileptic seizures after the creation of the Charlie Foundation, named for a 2-year-old boy with intractable epilepsy who was successfully treated with the ketogenic diet. Charlie’s father directed a film titled “Do No Harm” in 1997 which aired on national television, bringing more attention to the ketogenic diet (Wheless, 2008).

Nutritional Ketosis Definition and Biochemistry

In a fed state, the human brain is reliant on glucose as a fuel source, but in times of fasting, or when glycogen stores have been depleted, fatty acids from lipid stores are used to create ketone bodies which can sustain the brain (Stubbs et al., 2017). When dietary carbohydrate availability is low, insulin secretion is stabilized at lower levels, leading to an increased release of the counter regulatory hormone glucagon. Glucagon stimulates lipolysis to liberate fatty acids from stored adipose tissue. Those free fatty acids then undergo beta-oxidation in the hepatic mitochondria, resulting in the production of ketone bodies and Acetyl CoA. Acetyl CoA can act as an intermediate in the citric acid cycle creating the molecules need to generate
ATP via oxidative phosphorylation (Gershuni, Yan & Medici, 2018). Ketone bodies are formed through a metabolic pathway called hepatic ketogenesis, which results in the creation of acetone, acetoacetate and beta-hydroxybutyrate (Dhillon & Gupta, 2019). Each ketone body can result in the creation of 22 ATP molecules under normal metabolic circumstances, making them a valuable fuel source. Ketone bodies are interwoven with several crucial metabolic pathways including fat beta-oxidation, tricarboxylic acid cycle (TCA), gluconeogenesis and the biosynthesis of sterols (Puchalska & Crawford, 2017).

The healthy human body is continually producing small amounts of ketone bodies as a fuel source, and blood concentrations of ketones increase during even short durations of fasting, such as overnight while sleeping (Dhillon & Gupta, 2019). Glycogen depletion occurs and ketone production increases as a result of fasting, low-carbohydrate availability, sessions of intense or prolonged exercise, or due to a complete lack of insulin as seen in untreated type 1 diabetes (Gershuni, Yan & Medici, 2018).

Ketone bodies can be measured in the urine (acetoacetate) or in the blood (beta-hydroxybutyrate) and are typically less than 0.3mM in someone consuming a standard diet. Nutritional Ketosis is known as the intentional restriction of carbohydrate intake using a “well formulated” ketogenic diet in order to increase the production and concentration of circulating ketone bodies (Gershuni, Yan & Medici, 2018). Nutritional ketosis has been defined as blood concentrations of beta-hydroxybutyrate ranging from 0.5mM-3mM (Miller, Vollamena & Volek, 2018). It should be noted that the typical concentration of ketone bodies resulting from a ketogenic diet is lower than the range commonly seen in times of prolonged fasting (5-10mM) and well below those experienced during diabetic ketoacidosis (>25mM) (Paoli, Rubini, Volek & Grimaldi, 2013).
Ketogenic Diet Definition and Composition

Ketogenic diet (KD) is a term referring to any diet therapy that results in a metabolic state of ketosis. (Roehl & Sewak, 2017). Though several variations exist, KDs are generally high-fat, low-carbohydrate, moderate-protein diets which consequently lead to a switch from “glucocentric” to “adipocentric” metabolism, where lipids (dietary fat or stored adipose tissue) are used as the primary fuel source (Westman et al., 2008). The Academy of Nutrition and Dietetics Nutrition Care Manual defines the classic KD as a diet comprised of roughly 90% of dietary energy from fat (NCM, 2018). The classic KD offers the highest ketogenic potential but is the most restrictive form of the diet requiring precise monitoring and weighing of all food intake. Classic KDs are most commonly prescribed in a 4:1 or 3:1 ratio, referring to 3-4 grams of fat for every combined gram of carbohydrate and protein (Roehl & Sewak, 2017). The initiation of a classic KD, especially for children, requires a three to four-day hospitalization where a patient will enter ketosis gradually under supervised fasting conditions (NCM, 2018). The classic KD has the longest history in the treatment of epilepsy, but in addition to the need for supervised initiation of the diet, adherence is low for some patients due to the palatability and affordability of such a high-fat diet (Satte et al., 2017).

Several modified versions of the KD have been developed and tested for epilepsy treatment in recent years due to concerns regarding the protein restriction associated with the classic version as well as the tolerability of such a high-fat diet (Wirrell, 2008). Liberalized ketogenic diets used in the treatment of epilepsy include the 3:1 and 2:1 ratio modified versions of the classic diet, the medium chain triglyceride (MCT) diet, low-glycemic index treatment (LGIT) and modified Atkins diet (MAD). The MCT diet, MAD diet and LGIT
are less restrictive than classic versions of the diet and are commonly prescribed in a 1:1 ratio, allowing for a larger intake of calories from protein and carbohydrate (Roehl & Sewak, 2017). According to Miranda, et al. (2011), the key advantage to a more liberalized KD is that they can be initiated by the patient at home without the need for supervised fasting. Additionally, modified KDs have been found to effectively reduce seizure severity and frequency and improve quality of life among adults with drug-resistant epilepsy (Roehl, Falco-Walter, Ouyang, & Balabanov, 2019).

Additional Therapeutic Uses of Low-Carbohydrate Diets

Ketogenic diets have been extensively studied in the recent past for their possible therapeutic role in numerous conditions including obesity, diabetes, cardiovascular disease, cancer, polycystic ovarian syndrome (PCOS), acne and numerous neurological diseases including Alzheimer’s Disease, Amyotrophic Lateral Sclerosis, and Parkinson’s Disease (Paoli et al., 2013). It has been suggested that ketogenic diets induce a unique metabolic state that positively effects several conditions including the metabolic syndrome and dyslipidemia (Volek, Fernandez, Feinman & Phinney, 2008).

According to Gupta et al. (2017), KDs are beneficial for the treatment of metabolic conditions involving insulin resistance such as T2DM, PCOS, and metabolic syndrome due to the glucose and insulin lowering effects of the diet, which overtime can improve insulin sensitivity and restore normal endocrine function. Obesity is often closely linked to the above-mentioned endocrine disorders, and there is strong evidence supporting the use of very-low-carbohydrate diets for the long-term treatment of obesity (Bueno, Viera de Melo, Lima de Olivera, & Ataide, 2013). However, there is still significant debate concerning the mechanisms
leading to weight loss during ketosis. According to Paoli (2014), at least 4 distinct hypotheses attempt to explain the mechanism behind the KD weight loss effects. These include 1.) Reduced hunger due to the higher satiety effect of protein foods, or possibly an appetite suppressing effect of ketone bodies themselves, 2.) A reduction in lipogenesis and increase in lipolysis, 3.) Greater metabolic efficiency associated with consuming fats distinguished by a reduced respiratory quotient, or 4.) Increased metabolic cost of gluconeogenesis and the thermic effect of proteins.

Additionally, many new lines of research are exploring the use of ketogenic diet therapy for the treatment of cancer, neurological conditions and cognitive impairment. A small trial indicated that older adults with mild cognitive impairment experienced improvements in verbal memory performance due to a ketogenic diet, while also pointing to a correlation between blood ketone levels and memory enhancement (Krikorien et al., 2012). Furthermore, preliminary evidence suggests that KDs might play a role in the recovery of traumatic brain injuries. Animal research indicates that ketones may be the preferred fuel source of the brain after trauma. In rodent trials, KDs led to reduced cerebral edema, and apoptosis while improving cerebral metabolism and behavior of male rats with traumatic brain injury (McDougal, Bayley, & Munce, 2018).

Summary

Ketogenic diets have been used since the early 1920s to treat epilepsy but lost favor to emerging pharmaceutical treatments in the later decades of the 20th century. This dietary therapy gained favor again in the late 1990s as a treatment for patients who do not achieve seizure control using medication. There are several versions of the KD, including those with 4:1, 3:1, 2:1 or 1:1 ratios of fat to protein + carbohydrate. More liberalized versions of the diet, which
include the MAD, MCT and LGIT diet are less restrictive than the classic KD and typically prescribed at a 1:1 ratio. New research is emerging exploring the use of very-low-carbohydrate diets in the treatment of numerous conditions including obesity, diabetes and several neurological conditions.

**Use of the Ketogenic Diet to Treat Type 2 Diabetes**

**Weight Loss**

According to the American Diabetes Association (2016), there is strong evidence to suggest that obesity management can delay or prevent the progression of prediabetes to T2DM, and can be beneficial in the treatment of T2DM. Calorie restricted ketogenic diets have been shown to be as effective as, or more effective than traditional calorie-restricted diets for achieving weight loss among adults with T2DM. Goday et al. (2016) compared the safety and efficacy of a very-low-calorie ketogenic diet (600-800 kcal, < 50g carbohydrate/day) to a standard low-calorie (500-1000 kcal reduction based on kcal needs, <30% kcal from fat, 10-20% from protein and 45%-60% from carbohydrate) diet for 89 adults with T2DM. In this prospective, open-label, multi-centric, randomized clinical trial, participants were randomized to the very-low-calorie ketogenic diet group or the low-calorie diet group for 4 months. Each group was provided lifestyle and behavioral modification support from a registered dietitian. At the duration of the study, more than 85% of those who followed a very-low-calorie ketogenic diet lost more than 10% of their initial body weight (-14.7 kg average loss, p<0.001) compared to only 16% of individuals who lost >10% body weight (-5.05kg average loss, p= 0.596) following the standard low-calorie diet. Additionally, fasting plasma glucose levels were significantly reduced among the very-low-calorie ketogenic diet group (-26 mg/dL average reduction,
p<0.001), but not among the standard low-calorie group (-17.2 mg/dL average reduction, 
p=0.1821). Additionally, HbA1c levels were significantly reduced in the very-low-calorie 
ketogenic diet group (-0.9% average reduction, p<0.001), but not in the standard low-calorie 
group (-0.4% average reduction, p=0.1453). Both groups experienced significant reductions in 
insulin resistance as measured by HOMA index, though the very-low-calorie ketogenic diet 
group experienced more significant reductions (-3.4 average reduction, p< 0.0001) than the 
standard low-calorie group (-1.2 average reduction, p<0.0010). Finally, no significant differences 
were found in laboratory safety parameters between diet groups. This trial indicates the safety 
and efficacy of ketogenic diets for the treatment of obesity.

A non-randomized trial conducted by Houssain et al. (2012) compared the effect of a 
low-calorie diet to that of a ketogenic diet among 363 overweight and obese diabetic or pre-
diabetic adults. The participants were provided detailed information and instruction on each diet 
and were then asked to select a diet intervention method of their choice. The low-calorie group 
was instructed on dietary guidelines and given a sample 2,200 calorie menu. The ketogenic 
group was instructed to eat no more than 20 grams of carbohydrate per day and was given a list 
of “encouraged” and “discouraged” foods. At the completion of the 24-week trial, significantly 
greater weight loss was seen in diabetic and pre-diabetic individuals in the ketogenic group, 
compared to diabetic and pre-diabetic individuals in the low-calorie group. Among diabetic 
participants, those in the low-calorie group lost an average of 6.7 kg or 7% (p<0.0001) of their 
total body weight, compared to an average loss of 12.5 kg or 12% (p<0.0001) of total body 
weight in the ketogenic diet group. Similar weight reductions were seen in the pre-diabetic 
individuals in the ketogenic diet group. The average weight loss among pre-diabetics in the low-
calorie group was 4.6 kg or 5.1% of body weight (p<0.0001), compared to 11.8 kg or 12.4% of total body weight (p<0.0001) lost on average among the pre-diabetic ketogenic diet group.

Bueno et al. (2013) conducted a systematic review and meta-analysis of 13 randomized control trials evaluating the effectiveness of low-fat (LF) and very-low-carbohydrate ketogenic (VLCK) diets for long-term weight loss. Trials included in this meta-analysis were those with a duration of at least 12 months, including participants at least 18 years or older with a BMI greater than 27.5 kg/m² who were randomized to either a LF (energy restricted diets with <30% calories from fat), or VLCK (<50g of carbohydrate/day) diet. The primary outcome of this meta-analysis was body weight. The results of this analysis indicated that the VLCK diet group (n=790) achieved significantly greater reductions in body weight (-1.65kg, p=0.02) than the LF (n=787) diet group (-0.17 kg, p=0.47), with a weighted mean difference of -0.90kg. These results support the use of a ketogenic diet for long-term weight loss.

A randomized control trial conducted by Westman et al. (2008) examined the effects of a ketogenic diet compared to those of a low-glycemic index diet among 50 individuals with type 2 diabetes. Participants randomized to the ketogenic diet group were given a diet book and educational handouts and were instructed by a registered dietitian to restrict their carbohydrate intake to no more than 20 grams per day; no explicit calorie goals were given. Those randomized to the low-glycemic index diet group were also given literature on the diet and were instructed by a registered dietitian to follow a calorie reduced, low-glycemic index diet consisting of approximately 55% of energy from carbohydrate. Each participant was given an individualized calorie goal of 500 kcal less than calculated weight maintenance requirements. All participants were given physical activity recommendations, kept food logs, and attended group meetings once a week for the first 3 months of treatment, and then every other week for the last 3 months of
treatment. After 24 weeks of intervention, although both groups lost weight, those in the ketogenic diet group lost almost twice as much weight as those in the reduced calorie, low-glycemic index group, with the ketogenic group losing an average of 11.1 kg (p<0.05) of body weight compared to a loss of 6.9 kg (p<0.05) among those in the low-glycemic index group. In addition to producing more significant weight loss, the ketogenic diet group experienced greater mean improvements in glycemic control and several metabolic syndrome markers, including waist circumference (-5.3 inches, p<0.05), fasting glucose (-19.9mg/dL, p<0.05), HbA1c (-1.5%, p<0.05), systolic (-16.6 mmHg, p<0.05) and diastolic blood pressure (-8.1 mmHg, p<0.05).

Additionally, 95.2% (p<0.01) of those in the ketogenic diet group reduced or eliminated the need for glucose lowering prescription medications, including insulin, compared to 62.1% of those in the low-glycemic index diet who were able to reduce or eliminate the need for prescription diabetes medications.

Blood Glucose Control and HbA1c Reduction with the Ketogenic Diet

In addition to producing equal or greater weight loss when compared to standard calorie reduced diets that derive approximately 50% of energy from carbohydrates, the ketogenic diet has been shown to produce greater reductions in HbA1c values and the need for oral glucose-lowering medications. In a 12-month randomized control trial, Saslow et al. (2017) investigated the effectiveness of a very-low-carbohydrate ketogenic diet (VLCK) compared to a moderate-carbohydrate, low-fat, energy restricted (MCLF) diet for reducing HbA1c and fasting insulin among 34 individuals with T2DM or prediabetes. Participants randomized to the VLCK diet group were instructed to eat an ad libitum diet containing no more than 50g carbohydrate/day, while the MCLF diet group was instructed to reduce their fat intake and total energy intake (500...
kcal reduction per day) and maintain a diet comprised of 45-50% kcal from carbohydrates. After 12 months of dietary intervention, the VLCK diet group reduced their HbA1c significantly, while the MCLF group did not (VLCK: -0.5% from baseline to 12 months; MCLF: -0.2% from baseline to 12 months, p=0.07). The VLCK group achieved a greater reduction in body weight (VLCK: -7.9kg between baseline and 12 months; MCLF: -1.7 kg from baseline and 12 months, p<0.001) and BMI (VLCK: -2.6 kg/m^2 between baseline and 12 months; MCLF: -0.9 kg/m^2 between baseline and 12 months, p<0.001 between group comparison) compared to the MCLF group. Though no significant change in fasting insulin value was observed in either group, all participants assigned to the ketogenic group who received diabetes medication (6/6) were able to discontinue the use of these drugs at the conclusion of this study. Of the 4 participants receiving diabetes medications in the moderate carbohydrate diet group, none were able to discontinue the use of their medications.

In a pilot feasibility study, Saslow et al. (2017) compared a ketogenic diet to the American Diabetes Association’s “create your plate” diet plan for weight loss and glycemic control among overweight adults with T2DM. In this 32-week online intervention, 25 participants were randomized to the ketogenic diet group or the plate method group. Each group received online diet and lifestyle modification lessons based on the dietary treatment group assignment. The ketogenic diet group was encouraged to eat an ad libitum diet containing no more than 50 g of carbohydrate per day, while the plate method group was encouraged to follow a low-fat diet emphasizing an increase in leafy greens and lean protein while reducing sweet and starchy foods. The “create your plate” lesson plans taught participants about filling half of a 9-inch plate with non-starchy vegetables, one quarter of the plate with lean protein and 1 quarter of the plate with carbohydrates. At the end of the 32-week intervention, the ketogenic diet group
lost significantly more weight than plate method group (ketogenic group: -12.0 kg; plate method group: -3.0 kg, p<0.001). Additionally, significantly greater reductions in HbA1c were seen in the ketogenic diet group at 32 weeks (ketogenic group: -0.8%; plate method: -0.3%, p =0.002), with more than half (55%) of participants in the ketogenic diet group reducing their HbA1c to <6.5% (cutoff for T2DM) at 32 weeks compared to 0% of the plate method participants (p=0.02).

A randomized control trial conducted by Tay et al. (2015) compared the long-term health effects of a very-low-carbohydrate, high unsaturated fat diet to an energy matched low-fat, high-carbohydrate diet among 115 obese adults with T2DM. Participants were block-randomized for age, sex, BMI and diabetes medication use before random assignment to either the low-carbohydrate or high-carbohydrate diet group. Each participant received an individualized diet plan with a moderate (30%) energy restriction for weight loss. The low-carbohydrate (LC) diet composition target was 14% kcal from carbohydrate (<50g/day), 28% kcal from protein and 58% kcal from fat (35% monounsaturated fat and 13% polyunsaturated fat). The high-carbohydrate (HC) diet composition target was 53% kcal from carbohydrate (emphasis on low–glycemic index foods), 17% kcal from protein, and 30% kcal from fat (15% monounsaturated fat and 9% polyunsaturated fat). Both diets limited saturated fat intake to <10% of total energy intake. After 52-weeks of treatment, no significant differences were seen in body weight reductions (LC: -9.8 kg; HC: -10.1 kg, p=0.18), HbA1c (LC: -1.0%; HC: -1.0%, p=0.65), fasting blood glucose (LC: -0.7 mmol/L; HC: -1.5 mmol/L, p=0.10), or LDL cholesterol (LC: -0.1 mmol/L; HC: -0.2 mmol/L, p=0.76) between groups. However, compared with the high-carbohydrate group, the low-carbohydrate group achieved significantly greater reductions in serum triglycerides (LC: -0.4 mmol/L; HC: -0.01 mmol/L, p=0.001) and increases in HDL (LC: 0.1 mmol/L; HC 0.06,
p=0.002) cholesterol. Additionally, the low-carbohydrate group achieved a greater reduction in the use of antiglycemic medications (LC: -0.5 arbitrary units; HC: -0.2 arbitrary units, p=0.02), as well as a reduction in glycemic variability, assessed by measuring the continuous overall net glycemic action, (LC: −0.5 mmol/L; HC diet: −0.05 mmol/L, p= 0.003) than did the high-carbohydrate group.

An open label, non-randomized, control trial conducted by Hallberg et al. (2018) investigated the long-term safety and efficacy of a ketogenic diet for the treatment of type 2 diabetes. A total of 249 adults with type 2 diabetes volunteered to participate in this study. Participants self-selected into either the continuous care intervention group (CCI; subjects followed a ketogenic diet) or the usual care (UC; subjects continued standard diabetes care and education provided by their primary physician) group. The intent of the study was to examine the effects of a new care model, including a ketogenic diet and continuous supervision provided by a health coach or doctor, via a telemedicine application, on markers of glycemic control. After 1 year of intervention, participants in the CCI (ketogenic diet) group experienced a significant decrease in HbA1c (CCI: -1.3% , p < 0.001; UC: 0.20%, p=0.21), fasting glucose (CCI:-1.96mmol/L, p<0.001; UC: 0.59mmol/L, p=0.28), total body weight (CCI: -14.24 kg, p < 0.001; UC:0.04 kg, p=0.95), and plasma triglycerides (CCI: -0.56 mmol/L, p < 0.001; UC:0.34, p=0.22) compared to the usual care group. Additionally, the intervention group experienced a significant increase in HDL cholesterol (CCI: 0.20 mmol/L, p < 0.001; UC: -0.04, p=0.15) and LDL cholesterol (CCI: 0.28 mmol/L, p=7.7, UC: -0.28 mmol/L p= 0.05). Among the usual care group, no significant changes were noted in HbA1c, fasting insulin, or other markers of glycemic control after 1 year, despite a net increase in diabetes medication prescriptions. Among the CCI group, 69.8% achieved an HbA1c level less than 6.5% after 1 year of intervention. Of those
individuals, 42.3% were taking no medication, and 57.7% were taking Metformin alone, at the conclusion of the trial. Those in the CCI group achieved significant reductions in all prescribed diabetes medication except Metformin (56.9 ±3.1% to 29.7±3.0%, p < 0.001). Of those CCI participants who were taking prescribed insulin at the start of the intervention, 40% eliminated the need for insulin altogether, while the remaining 60% of insulin users saw a decreased in their mean insulin dosage by 51.4 units/day (p<0.001). In contrast, no significant reduction in prescription medications were noted in the usual care group. In addition, 34 of the individuals in the UC group who were prescribed insulin at the start of the usual care intervention increased their mean dosage by 15.9 units/day.

**Cardiovascular Concerns Associated with a Ketogenic Diet**

Because the ketogenic diet is very high in fat, there is a concern that following such a diet may increase one’s LDL cholesterol and one’s overall cardiovascular disease risk. As will be described below, recent evidence suggests that, in addition to the importance of LDL, one’s HDL cholesterol and triglycerides (TG) are very important cardiovascular risk factors that must be considered, especially for individuals with T2DM. Carbohydrate restricted diets have been shown to effectively reduce triglyceride levels while increasing HDL cholesterol, and therefore lowering the HDL/TG ratio.

As part of the Strong Heart Study (SHS), an ongoing prospective cohort study of American Indians from South Dakota, North Dakota, Oklahoma, and Arizona, 3,216 participants (42% with diabetes) were studied for a median follow-up of 17 years to evaluate the incidence of ischemic stroke and coronary heart disease in relationship to triglyceride and HDL cholesterol levels. This analysis indicated that individuals with high fasting triglyceride (≥ 150mg/dL) levels
and low fasting HDL (<40mg/dL for men, <50mg/dL for women) levels had a 1.32-fold greater hazard ratio (95% CI 1.06–1.64) for coronary heart disease than those with normal triglyceride and HDL levels. Additionally, it was observed in participants with diabetes who had high TG levels and low HDL levels had a 1.54-fold greater hazard ratio (95% CI 1.15–2.06) for coronary heart disease and a 2.13-fold greater hazard ratio (95% CI 1.06–4.29) for stroke (Lee et al., 2012) compared to those who did not have diabetes. These results provide additional support for the HDL cholesterol-raising and triglyceride-lowering effect of ketogenic diets.

A longitudinal study conducted by Vega, Barlow, Grundy, Leonard & Defina (2014) focused on evaluating survival analysis among 39,447 male participants grouped by TG/HDL ratio and by metabolic syndrome. The data for the survival analysis was collected between 1970 and 2008. Results indicated that a high TG/HDL ratio (≥ 3.5) was a strong independent predictor of coronary heart disease (hazard ratio: 1.92, 95% CI 1.64-2.25), cardiovascular disease (hazard ratio: 1.62, 95% CI 1.43-1.84), and all-cause mortality (hazard ratio: 1.36, 95% CI 1.26-1.47) before and after adjustment for age, smoking, BMI, or systolic blood pressure. These authors concluded that a high TG/HDL ratio was indicative of insulin resistance and metabolic syndrome.

A meta-analysis of randomized control trials conducted by Hu et al. (2012) investigated the effects of low-carbohydrate versus low-fat diets on metabolic risk factors. This analysis included 23 randomized control trials from multiple countries including a total of 2,788 participants. Low-carbohydrate diets contained from 4-45% of calories from carbohydrate (average of 23% calories from carbohydrate), and low-fat diets contained 10-30% of calories from fat (average of 26% of calories from fat). The results of this analysis indicated that, compared with participants on low-fat diets, those on low-carbohydrate diets experienced a
slight, but statistically significantly, reduction in total cholesterol (pooled mean net change, 2.7 mg/dL, 95% CI: 0.8, 4.6) and LDL cholesterol (pooled mean net change, 3.7 mg/dL, 95% CI: 1.0, 6.4), but a greater increase in HDL cholesterol (pooled mean net change, 3.3 mg/dL, 95% CI: 1.9, 4.7) and a greater decrease in triglycerides (pooled mean net change, −14.0 mg/dL, 95% CI: −19.4, −8.7). These differences remained statistically significant after correction for multiple comparisons. Both diets effectively lowered systolic and diastolic blood pressure, however, no significant differences were found in these reductions between the intervention groups. This study suggests that low-carbohydrate diets are at least as effective as low-fat diets at improving metabolic risk factors in obese individuals.

A 2-year randomized control trial conducted by Foster et al. (2013) investigated the effects of low-carbohydrate and low-fat diets, in combination with comprehensive lifestyle modifications, for weight loss effects and metabolic outcomes in 307 obese adults. Those randomized to the low-carbohydrate diet group (n=153) were instructed to consume <20 g carbohydrate for the first 12 weeks and then add 5g carbohydrate to their diet each week thereafter until goal weight was achieved. Those randomized to the low-fat diet group (n=154) were instructed to consume an energy restricted diet (1,200-1,500 kcal/day for women, 1,500-1,800 kcal/day for men) comprised of approximately 55% of calories from carbohydrate, 30% from fat, and 15% from protein. All participants received in-person group behavioral treatment weekly for 20 weeks, every other week for 20 weeks, and then every other month for the remainder of the 2-year study period. No statistical differences in weight were found between groups at any time period. No significant differences were found in total cholesterol, VLDL cholesterol, or LDL cholesterol at 24 months. Although the low-carbohydrate group experienced significantly greater reductions in triglycerides at 3 months (LC: -40.08mg/dL, LF: -17.99
mg/dL, p<0.001) 6 months (LC: -40.06 mg/dL, LF: -24.30, p<0.001) and 12 months (LC: -31.52 mg/dL, LF: -17.92 mg/dL, p=0.039), those changes were no longer significant at 24 months when carbohydrate intake was significantly increased during the “weight maintenance” phase. However, reductions in diastolic blood pressure were significantly greater in the low-carbohydrate group at 24 months (LC: -3.19 mmHg, LF: -0.50, p=0.016), compared to the low-fat group. Additionally, HDL cholesterol increased more significantly among the low-carbohydrate group (LC: 7.75 mmHg, LF: 4.64 mmHg, p=0.008) at 24 months.

A systematic review and meta-analysis by Bueno et al. (2013) analyzed 12 randomized control trials for differences in plasma triglyceride levels and HDL cholesterol levels between subjects consuming a very low carbohydrate diet (VLCK) and those consuming a low-fat (LF) diet. The VLCK diet group experienced greater reductions (-0.27 mmol/L, p<0.01) in triglycerides than those in the LF diet group (-0.08mmol/L, p=0.33) with a weighted mean difference of -0.18mmol/L. Subjects’ HDL cholesterol was significantly higher in the VLCK (0.12mmol/L, P<0.001) than the LF diet group (0.06, P=0.36), with a weighted mean difference of 0.09 mmol/L. The VLCK diet group also had a significant increase in LDL cholesterol (0.2 mmol/L, p<0.001) compared to the LF diet group (0.04, p=0.7), with a weighted mean difference of 0.12mmol/L. Finally, 11 studies compared systolic and diastolic blood pressure between VLCK and LF diet groups and indicated no significant differences in systolic blood pressure between groups. However, there was a significantly greater reduction in diastolic blood pressure among those in the VLCK (-2.49mmHg, p=0.008) compared to the LF (-0.37mmHg, p=0.41) diet group, with a weighted mean difference of -1.43 mmHg.

An expert review by Volek et al. (2005) described the effect of a very-low-carbohydrate, ketogenic diet on cardiovascular risk factors. The authors described that, while ketogenic diets
are not as effective at lowering LDL cholesterol, they offer a unique improvement the lipoprotein profile independent of weight loss. These authors summarized that very-low-carbohydrate diets consistently reduce triglycerides and increase HDL cholesterol while improving LDL-C distribution subfractions to a greater extent than low-fat diets. They concluded that very-low-carbohydrate diets are effective at increasing fat loss and improving metabolic syndrome and should be considered in the treatment of obesity related conditions.

Summary

Ketogenic diets have been extensively studied for the treatment of obesity and T2DM. Ketogenic diets of varying macronutrient composition have been proven effective in reducing weight, BMI, body fat and HbA1c. Several studies have indicated that a ketogenic diet results in greater reductions in HbA1c than low-calorie diets, moderate-carbohydrate diets, low-glycemic index diets, low-fat diets or the “create your plate” diet recommended by the American Diabetes Association. Ketogenic diets result in a greater reduction in diabetes medication use than other diets, even achieving T2DM remission in some trials. Additionally, ketogenic diets favorably modify cardiovascular risk factors by reducing blood pressure and serum triglycerides and increasing HDL cholesterol.

Role of the Registered Dietitian Nutritionist in the Treatment of Type 2 Diabetes

MNT for the Prevention and Management of Type 2 Diabetes

Medical nutrition therapy is the cornerstone of successful treatment of T2DM and plays a crucial role in weight loss and prevention of T2DM (Early & Stanley, 2018). Registered dietitians must provide individualized diet recommendations for the treatment of T2DM that are
tailored for a specific patient’s needs. The Academy of Nutrition and Dietetics nutrition practice guidelines for the treatment of T1DM and T2DM does not support the use of one specific diet for the treatment of diabetes, but state that an RD should use evidence-based practice to choose the most effective dietary strategy for each patient, keeping in mind preference and adherence, because a variety of eating patterns are effective in the management of diabetes (Franz et al., 2017).

Despite the diet therapy chosen, medical nutrition therapy provided by a registered dietitian is clearly more effective for reducing weight and reaching glycemic goals of individuals with T2DM than dietary advice provided by health care providers who are not nutrition experts. A systematic review and meta-analysis conducted by Moller, Andersen & Snorgaard (2017) compared the effectiveness of medical nutrition therapy provided by registered dietitians to that of dietary advice provided by other health care providers for the treatment of T2DM. These authors analyzed 5 randomized control trials, including 912 participants to evaluate if MNT provided by a registered dietitian led to greater reductions in BMI and HbA1c among individuals with T2DM when compared to dietary advice provided by other health care professionals. This analysis indicated that MNT provided by dietitians led to 0.45% (95% CI: 0.36- 0.53%) lower mean HbA1c in trials with a duration of 12 months or less. Body weight was 2.1 kg (95% CI: 1.2, 2.9 kg) lower, BMI was 0.55 kg/m² (95% CI: 0.02, 1.1) lower, and LDL cholesterol was 0.17 mmol/L (95% CI: 0.11, 0.23 mmol/L) lower in trials that provided MNT from an RD to their participants, compared to those who provided dietary advice from nurses or physicians.

A descriptive, retrospective chart review study conducted by Marinic et al. (2019) evaluated the effectiveness of nutrition intervention provided by a registered dietitian for glycemic control and diabetic dyslipidemia. Retrospective chart review was used to extract
outcome data from 4 ADA recognized diabetes education centers after the provision of diabetes self-management education (DSME) and medical nutrition therapy (MNT) provided by registered dietitians. The researchers included 392 charts in the analysis. Outcome measures included anthropometrics (weight and BMI), glycemic control, lipids and diabetes medication use. Significant reductions were observed in weight (-2.67±5.54 kg, p<0.001; -2.25±5.45 kg, p=0.001), BMI (-0.93±1.91, p<0.001; -0.76±1.93, p=0.001) and HbA1c (-1.82%±2.23%, p<0.001; -1.22%±2.15%, p<0.001) at the end of the program, and at 1 year, respectively. Significant reductions in triglycerides were observed from baseline (162±74 mg/dL) to follow-up (109±36 mg/dL) (P<0.001), HDL increased from baseline (45±13 mg/dL) to follow-up (48±11 mg/dL) (P=0.05), and the TG-to-HDL ratio improved from a baseline of 4.07±2.41 to 2.48±1.26 at follow-up (P<0.001). Subjects managed with diet plus drug therapy saw greater reductions in HbA1c from baseline than those managed with drug therapy alone; those managed with diet plus drug therapy had a baseline HbA1c of 9% and exhibited a 2.09% reduction in HbA1c (p<0.001).

Evidence Based Practice for Type 2 Diabetes MNT

The Academy of Nutrition and Dietetics defines evidence-based nutrition practice guidelines as a series of guiding statements and treatment algorithms designed to assist the RD in decision making about appropriate nutrition therapy for specific disease states or conditions (Academy of Nutrition and Dietetics, 2018). These evidence-based nutrition practice guidelines from the Academy are derived from systematic reviews completed by the Evidence Analysis Library. The Evidence Analysis Library concludes that there is no ideal macronutrient composition for the management of T1DM or T2DM in all people. It is suggested that dietary
macronutrient distribution be based on current dietary intake, preferences and metabolic goals (Academy of Nutrition and Dietetics Evidence Analysis Library, 2015).

A consensus report by Evert et al. (2019), recently published by the American Diabetes Association, reviews the evidence for MNT for adults with prediabetes and diabetes. The report indicates there is strong evidence to support the effectiveness of MNT interventions provided by RDs for improving A1C, with absolute decreases up to 2.0% (in type 2 diabetes) and up to 1.9% (in type 1 diabetes) at 3–6 months. This report mentions several effective dietary therapy strategies to be used in the treatment of prediabetes and T2DM, including very-low-carbohydrate, low-carbohydrate, very-low-fat, low-fat, vegetarian or vegan, Mediterranean, or DASH (dietary approaches to stop hypertension) diets. This report notes that very-low-carbohydrate diets are among the most studied diet for the treatment of T2DM. Evidence supports the use of very-low-carbohydrate (defined by these authors as any dietary pattern containing < 26% of total calories from carbohydrate) and low-carbohydrate diets (defined by these authors as a dietary pattern deriving 26–45% of total calories from carbohydrate) for the reduction of weight, HbA1c, blood pressure, and triglycerides as well as the increase of HDL cholesterol. Furthermore, the report noted that low-carbohydrate and very-low-carbohydrate diets are safe when no contraindications exist (e.g., renal disease, pregnancy, lactation) and when the diet is overseen by a knowledgeable practitioner.

Summary

In summary, the registered dietitian is considered an expert in nutrition and should be consulted to provide medical nutrition therapy for patients with T2DM. Evidence suggests that medical nutrition therapy and diabetes self-management education provided by a registered
dietitian is more effective at producing glycemic control and improvements in lipid markers of individuals with T2DM than dietary advice provided by other health care providers. Additionally, medical nutrition therapy in combination with pharmaceutical treatment is more effective than pharmaceutical treatment alone for reaching glycemic targets. With no clear diet composition recommendations for the management and prevention of T2DM, it is incumbent upon the registered dietitian to analyze current literature before providing a nutrition prescription for each patient. Dietary preferences, cultural norms, economic factors and metabolic goals should be considered individually for each patient before MNT for T2DM is prescribed. A newly released consensus report from the American Diabetes Association provides evidences for the use of low-carbohydrate and very-low-carbohydrate diets for the prevention treatment of T2DM, indicating that this dietary pattern is at least as effective as others more conventional dietary patterns at reducing weight, HbA1c, blood pressure and triglycerides and increasing HDL cholesterol.

Summary

The prevalence of obesity and T2DM is rising in the United States and around the world. Dietary interventions that lead to weight loss, a reduction in fasting plasma glucose and HbA1c are effective for preventing and treating T2DM. Many dietary strategies have been evaluated for weight loss and glycemic control, including a ketogenic diet which is very low in carbohydrate derived energy and high in energy derived from fat. The ketogenic diet was first used as a treatment for epilepsy in the early 1900s but has since been studied as a therapeutic treatment in numerous disease states. Evidence suggests adherence to a ketogenic diet leads to an equal or greater amount of weight loss than more traditional low-calorie, low-fat diets containing a
moderate amount of carbohydrates. In addition, several studies indicate that very-low-carbohydrate diets lead to a greater reduction in HbA1c than moderate carbohydrate diets and ultimately may allow for less pharmaceutical intervention to manage blood glucose.

The role of the registered dietitian is vital in the management and prevention of T2DM using medical nutrition therapy. Registered dietitians are encouraged to consider an individual’s needs and use evidence-based practice to create a nutrition therapy intervention that will be successful in achieving weight loss and better glycemic control. There are no specific macronutrient recommendations for the treatment of all patients with T2DM as several dietary patterns have been successful at managing T2DM. Evidence suggests that a ketogenic diet may achieve greater weight loss and glycemic control than a moderate-carbohydrate, calorie restricted diets and has recently been endorsed by the American Diabetes Association as a safe an effective therapy option for some individuals with T2DM. For these reasons this dietary pattern should be considered by an RD when prescribing nutrition therapy for T2DM.
CHAPTER 3

METHODOLOGY

The purpose of this study was to examine the attitudes, beliefs, and practices of registered dietitians who are members of the Indiana Academy of Nutrition and Dietetics regarding dietary treatments for type 2 diabetes mellitus (T2DM). This chapter describes the methods used to conduct this study.

Institutional Review Board

Permission was requested and granted from Ball State University Institutional Review Board prior to distributing the survey for this study. This project was declared exempt (Appendix A-1). The researcher conducting this analysis completed the Collaborative Institutional Training Initiative training (Appendix A-2).

Subjects

The population for this study included members of the Indiana Academy of Nutrition and Dietetics (IAND) who are registered dietitians, 18 years of age or older, and able to read and understand English. According to the Executive Director of the IAND, there were 1,257 IAND members in March of 2019; of these, 241 were student members, leaving 1,016 potential subjects. Using the Creative Research System sample size calculator (https://www.surveysystem.com/sscalc.htm), and applying a 95% confidence level, a confidence
interval (margin of error) of 4, and a population of 1016, an estimated 378 responses were needed to achieve results that are representative of the target population. Lowering the CI to 5 reduced the number of responses needed to 279.

**Instruments**

Participants of this study completed the *Attitudes, Beliefs and Practices of Registered Dietitians Regarding Dietary Treatments for T2DM Survey* (Appendix B) created by the researcher using the Qualtrics™ Survey Software. The survey was designed to assess the attitudes, beliefs and practices of members of the IAND who are registered dietitians, regarding current recommendations for the treatment of T2DM, with a focus on diets that cause nutritional ketosis. This 21-question survey collected demographics (i.e., education level, area of dietetics practice, and years of dietetics practice), information related to attitudes and beliefs about nutritional ketosis, and information regarding currently used dietary treatment methods for T2DM.

To ensure the study population examined in this study only included results from individuals who are already registered dietitians, the first survey question asked, “Are you a registered dietitian/dietitian nutritionist?” Data from individuals who answered “Not yet-but I hope to be in the future!” were deleted from the analyses in the present study.

The survey instrument was evaluated for face and content validity by two registered dietitians and two faculty members with expertise in survey design and evaluation from the Department of Nutrition and Health Science at Ball State University.
Letter of Permission and Consent

A letter of permission to distribute the survey three times using the Indiana Academy of Nutrition and Dietetics member electronic mailing list was obtained from the president of the Indiana Academy of Nutrition and Dietetics (Appendix C-1). Each respondent was required to provide consent prior to answering the questions in this anonymous online survey (Appendix C-2).

Methods

The Attitudes, Beliefs and Practices of Registered Dietitians Regarding Dietary Treatments for T2DM Survey (Appendix B-1) was distributed electronically to members of the Indiana Academy of Nutrition and Dietetics (IAND) via the group’s electronic mailing list. The electronic survey was emailed to the members of the IAND by the executive director three times over a one-month period (Appendix D-1 through D-3). In keeping with the Dillman Method (Dillman, Smyth, & Christian, 2009), the first request was sent Tuesday, April 2nd; the second request was sent out eight days later (Wednesday, April 10th); and the third request was sent eight days after that (Thursday, April 18th).

To encourage participation, dietitians were recruited in person at the 2019 annual meeting of the Indiana Academy of Nutrition and Dietetics held April 11th and 12th. During the meeting, the primary researcher and another CITI certified graduate assistant approached meeting attendees to request their participation in the study. Interested individuals were given a half-sheet of paper with a printed QR code (Appendix D-4) that, through a smart phone app, linked directly to the survey, allowing potential respondents to complete the survey at a later time.
In an effort to reach the target number, a request was made to send a fourth email attempt. However, per the Executive Director, IAND would not allow the survey to be sent out a fourth time, indicating: “We have to be very careful about sending too many eblasts to membership. If there is too much in the inbox from IAND they start to unsubscribe which we try to prevent. I feel that if they see this for the 4th time, it will be ignored.” (Email communication, May 4, 2019).

**Data Analysis**

Survey response data was downloaded from Qualtrics™ into SPSS v.25 for Windows (SPSS, 2018) for analysis. Individuals who were not currently registered dietitians, and any incomplete survey responses, were deleted from the data base. Descriptive statistics and frequency counts were run on all variables. Frequency counts (number and percent) were used to determine the overall prevalence of specific survey responses. Crosstab and Chi Square analyses were run to compare results based on education level, frequency of counseling clients with type 2 diabetes, and professional certifications held (i.e., Certified Diabetes Educator). For select questions, the two positive attitude categories were collapsed into one variable (positive), the two negative attitude categories were collapsed into a second variable (negative), and the neutral responses were eliminated. Statistical significance was set at \( p \leq 0.05 \).

**Summary**

This study was designed to examine the attitudes, beliefs and current practices of registered dietitians who are members of the IAND regarding ketogenic diets for the treatment and management of T2DM. The survey instrument was created to determine if statistically
significant differences in attitudes, beliefs or practices regarding nutritional ketosis as a T2DM treatment method exist between registered dietitians who frequently counsel individuals with T2DM and those who do not. All survey responses were compared based on the respondent’s education level and professional credentials. This study aims to fill a gap in the literature concerning dietary recommendations provided by registered dietitians for the treatment and management of T2DM.
CHAPTER 4

RESULTS

The purpose of this study was to examine the attitudes, beliefs, and practices of registered dietitians who are members of the Indiana Academy of Nutrition and Dietetics regarding dietary treatments for type 2 diabetes mellitus (T2DM). This chapter includes the results obtained from the study.

Response Rate

According to the Executive Director, as of March 2019, the Indiana Academy of Nutrition and Dietetics (IAND) had 1,257 members, including both registered dietitians and individuals—primarily undergraduate dietetic students—who were not yet registered dietitians. Because the Academy classifies membership by employment status (i.e., student, employed full-time, employed part-time, retire), rather than by registration status, a decision was made to send the emails requesting participation in this survey to all IAND member. Rather than deleting the emails of all student members, this decision allowed the researcher to capture the responses of any registered dietitian who is currently a student completing an advanced degree.

Overall, 265 survey responses were obtained (21% initial response rate) between April 2 and May 6, 2019 (Table 1). Of these, three (1.1%) did not indicate if they were a registered dietitian and had to be discarded, leaving 262 surveys. Of these, 28 (10.6%) respondents
indicated they were not yet a registered dietitian, leaving 234 surveys from the desired population. Of these, 35 dietitians did not complete the entire survey and they had to be discarded, leaving 199 useable surveys to include in the analyses for this study (75.1% of the initial responses). This number falls short of the 378 responses (CI=4) or 279 responses (CI=5) required to obtain results that reflect the target population as precisely as needed. The Indiana Academy, however, was not willing to send out the request a fourth time in an effort to increase the response rate. As a result, the Confidence Interval or margin of error for this survey is 6.23, rather than the desired CI of 4 (https://www.surveysystem.com/sscalc.htm). Consequently, the results of this study are considered preliminary and should be interpreted with caution.

**Table 1. Survey Response Rate by Wave**

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Surveys Removed

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<td>Total Removed (n)</td>
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</table>

Final Responses Analyzed by Wave (n)

|                     | 126      | 34       | 39       | 199   |

Percent Useable Surveys by Wave (%)

|                      | 79.7     | 63.0     | 73.5     | 75.1  |

The electronic survey was distributed to members of the Indiana Academy of Nutrition and Dietetics on three separate occasions or email “waves” that were eight days apart and did not
including a Monday or a Friday (i.e., April 2, April 10, and April 18, 2019). The first wave resulted in 158 surveys (59.6% of the total received), with an additional 54 surveys (20.4% of the surveys received) after the second wave and 53 surveys (20.0% of the surveys received) after the third request (Table 1). The final response rate was 19.6% (n=199/1,016).

The IAND 2019 annual conference was held April 11-12, between the second and third survey distribution wave. During this conference, a QR coded link to the survey (Appendix D-4) was distributed to interested attendees. During the conference, Mary Susan Spears, MS, RD, CSP, LD, presented a lecture about therapeutic uses of ketogenic diets, including for the treatment of T2DM. To estimate the effect of attending this presentation on the attitudes or opinions of dietitians in Indiana, an additional question inquiring about attendance of this presentation was added to the survey before being distributed the third time. Five of the 48 respondents indicated they attended Mary Susan Spears’ presentation. Subsequent analyses indicated there were no significant differences in any responses between those who did and did not attend the presentation.

**Demographic Description of Respondents**

Among participants, the length of time practicing as a dietitian ranged from 1 to 57 years, with a mean of 17.6 ± 14.9 years (n=198). Two-thirds of the dietitians surveyed were employed full-time (67.2%, n=133), 23.7% (n=47) were employed part-time, 7.6% (n=15) were retired and 1.5% (n=3) were not currently employed; of these 3, one indicated they are currently a student (Table 2). One participant did not provide demographic information.
Table 2. Demographic Characteristics of Participants (n=199)

<table>
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<th>Employment Status</th>
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<td>Not currently employed</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Retired</td>
<td>15</td>
<td>7.6</td>
</tr>
<tr>
<td>Student (but RDN)</td>
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<td>0.5</td>
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<td>Total</td>
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<table>
<thead>
<tr>
<th>Highest Earned Degree</th>
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<th>%</th>
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<tbody>
<tr>
<td>Bachelors</td>
<td>79</td>
<td>39.9</td>
</tr>
<tr>
<td>Masters</td>
<td>111</td>
<td>56.1</td>
</tr>
<tr>
<td>PhD</td>
<td>8</td>
<td>4.0</td>
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<tr>
<td>Total</td>
<td>198</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Generational Category</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silent Generation</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Baby Boomer</td>
<td>64</td>
<td>32.7</td>
</tr>
<tr>
<td>Generation X</td>
<td>38</td>
<td>19.4</td>
</tr>
<tr>
<td>Millennial</td>
<td>92</td>
<td>46.9</td>
</tr>
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<td>196</td>
<td></td>
</tr>
</tbody>
</table>

By education, the master’s degree (n=111, 56.1%) was the highest degree earned by the majority of participants followed by a baccalaureate degree (n=79, 39.9%), and a doctorate degree (n=8, 4.0%) (Table 2).

By generational category, 46.9% (n=92) of the dietitian-only respondents self-identified as being Millennials (i.e., born between 1981 and 1996), 19.4% (n=38) as Generation X (born between 1965 and 1980), 32.7% (n=64) as Baby Boomers (born between 1946 and 1964), and 1% (n=2) as Silent Generation (born between 1928 and 1945). No registered dietitians identified as belonging to the Generation Z category (born between 1997 and 2012) (Table 2).
The most commonly reported primary area of dietetics practice was acute or long-term health care (n=91; 46.2%), followed by community nutrition (n=21; 10.7%), and education (n=16; 8.1%) (Table 3). Almost one-fifth of the respondents (n=39; 19.8%) reported their primary area of dietetics practice as “other.” Of those who chose “other” and provided explanatory text (n=38; 97.4%), approximately one-third (32.4% (n=12) reported working in an outpatient setting (Table 3).

Table 3. Participants Primary Area of Dietetics Practice (n=197)

<table>
<thead>
<tr>
<th>Area of Dietetics Practice</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute or Long-term health care (clinical)</td>
<td>91</td>
<td>46.2</td>
</tr>
<tr>
<td>Public Health</td>
<td>9</td>
<td>4.6</td>
</tr>
<tr>
<td>Community Nutrition</td>
<td>21</td>
<td>10.7</td>
</tr>
<tr>
<td>Education</td>
<td>16</td>
<td>8.1</td>
</tr>
<tr>
<td>Private Practice</td>
<td>9</td>
<td>4.6</td>
</tr>
<tr>
<td>Industry</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>Research</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Food Systems Management</td>
<td>7</td>
<td>3.6</td>
</tr>
<tr>
<td>Other (see below)</td>
<td>39</td>
<td>19.8</td>
</tr>
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</table>

"Other" Areas of Dietetics Practice (n=38)

<table>
<thead>
<tr>
<th>Area of Dietetics Practice</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outpatient</td>
<td>12</td>
<td>6.15</td>
</tr>
<tr>
<td>Cooperate Extension Service</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Corporate/Worksite Wellness</td>
<td>4</td>
<td>2.0</td>
</tr>
<tr>
<td>Diabetes Education</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Bariatrics/Weight Loss</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Renal Dialysis</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Mental Health</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>School Nutrition</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Pediatric</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>Sales</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Management</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Retired/Not currently employed</td>
<td>5</td>
<td>2.5</td>
</tr>
<tr>
<td>Long Term Care</td>
<td>1</td>
<td>0.5</td>
</tr>
</tbody>
</table>
In addition to holding the credential RD (RDN), slightly more than one-quarter (n=52; 26.4%) of the participants reported having additional professional credentials or certifications (Table 4). Of these, 12% (n=25) held the Certified Diabetes Educator (CDE) credential, 2% (n=4) held the Certified Nutrition Support Clinician (CNSC) credential, and 19.0% (n=39) held “other” professional credentials (Table 4). Among those who held “other” professional certifications or credentials, 95% (n=37) provided a written description of their credentials, with the most common professional credential listed being Certified Dietitian (CD), held by 3.0% (n=6) of dietitian respondents.

Table 4. Participants Professional Credentials/Certifications (n=199)

<table>
<thead>
<tr>
<th>Professional Credentials/Certifications</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certified Lactation Counselor (CLC)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Certified Diabetes Educator (CDE)</td>
<td>25</td>
<td>12.7</td>
</tr>
<tr>
<td>Certified Nutrition Support Clinician (CNSC)</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Certified Specialist in Gerontological Nutrition (CSG)</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Certified Specialist in Oncology Nutrition (CSO)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Certified Specialist in Pediatric Nutrition (CCSP)</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>Certified Specialist in Renal Nutrition (CSR)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Other (Please Specify)</td>
<td>13</td>
<td>6.5</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td></td>
</tr>
</tbody>
</table>

"Other" Credentials/Certifications

<table>
<thead>
<tr>
<th>Professional Credentials/Certifications</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certified Dietitian (CD)</td>
<td>7</td>
<td>3.0</td>
</tr>
<tr>
<td>Certified Specialist in Obesity and Weight Management (CSOWM)</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Certified Personal Trainer (CPT)/Certified Fitness Trainer (CFT)</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Certified Intuitive Eating Counselor (CIEC)</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>
RQ # 1. Methods Recommended to Patients with T2DM to Manage Blood Glucose

The Diabetic Exchange System, taught to dietitians in medical nutrition therapy classes for years, has long been the standard method for teaching patients how to control their blood glucose through dietary measures. Recently, however, this system is seemingly falling out of favor by practitioners. Thus, the first research question of this study addressed the question “What method(s) do registered dietitians recommend to help clients with T2DM manage their blood glucose levels?”

Of the 199 registered dietitians who responded to this question, 16.6% (n=33) indicated they do not counsel clients with T2DM (Figure 1). Among the 166 dietitians who do counsel patients, carbohydrate counting was the preferred method of teaching clients how to self-manage their blood glucose, with more than three-quarters of respondents selecting this method (n=127; 76.5% of those who counsel; 63.8% of all respondents). Coming in a distant second was the Diabetic Exchange List, with only 6% (n=10; 5.0% of all respondents) of those who counsel patients indicating they use this method to teach clients how to self-manage their blood glucose. Two individuals (1.2%) selected the Glycemic Index as their preferred educational tool. Only one dietitian (0.6%) selected the Ketogenic Diet as their preferred method of teaching clients with T2DM how to self-manage their blood glucose.
Figure 1. Methods used by Dietitians to help Clients with T2DM Manage Blood Glucose

Twenty-six (15.7%) of the dietitians who counsel patients (13.1% of all respondents) indicated that they use “other methods” to teach patients with T2DM how to control their blood glucose levels. Of these, 92% (n=24) described their preferred methods. Responses, collapsed into six discrete categories, are presented in Table 5.

Table 5 “Other” Methods Used to Help Clients with T2DM Manage Blood Glucose (n=24)

<table>
<thead>
<tr>
<th>Method</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individualized or prefer several methods</td>
<td>7</td>
<td>3.5</td>
</tr>
<tr>
<td>Whole foods, plant-based diet</td>
<td>5</td>
<td>2.5</td>
</tr>
<tr>
<td>Lower carbohydrate intake overall</td>
<td>5</td>
<td>2.5</td>
</tr>
<tr>
<td>MyPlate/Plate Method</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>Portion control/regular meal timing</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>Weight maintenance</td>
<td>1</td>
<td>0.5</td>
</tr>
</tbody>
</table>
RQ #2 Macronutrient Distributions Recommended for Management of T2DM

Currently, the Dietary Reference Intakes (DRI) recommend that individuals consume between 45-65% of their total calories from carbohydrate. Recent literature, however, suggests this may be inappropriate for individuals with T2DM. Thus, the second research question of this study asked: “What macronutrient distributions do registered dietitians recommend for the dietary management of T2DM?”

Percent Calories: Carbohydrate

For this question, the respondents were asked to indicate what percent of calories they typically recommend for the dietary treatment of T2DM for each of the three macronutrients (i.e., carbohydrate, protein and lipids). The Qualtrics question automatically summed the three macronutrients, so respondents would know when their selections totaled 100%.

Only 84.7% (n=167) of the respondents completed this question. Results indicated that dietitians recommend, on average, 48.1 ± 6.9 percent of calories from carbohydrate, with a range from 10% to 75%. Nearly one-half (46.7%, n=78) of the respondents indicated that they would recommend that half (50%) of an individual’s calories come from carbohydrate (Figure 3). Other common responses included 40% of calories (16.8%, n=28), 45% of calories (16.8%, n=28), and 55% of calories from carbohydrate (10.8%, n=18).
Dietitians (n=167) in this study recommend that individuals with T2DM eat, on average, 24.6 ± 7.1 percent of their calories from protein, with the values ranging from a low of 15% to a high of 70% of total calories. Nearly one-half (43.7%, n=73) of the respondents indicated that they would recommend that 20% of an individual’s calories come from protein (Figure 4). Nearly one-quarter (24.6%, n=41) of dietitians reported they would recommend that 30% of an individual’s calories come from protein, while 19.8% (n=33) indicated that they would recommend 25% of calories from protein for a client with T2DM.
Percent Calories: Fat

On average, dietitians (n=167) in this study recommend that individuals with T2DM consume 27.3 ± 6.6 percent of their calories from fat, with the percent ranging from 5% to 50%. Almost half of the respondents (48.5%; n=81) indicated that they would recommend 30% of calories from fat for the management of T2DM (Figure 5). Approximately one in five dietitians (19.2%; n=32) indicated they recommend 20% of calories from fat, with 15.6% (n=26) recommending 25% of calories from fat for a client with T2DM.
Figure 5. Percent of Calories from Fat Recommended by Dietitians for the Dietary Management of T2DM

Ketogenic Diet Recommendations for the Management of T2DM

Several questions were included in the survey to assess whether or not dietitian recommend a macronutrient distribution that would result in nutritional ketosis (i.e., a ketogenic diet). When asked about previous practices, the vast majority (92.8%; n=181) of dietitians revealed that they have never recommended a ketogenic diet for the treatment of T2DM (Figure 6).
When asked which type of ketogenic diet they would recommend for the treatment of T2DM, more than almost two-thirds (64.5%, n=127) of the dietitians indicated they would not recommend any type of ketogenic diet to a client with T2DM (Figure 7). Approximately one-quarter (26.4%, n=52) reported that they would recommend a Modified Atkins Diet (i.e., 70% fat, 15% protein, 15% carbohydrate). Approximately one in ten (9.6%; n=19) indicated they would recommend a 2:1 ratio modified ketogenic diet (82% fat, 12% protein, 6% carbohydrate). A much smaller number of dietitians (3%; n=6) indicated that they would recommend a 3:1 ratio modified ketogenic diet (87% fat, 10% protein, 4% carbohydrate), and only one respondent (0.5%) indicated they would recommend a classic 4:1 ratio ketogenic diet (90% fat, 6% protein, 4% carbohydrate) for to treat or manage T2DM.
Lastly, the dietitians were asked if they believe they might recommend a ketogenic diet to a client with T2DM in the future (yes/no/unsure). Of the 193 dietitians who answered this question, almost half (49.2%; n=95) indicated they do not believe they will recommend any type of ketogenic to a client with T2DM in the future. Slightly more than one-third (38.9%; n=75) of the dietitians reported being unsure of their future recommendations and 11.9% (n=23) indicated that they believe they will recommend a ketogenic diet for the treatment of T2DM in the future (Figure 8).
In recent years, many modified versions of the classic ketogenic diet, have been studied for the treatment of T2DM. The classic ketogenic diet, commonly referred to as a 4:1 ratio diet, derives 90% of calories from fat. However, modified versions of the classic diet can still result in nutritional ketosis, while allowing for a greater intake of calories from protein and carbohydrate. To investigate the attitudes and beliefs of registered dietitians regarding ketogenic diets, it was necessary to understand what macronutrient ratios they believe will result in nutritional ketosis. Therefore, the third research question of this study asked, “What macronutrient distributions do registered dietitians associate with nutritional ketosis?”
To answer this research question, study participants were asked to respond “yes” or “no” to the question “Which of these dietary combinations can result in nutritional ketosis?” Four macronutrient distributions were displayed: 1) the classic ketogenic diet (90% fat, 6% protein, 4% carbohydrate), 2) the 2:1 ratio modified ketogenic diet (82% fat, 12% protein, 6% carbohydrate), 3) the 1:1 ratio modified Atkins diet (70% fat, 15% protein, 15% carbohydrate), and 4) a standard diet composition that falls within the Institute of Medicine’s *Dietary Reference Intakes Acceptable Macronutrient Distribution Range (AMDR)* (35% fat, 25% protein, 45% carbohydrate).

The vast majority of respondents (92.7%; n=175) correctly indicated that a 4:1 ratio classic ketogenic diet would result in nutritional ketosis; only 2.8% (n=5) did not know a 4:1 ratio classic ketogenic diet would result in nutritional ketosis (Figure 9). Similarly, 90.9% (n=160) correctly indicated a 2:1 ratio modified ketogenic diet would result in nutritional ketosis; only 9.1% (n=16) did not know a 2:1 ratio modified ketogenic diet would result in nutritional ketosis (Figure 9). Fewer dietitians (53%, n=94), however, correctly knew that a 1:1 ratio Modified Atkins diet could result in nutritional ketosis; almost half (47%; n=83) did not know that a 1:1 ratio Modified Atkins diet would result in nutritional ketosis (Figure 9). An overwhelming majority of dietitians (97.5%, n=155) correctly knew a standard macronutrient distribution of 35% fat 25% protein, and 45% carbohydrate will not lead to nutritional ketosis.
RQ # 4 Attitudes of Dietitians Toward Recommending a Ketogenic Diet to Treat T2DM

To understand the practice recommendations of dietitians regarding diets that result in nutritional ketosis, it is crucial to understand their attitudes about ketogenic diets for the treatment of T2DM. Thus, the fourth research question addressed in this study asked, “What are the attitudes of registered dietitians toward recommending a diet that results in nutritional ketosis to treat T2DM?”

Dietitians were asked to select a response that best represents their attitude toward the ketogenic diet using a 5-point Likert scale, with response options ranging from “very positive” to “very negative.” Of the 192 dietitians who responded to this question, two-thirds (67.7%) described their attitude toward the ketogenic diet as either “very negative” (14.1%; n=27) or “somewhat negative” (53.6%; n=103) (Figure 10). “Neither negative nor positive” was selected.
by 19.8% (n=38) of respondents. Only 12.5% of dietitians reported a “somewhat positive” (9.4%; n=18) or a “very positive” (3.1%; n=6) attitude toward ketogenic diets.

![Attitude of Dietitians Toward Ketogenic Diet](image)

**Figure 10.** Attitudes of Registered Dietitians toward the Ketogenic Diet

**RQ#5 Beliefs of Dietitians about Recommending a Ketogenic Diet to treat T2DM**

Although registered dietitians are advised to rely on evidence-based practice guidelines when providing dietary advice, it is possible their personal beliefs, whether based on current evidence or not, may affect the dietary recommendations they provide clients. In order to explore the relationship between the beliefs of registered dietitians and their practice recommendations, the fifth research question addressed in this study was “What are the beliefs of registered dietitians about recommending a diet that results in nutritional ketosis to treat T2DM?”
Familiarity with Ketogenic Diets

In order to explore the beliefs of dietitians regarding ketogenic diets, it was necessary to understand how familiar they consider themselves to be with diets that induce nutritional ketosis. Therefore, a survey question was created asking, “How familiar are you with diets that result in nutritional ketosis (e.g., ketogenic diets)?” Participants were offered responses using a 5-point Likert scale, ranging from “extremely familiar,” to “not familiar at all.”

Of the 199 dietitians who answered this question, responses reflect a standard bell-shaped curve. The most common response (44.2%; n=88) indicated dietitians are only “moderately familiar” with diets that result in nutritional ketosis (Figure 11), with roughly one-quarter “slightly familiar” (25.1%, n=50) and “very familiar” (22.6%, n=45) with ketogenic diets. A much smaller percent of dietitians described themselves as being “extremely familiar” (5.5%, n=11) or “not at all familiar” (2.5%, n=5) with ketogenic diets.

Figure 11. Familiarity of Registered Dietitians with Diets that Result in Nutritional Ketosis
Beliefs about the Frequency of Ketogenic Diet Recommendations

To evaluate how dietitians feel about the use of ketogenic diets for the treatment of T2DM, it was relevant to explore their beliefs about ketogenic diet recommendations made by other dietitians in the field. For this purpose, a question asked: “In your opinion, ketogenic diets are:’” and offer the responses, “Recommended too frequently by dietitians,” “Recommended appropriately by dietitian,” or “Not recommended frequently enough by dietitians.”

Of the 181 dietitians who responded to this question, the majority (59.7%, n=44) indicated that they believe ketogenic diets are recommended appropriately by registered dietitians (Figure 12). Approximately one-quarter (24.3%, n=44) were of the opinion that registered dietitians recommend ketogenic diets too frequently, while 16% (n=29) believed that ketogenic diets are not recommended frequently enough, for the treatment of T2DM.

![Figure 12 Beliefs of Registered Dietitians about Ketogenic Diet Recommendations](image)
Should Individuals with T2DM be Discouraged from Following a Ketogenic Diet?

To understand the dietary recommendations made by dietitians for the treatment of T2DM, participants were asked: “To what extent do you agree or disagree with this statement: I believe that individuals with T2DM should be discouraged from following a ketogenic diet.” Responses ranged from “strongly agree” to “strongly disagree” on a 5-point Likert scale.

Of the 181 dietitians who responded, more than half (59%) either agreed (41%; n=78) or strongly agreed (18%; n=34) with the statement that individuals with T2DM should be discouraged from following a ketogenic diet (Figure 13). Approximately one-third (31%; n=60) of respondents neither agree nor disagree with the statement. Only 10% (n=18) either disagreed (8%, n=15) or strongly disagree (2%, n=3) that individuals with T2DM should be discouraged from following a ketogenic diet.

![Figure 13](image.png)

**Figure 13**  Beliefs of Registered Dietitians regarding whether Individuals with T2DM should be Discouraged from Following a Ketogenic Diet
Judgement from Peers if they Recommended a Ketogenic Diet to Treat T2DM

A dietitian’s beliefs about how they are perceived by their peers may play an important role in their professional decision-making. If a dietitian believes their colleagues will judge them unfavorably based on specific dietary treatment recommendations, they may be less likely to recommend such treatments. To better understand this topic, a question asked “To what extent do you agree or disagree with this statement: I believe I would be judged negatively by my peers/colleagues if I recommended a ketogenic diet to a client with T2DM.” The responses ranged from “strongly agree” to “strongly disagree” using a 5-point Likert scale.

Of the 189 dietitians who answered this question, almost half (44%; n=83) “strongly agreed” (10%; n=19) or “agreed” (34%; n=64) they would be judged negatively by their peers/colleagues if they recommended a ketogenic diet to a client with T2DM. One-third (39.2%; n=74) neither agreed nor disagreed with the statement. Only 17% (n=32) either “disagreed” (14%; n=27) or “strongly disagreed” (3%; n=5) with this statement (Figure 14).

Figure 14  Registered Dietitian’s Beliefs about Being Judged Negatively for Recommending a Ketogenic Diet to Treat T2DM
Beliefs about the Macronutrient Distribution Range for Individuals with T2DM

The Institute of Medicine’s Dietary Reference Intakes Acceptable Macronutrient Distribution Range (AMDR) recommends that 45-65% of one’s daily calories be derived from carbohydrates. Because carbohydrates, more than protein or lipids, strongly affect blood glucose levels, there remains debate about the appropriate amount of carbohydrate intake for individuals with T2DM. To understand what dietitians believe about these recommendations, survey participants were asked to what extent they agree or disagree with the recommendation of 45-65% of calorie from carbohydrate for individuals with T2DM. The response options were presented on a 5-point Likert scale and ranged from “strongly agree” to “strongly disagree.”

A total of 195 dietitians provided responses to this question. Of these, more than three-quarters (76.5%) either “strongly agreed” (16.4%, n=32), or “agreed” (60.5%, n=118) with the current recommendation of 45-65% of calorie from carbohydrate for individuals with T2DM. A neutral response (i.e., “neither agree nor disagree”) was selected by 11.8% (n=23). Only 11.3% of respondents (n=22) either “disagreed” (10.3%; n=20) or “strongly disagreed” (1%; n=2) with this recommendation for individuals with T2DM (Figure 15).
Appropriateness of CHO Dietary Guideline for T2DM

- **Strongly Agree:** 16%
- **Agree:** 61%
- **Neither Agree nor Disagree:** 12%
- **Disagree:** 10%
- **Strongly Disagree:** 1%

Figure 15. Beliefs of Registered Dietitians Regarding the Appropriateness of the Dietary Guidelines Recommendations for Carbohydrate for Individuals with T2DM

**How Strong is the Evidence to Support the Use of a Ketogenic Diet to Treat T2DM?**

Registered Dietitians are experts in nutrition who must use scientific evidence to create evidence-based practice guidelines. For this reason, it is important to understand how dietitians feel about the existing evidence to support the use of a ketogenic diet to treat T2DM. To answer this question, participants were asked, “In your opinion, how strong is the evidence supporting the use of a ketogenic diet for the treatment of T2DM?”

Of the 191 dietitians who provided a response to this question, more than half (61.8%, n=118) indicated that they believe the evidence supporting a ketogenic diet for the treatment of T2DM is inconclusive (Figure 16), with an additional 30% believing the evidence is weak (23%)
or very weak (7%). Only 9% of respondents thought the evidence supporting the use of a ketogenic diet for the treatment of T2DM was strong (7%) or very strong (2%).

**Figure 16** Beliefs of Registered Dietitian Regarding the Strength of Evidence Supporting the Use of Ketogenic Diets to Treat T2DM

**Perceived Benefits of Nutritional Ketosis for the Treatment of T2DM**

In order to understand why registered dietitians do or do not recommend diets resulting in nutritional ketosis for the treatment of T2DM, it is imperative to evaluate what benefits they believe this way of eating may provide. To answer this question, survey participants were presented with a list of possible benefits of nutritional ketosis and asked to select “yes” or “no” to indicate if they believe that nutritional ketosis may result in each specified outcome. The
benefits listed included: “weight loss,” “better blood glucose management,” “reduced hemoglobin A1c,” “reduced hunger,” “reduced insulin resistance,” “reduced blood pressure,” “reduced triglycerides,” and “reduced requirement for diabetes medication/insulin.” The results will be reported in order from the greatest perceived benefit to the least perceived benefit.

*Lose Weight*

A total of 190 dietitians provided a response to the section of the question regarding weight loss. Of these, the majority (85.7%, n=163) indicated they believe nutritional ketosis can aid weight management, while 14.2% (n=27) did not (Figure 17).

*Reduce Hemoglobin A1c*

Of the 182 dietitians who responded to the question, approximately three-quarters (76.4%, n=139) indicated that they believed nutritional ketosis could help reduce Hemoglobin A1c levels (a marker of blood sugar control). Slightly less than one-quarter (23%; n=43) did not believe a ketogenic diet could help reduce Hemoglobin A1c levels (Figure 17).

*Improve Blood Glucose Management*

Of the 178 dietitians who responded to the question, more than two thirds (69.7%; n=124) reported that they believe nutritional ketosis could lead to better blood glucose management. In contrast, slightly less than one-third (30.3%; n=54) indicated that they did not believe that ketogenic diets could lead to better blood glucose management (Figure 17).
Of the 180 dietitians who responded to the question, 65% (n=117) reported that nutritional ketosis could reduce insulin resistance. In contrast, approximately one-third (35%; n=63) did not believe that a ketogenic diet would reduce insulin resistance (Figure 17).

*Reduce Insulin Resistance*

Of the 180 dietitians who responded to the question, 65% (n=117) reported that nutritional ketosis could reduce insulin resistance. In contrast, approximately one-third (35%; n=63) did not believe that a ketogenic diet would reduce insulin resistance (Figure 17).

*Reduce Requirement for Medications/Insulin*

Of the 178 dietitians who responded to the question, more than two-thirds (68%, n=121) reported that they believe nutritional ketosis can lead to a reduced requirement for diabetes medication or insulin. Slightly less than one-third (32%; n=57) did not believe that a ketogenic diet can lead to a reduced requirement for diabetes medication or insulin (Figure 17).
Reduce Hunger

Of the 180 dietitians who responded to this question, more than half (60%, n=108) reported that they believe a benefit of nutritional ketosis is reduced hunger. Slightly less than half (40%; n=72) of the dietitians who completed this survey indicated they did not believe nutritional ketosis could lead to reduced hunger (Figure 17).

Reduce Triglycerides

Of the 177 dietitians who responded to this question, slightly more than one-third (37.9%; n=61) believed that a ketogenic diet could lead to reduced triglycerides. The majority of respondents (62.1%, n=110) indicated they did not believe that a ketogenic diet could lead to reduced triglycerides (Figure 17).

Reduce Blood Pressure

Of the 177 dietitians who responded to this question, slightly more than one-third 34.5% (n=61) believed that a ketogenic diet could reduce blood pressure. The majority of respondents (65.5%, n=116) indicated they did not believe that a ketogenic diet could lead to reduced blood pressure (Figure 17).

RQ#6. Concerns that Prevent Dietitians from Recommending Ketogenic Diets for T2DM

To evaluate the practices of registered dietitians regarding the use of nutritional ketosis for the treatment of T2DM, it was necessary to identify concerns that might prevent a dietitian from recommending this therapeutic strategy. Therefore, the sixth research question in this study
asked, “What concerns prevent registered dietitians from recommending a diet that results in nutritional ketosis to treat T2DM?”

To answer this question, participants were presented with a list of possible concerns regarding negative outcomes or side effects related to nutritional ketosis and asked, “Would any of the following prevent you from recommending a ketogenic diet for the treatment of T2DM?” The possible concerns included “cardiovascular concerns,” “long-term dietary adherence,” “palatability of the diet,” “renal concerns,” “possible side effects of ketosis,” “patient’s ability to access/afford healthy ketogenic foods,” “possible hypoglycemia,” and “standard of care in current workplace prevents me from recommending.” Respondents were instructed to select “yes” or “no” for each of these concerns indicating if it would in fact prevent them from recommending a ketogenic diet to treat T2DM. The results will be reported in order from the area of greatest concern to the area of least concern.

**Long Term Adherence**

A total of 191 dietitians provided responses regarding long-term adherence to a ketogenic diet. Of these, 91.6% (n=175) reported that they would not recommend a ketogenic diet due to concerns about patient adherence, whereas 8.4% (n=16) indicated that dietary adherence was not concerning enough to prevent them from recommending a ketogenic diet (Figure 18).

**Cardiovascular Concerns**

The question regarding cardiovascular concerns was completed by 188 dietitians. Of these, the majority (90.4%, n=170) reported that cardiovascular concerns related to nutritional
ketosis would prevent them from recommending a ketogenic diet. Only 9.6% (n=18) indicated cardiovascular concerns would not deter them from making this recommendation (Figure 18).

Figure 18. Concerns that Prevent Registered Dietitians from Recommending Nutritional Ketosis for the Treatment of T2DM: Percent Responding “Yes”

**Possible Side Effects of Ketosis**

Of the 191 dietitians who responded to this question, the majority (90.1%; n=173) indicated the possible side effects of ketosis would prevent them from recommending a ketogenic diet. Only 9.9% (n=19) indicated that the possible side effects of ketosis would not prevent them from recommending a ketogenic diet (Figure 18).
Access/Affordability of Healthy Ketogenic Foods

Of the 187 dietitians who responded to this question, the majority (85.0%; n=159) indicated they were concerned about a client not being able to access or afford healthy ketogenic food and that this concern would prevent them from recommending a ketogenic diet. Only 15% (n=28) indicated they were not concerned about a client not being able to access or afford healthy ketogenic food and that this concern would not prevent them from recommending a ketogenic diet (Figure 18).

Renal Concerns

Of the 188 dietitians who responded to this question, the majority (84.0%; n=151) indicated that concerns about their client’s renal health would prevent them from recommending a ketogenic diet. Only 16% (n=30) indicated concerns about renal health would not prevent them from recommending a ketogenic diet (Figure 18).

Hypoglycemia Concerns

Of the 188 dietitians who responded to this question, 78.7% (n=148) indicated they were concerned about hypoglycemia caused by nutritional ketosis and that this concern would prevent them from recommending a ketogenic diet. Only 21.3% (n=40) of respondents did not report hypoglycemia as a concern.

Palatability of the Diet

Of the 188 dietitians who responded to this question regarding, 72.3% (n=136) indicated that the palatability of ketogenic foods would prevent them from recommending this diet for
individuals with T2DM. For slightly more than one-quarter (27.7%; n=52) of the respondents, the palatability of the ketogenic diet as not a cause for concern (Figure 18).

**Workplace Standards of Care Prevent Me from Selecting a Ketogenic Diet**

Finally, of the 188 dietitians who responded to this question, slightly more than half (61.7%, n=116) indicated that the standards of care in their workplace would prevent them from recommending a ketogenic diet for clients with T2DM. Slightly more than one-third of the respondents (38.3%; n=72) indicated that their current workplace standards would not prevent them from recommending a ketogenic diet to treat T2DM (Figure 18).

**RQ#7. Differences among Dietitians Recommending a Ketogenic Diet to Treat T2DM**

The final research question of this study sought to explore whether differences in the practice recommendations of registered dietitians could be detected based on participant characteristics. Therefore, the seventh research question addressed by this study asked, “Are there differences in attitudes, beliefs or practices among registered dietitians regarding recommending a diet that results in nutritional ketosis to treat T2DM based on the following respondent characteristics: a.) education level, or b.) frequency of counseling clients with T2DM?”

**Education Level**

Participants were asked to select their highest educational degree from three levels of formal education (i.e., Bachelor’s degree, Master’s degree, and Doctorate degree). Results indicated 79 individuals held the bachelor’s degree as their highest degree, 111 individuals held
the master’s degree as their highest degree, and 8 respondents held a doctorate degree as their highest degree. Due to the low number of participants with a doctorate degree, responses from those with a master’s or doctorate degree were collapsed into a single “post-graduate education” category (Table 6). Each variable will be assessed by educational level.

**Ever Having Recommended a Ketogenic Diet**

Participants were asked to indicate if they have ever recommended a ketogenic diet to treat T2DM (i.e., yes, no, unsure). After removing the “unsure” responses, and using the collapsed education variable, a 2 x 2 Chi square analysis indicated no significant difference ($\chi^2=0.063$, $p=0.802$) between the percent of dietitians who have ever recommended a ketogenic diet to treat T2DM by level of education (Table 6).

**Beliefs about Recommending a Ketogenic Diet in the Future**

Participants were asked to indicate if they believe they might recommend a ketogenic diet for patients with T2DM in the future. After removing the “unsure” responses, and using the collapsed education variable, a 2 x 2 Chi square analysis indicated no significant difference ($\chi^2=0.660$, $p=0.416$) between the percent of dietitians who believe that they might recommend a ketogenic diet to treat T2DM in the future by level of education (Table 6).

**Attitudes toward Ketogenic Diet**

Dietitians were asked to describe their attitudes toward the ketogenic diet, and offered response options on a 5-point Likert scale ranging from “very positive” to “very negative”. The “very positive” and “somewhat positive” responses were combined into a single “positive”
variable, the “very negative” and “somewhat negative” responses were combined into a single “negative” variable, and the “neither positive nor negative” responses were removed. Then, using the collapsed education variables, a 2x2 Chi square analysis indicated no significant difference ($\chi^2=0.751$, $p=0.386$) between the percent of dietitians who had a positive or a negative attitude toward the use of a ketogenic diet for the treatment of T2DM by education level (Table 6).

**Perceived Safety of Nutritional Ketosis**

Dietitians were asked to describe their beliefs about the safety of nutritional ketosis for the treatment of T2DM using a 5-point Likert scale ranging from “very safe” to “definitely not safe.” Due to the response distribution, the “very safe” and “somewhat safe” responses were combined into a single “safe” variable, the “probably not safe” and “definitely not safe” responses were combined into a single “not safe” variable, and the “neither safe nor unsafe” response was removed from the analysis. Then, using the collapsed education variables, a 2x2 Chi square analysis indicated no significant difference ($\chi^2=0.719$, $p=0.396$) between dietitian’s perceived safety of nutritional ketosis for the treatment of T2DM by education level (Table 6).

**Beliefs about the Appropriateness of Ketogenic Diet Recommendations**

Participants were asked their opinion regarding the appropriateness of the frequency with which ketogenic diets are being recommended by registered dietitians for the treatment of T2DM. Response options included “recommended too frequently,” “recommended appropriately,” and “not recommended frequently enough.” Using the collapsed education variable, a 2x3 chi square analysis indicated no significant differences ($\chi^2=0.191$, $p=0.909$)
between dietitian’s beliefs about the appropriateness of the frequency with which ketogenic diets are recommended to treat T2DM by education level (Table 6).

**Table 6.** Differences in the Attitudes, Beliefs and Practices of Dietitians Regarding Ketogenic Diets for the Treatment of T2DM by Education Level

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<th>( \chi^2 )</th>
<th>p</th>
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Concerns that Prevent Dietitians from Recommending Ketogenic Diet by Education Level

Dietitians were asked to identify from a list of concerns which concern(s) might prevent them from recommending a ketogenic diet for the treatment of T2DM. Each of the concerns were then compared by education level to determine if there were significant differences.

Cardiovascular Concerns

Using the collapsed education variables, a 2x2 Chi square analysis indicated no significant differences between the percent of dietitians who reported that cardiovascular concerns ($\chi^2 = 1.046$, p=0.307) would prevent them from recommending a ketogenic diet for the treatment of T2DM by education level (Table 7).

Long-Term Dietary Adherence

Using the collapsed education variable, dietitians who held post-graduate degrees were significantly more likely than those with an undergraduate degree to indicate concerns regarding long-term diet adherence to a ketogenic diet would prevent them from recommending a ketogenic diet to patients with T2DM ($\chi^2 = 3.953$, p=0.047, A.R. 2.0) (Table 7).

Diet Palatability

Using the collapsed education variable, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.714$, p=0.398) between the percent of dietitians who reported that concerns regarding ketogenic diet palatability would prevent them from recommending a ketogenic diet for the treatment of T2DM by education level (Table 7).
Table 7. Differences in the Concerns that Prevent Dietitians from Recommending Ketogenic Diets for the Treatment of T2DM, Compared by Education Level

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</table>
Renal Concerns

Using the collapsed education variable, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 2.410, p=0.121$) between the percent of dietitians who reported that renal concerns would prevent them from recommending a ketogenic diet for the treatment of T2DM by education level (Table 7).

Hypoglycemia

Using the collapsed education variable, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.314, p=0.505$) between the percent of dietitians who reported that concerns regarding hypoglycemia would prevent them from recommending a ketogenic diet for the treatment of T2DM by education level (Table 7).

Side Effects of Ketosis

Using the collapsed education variable, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.803, p=0.750$) between the percent of dietitians who reported that concerns regarding side effects of ketosis would prevent them from recommending a ketogenic diet for the treatment of T2DM by education level (Table 7).

Patient’s Ability to Access/Afford Healthy Ketogenic Foods

Using the collapsed education variable, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.149, p=0.700$) between the percent of dietitians who reported that concerns regarding side effects of ketosis would prevent them from recommending a ketogenic diet for the treatment of T2DM by education level (Table 7).
Standards of Care in Current Workplace

Using the collapsed education variable, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.560, p=0.454$) between the percent of dietitians who reported that concerns regarding side effects of ketosis prevent them from recommending a ketogenic diet for the treatment of T2DM by education level (Table 7).

Perceived Benefits of Nutritional Ketosis by Educational Level

Dietitians were asked about the benefits that they believe can result from a ketogenic diet for the treatment of T2DM. Each of the responses to the question regarding the benefits of ketogenic diets for the treatment of T2DM were compared by education level (Table 8).

Weight Loss

Using the collapsed education variable, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 2.400, p=0.121$) between the percent of dietitians who reported that they believe weight loss to be a benefit of ketogenic diets for the treatment of T2DM by education level (Table 8).

Better Blood Glucose Management

Using the collapsed education variable, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.212, p=0.646$) between the percent of dietitians who reported that they believe better blood glucose management to be a benefit of ketogenic diets for the treatment of T2DM by education level (Table 8).
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<th></th>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
**Reduced HbA1c**

Using the collapsed education variable, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.373, p=0.541$) between the percent of dietitians who reported that they believe reduced HbA1c to be a benefit of ketogenic diets for the treatment of T2DM by education level (Table 8).

**Reduced Hunger**

Using the collapsed education variable, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.000, p=1.000$) between the percent of dietitians who reported that they believe reduced hunger to be a benefit of ketogenic diets for the treatment of T2DM by education level (Table 8).

**Reduced Insulin Resistance**

Using the collapsed education variable, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 3.108, p=0.078$) between the percent of dietitians who reported that they believe reduced insulin resistance to be a benefit of ketogenic diets for the treatment of T2DM by education level (Table 8).

**Reduced Triglycerides**

Using the collapsed education variable, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 1.079, p=0.299$) between the percent of dietitians who reported that they believe...
Reduced triglycerides are a benefit of ketogenic diets for the treatment of T2DM by education level (Table 8).

Reduced Blood Pressure

Using the collapsed education variable, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.627, p=0.428$) between the percent of dietitians who reported that they believe reduced blood pressure to be a benefit of ketogenic diets for the treatment of T2DM by education level (Table 8).

Reduced Requirements for Medication or Insulin

Using the collapsed education variable, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.066, p=0.798$) between the percent of dietitians who reported that they believe reduced requirements for diabetes medication or insulin to be a benefit of ketogenic diets for the treatment of T2DM by education level (Table 8).

Frequency of Counseling Clients with T2DM

In addition to comparison by education level, Chi square analyses were run to compare the attitudes, beliefs and practices of registered dietitians regarding ketogenic diet recommendations for the treatment of T2DM by how frequently they counsel clients with T2DM. Participants were asked to indicate if they counseled clients with T2DM “daily,” “a few times per week,” “a few times per month,” or “rarely or never.” Due to the response rate, the “daily” and a “a few times per week” responses were combined into one variable titled “frequently,” while the “a few times per month” and “rarely or never” responses were combined into a single variable titled “infrequently.”
**Ever Having Recommended a Ketogenic Diet**

Participants were asked to indicate if they have ever recommended a ketogenic diet to treat T2DM (i.e., yes, no, unsure). After removing the “unsure” responses, and using the collapsed frequency of counseling variables, a 2 x 2 Chi square analysis indicated no significant differences ($\chi^2=0.308$, $p=0.579$) between the percent of dietitians who have ever recommended a ketogenic diet to treat T2DM by frequency of counseling (Table 9).

**Beliefs about Recommending a Ketogenic Diet in the Future**

Participants were asked to indicate if they believed they might recommend a ketogenic diet for patients with T2DM in the future. After removing the “unsure” responses, and using the collapsed frequency of counseling variables, a 2 x 2 Chi square analysis indicated no significant differences ($\chi^2=0.473$, $p=0.492$) between the percent of dietitians who believe that they might recommend a ketogenic diet to treat T2DM in the future by frequency of counseling (Table 9).

**Attitudes toward Ketogenic Diet**

Dietitians were asked to describe their attitudes toward the ketogenic diet, and offered response options on a 5-point Likert scale ranging from “very positive” to “very negative.” The “very positive” and “somewhat positive” responses were combined into a single “positive” variable, the “very negative” and “somewhat negative” responses were combined into a single “negative” variable, and the “neither positive nor negative” response was removed. Then, using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences ($\chi^2=0.356$, $p=0.551$) were found between those who had positive and
negative attitudes about ketogenic diets for the treatment of T2DM compared by frequency of counseling (Table 9).

**Perceived Safety of Nutritional Ketosis**

Dietitians were asked to describe their beliefs about the safety of nutritional ketosis for the treatment of T2DM, and offered response options on a 5-point Likert scale ranging from “very safe” to “definitely not safe.” The “very safe” and “somewhat safe” responses were combined into a single “safe” variable, the “probably not safe” and “definitely not safe” responses were combined into a single “not safe” variable, and the “neither safe nor unsafe” response was removed. Then, using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences ($\chi^2=0.796$, $p=0.372$) between the perceived safety of nutritional ketosis among dietitians for the treatment of T2DM compared by frequency of counseling (Table 9).

**Beliefs about the Appropriateness of Ketogenic Diet Recommendations**

Participants were asked their opinion regarding how frequently ketogenic diets are recommended by registered dietitians for the treatment of T2DM. Using the collapsed frequency of counseling variables, a 2x3 Chi square analysis indicated no significant differences ($\chi^2=1.443$, $p=0.486$) between dietitian’s beliefs about the appropriateness of ketogenic diet recommendations by frequency of counseling (Table 9).
Table 9. Differences in the Attitudes, Beliefs and Practices of Dietitians Regarding Ketogenic Diets for the Treatment of T2DM, When Compared by Frequency of Counseling Clients with T2DM

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Frequently</th>
<th>Infrequently</th>
<th>χ²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ever Recommended a Ketogenic Diet for T2DM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
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<td>8</td>
<td>6</td>
<td>0.308</td>
<td>0.579</td>
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<tr>
<td>No</td>
<td>88</td>
<td>90</td>
<td></td>
<td></td>
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<tr>
<td><strong>Believe you Might Recommend a Ketogenic Diet for T2DM in the Future</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>118</td>
<td>11</td>
<td>12</td>
<td>0.473</td>
<td>0.492</td>
</tr>
<tr>
<td>No</td>
<td>12</td>
<td>42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Attitude Toward Ketogenic Diets</strong></td>
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</tr>
<tr>
<td>Positive</td>
<td>153</td>
<td>12</td>
<td>12</td>
<td>0.356</td>
<td>0.551</td>
</tr>
<tr>
<td>Negative</td>
<td>73</td>
<td>56</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td><strong>Safety of Nutritional Ketosis for T2DM</strong></td>
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<tr>
<td>Very Safe or Somewhat Safe</td>
<td>136</td>
<td>15</td>
<td>18</td>
<td>0.796</td>
<td>0.372</td>
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<tr>
<td>Probably or Definitely Not Safe</td>
<td>56</td>
<td>47</td>
<td></td>
<td></td>
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<tr>
<td><strong>Appropriateness of Ketogenic Diet Recommendations</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Too Frequently</td>
<td>180</td>
<td>24</td>
<td>19</td>
<td>1.443</td>
<td>0.486</td>
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<tr>
<td>Appropriately</td>
<td>54</td>
<td>54</td>
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<td></td>
<td></td>
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<tr>
<td>Not Frequently Enough</td>
<td>12</td>
<td>17</td>
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</tr>
</tbody>
</table>

Concerns that Prevent Dietitians from Recommending Ketogenic Diet

Dietitians were asked about the concerns that prevent them from recommending a ketogenic diet for the treatment of T2DM. Each of the responses to the question regarding concerns that might prevent dietitians from recommending ketogenic diets for the treatment of T2DM were compared by frequency of counseling.
**Cardiovascular Concerns**

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences between the percent of dietitians who reported that cardiovascular concerns ($\chi^2 = 1.131$, $p=0.288$) would prevent them from recommending a ketogenic diet for the treatment of T2DM by frequency of counseling (Table 10).

**Diet Adherence**

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences between the percent of dietitians who reported that concerns regarding diet adherence ($\chi^2 = 0.002$, $p=0.965$) would prevent them from recommending a ketogenic diet for the treatment of T2DM by frequency of counseling (Table 10).

**Diet Palatability**

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences between the percent of dietitians who reported that concerns regarding diet palatability ($\chi^2 = 0.623$, $p=0.430$) would prevent them from recommending a ketogenic diet for the treatment of T2DM by frequency of counseling (Table 10).

**Renal Concerns**

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences between the percent of dietitians who reported that renal concerns ($\chi^2 = 2.857$, $p=0.091$) would prevent them from recommending a ketogenic diet for the treatment of T2DM by frequency of counseling (Table 10).
Table 10. Differences in the Concerns that Prevent Dietitians from Recommending Ketogenic Diets for the Treatment of T2DM, Compared by Frequency of Counseling Clients with T2DM

<table>
<thead>
<tr>
<th>Concern</th>
<th>Frequently</th>
<th>Infrequently</th>
<th>$\chi^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cardiovascular Concerns</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>187</td>
<td>88</td>
<td>81</td>
<td>1.131</td>
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<tr>
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<td>7</td>
<td>11</td>
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<tr>
<td><strong>Adherence</strong></td>
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<tr>
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<td>190</td>
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<td>8</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Palatability</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>71</td>
<td>64</td>
<td>0.623</td>
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<tr>
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<tr>
<td><strong>Renal Concerns</strong></td>
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<td></td>
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<tr>
<td>Yes</td>
<td>187</td>
<td>84</td>
<td>73</td>
<td>2.857</td>
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<tr>
<td>No</td>
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<tr>
<td><strong>Hypoglycemia</strong></td>
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<td></td>
</tr>
<tr>
<td>Yes</td>
<td>187</td>
<td>78</td>
<td>69</td>
<td>0.818</td>
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<tr>
<td>No</td>
<td>18</td>
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<tr>
<td><strong>Side Effects of Ketosis</strong></td>
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<tr>
<td>Yes</td>
<td>191</td>
<td>91</td>
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<td>4.839</td>
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<tr>
<td>Yes</td>
<td>186</td>
<td>79</td>
<td>79</td>
<td>0.121</td>
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<tr>
<td>No</td>
<td>15</td>
<td>13</td>
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<td><strong>Standard of Care in Workplace</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Yes</td>
<td>187</td>
<td>78</td>
<td>69</td>
<td>0.818</td>
</tr>
<tr>
<td>No</td>
<td>18</td>
<td>22</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hypoglycemia

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences between the percent of dietitians who reported that concerns regarding hypoglycemia ($\chi^2 = 0.818$, $p=0.366$) would prevent them from recommending a ketogenic diet for the treatment of T2DM by frequency of counseling (Table 10).

Side Effects of Ketosis

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated that dietitians who counsel clients with T2DM frequently were significantly ($\chi^2 = 4.839$, $p=0.028$) more likely to report that concerns regarding side effects of ketosis would prevent them from recommending a ketogenic diet for the treatment of T2DM, compared to those who counsel T2DM clients less frequently (Table 10).

Patient’s Ability to Access/Afford Healthy Ketogenic Foods

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences between the percent of dietitians who reported that concerns regarding the patient’s ability to access or afford healthy ketogenic foods ($\chi^2 = 0.121$, $p=0.728$) would prevent them from recommending a ketogenic diet for the treatment of T2DM by frequency of counseling (Table 10).

Standard of Care in Current Workplace.

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences between the percent of dietitians who reported that the
standard of care in their current workplace ($\chi^2 = 0.818, p=0.366$) would prevent them from recommending a ketogenic diet for the treatment of T2DM by the frequency of counseling (Table 10).

*Perceived Benefits of Nutritional Ketosis by Frequency of Counseling*

Dietitians were asked about the benefits they believe can result from a ketogenic diet for the treatment of T2DM. Each response to the question regarding the benefits of ketogenic diets for the treatment of T2DM was compared by frequency of counseling (Table 11).

**Weight Loss**

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.286, p=0.593$) between the percent of dietitians who reported that they believe weight loss to be a benefit of ketogenic diets for the treatment of T2DM by frequency of counseling (Table 11).

**Better Blood Glucose Management**

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 1.005, p=0.316$) between the percent of dietitians who reported that they believe better blood glucose management to be a benefit of ketogenic diets for the treatment of T2DM by frequency of counseling (Table 11).

**Reduced HbA1c**

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.373, p=0.752$) between the percent of dietitians who...
reported that they believe reduced HbA1c to be a benefit of ketogenic diets for the treatment of T2DM by frequency of counseling (Table 11).

**Reduced Hunger**

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.092, p=0.762$) between the percent of dietitians who reported that they believe reduced hunger to be a benefit of ketogenic diets for the treatment of T2DM by frequency of counseling (Table 11).

**Reduced Insulin Resistance**

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.381, p=0.537$) between the percent of dietitians who reported that they believe reduced insulin resistance to be a benefit of ketogenic diets for the treatment of T2DM by frequency of counseling (Table 11).

**Reduced Triglycerides**

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences ($\chi^2 = 0.040, p=0.842$) between the percent of dietitians who reported that they believe reduced triglycerides are a benefit of ketogenic diets for the treatment of T2DM by frequency of counseling (Table 11).
Table 11. Differences in the Beliefs of Dietitians Regarding Benefits of Ketogenic Diets Treatment for T2DM, Compared by Frequency of Counseling Clients with T2DM

<table>
<thead>
<tr>
<th>Benefits</th>
<th>n</th>
<th>Frequently</th>
<th>Infrequently</th>
<th>X²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight Loss</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Yes</td>
<td>189</td>
<td>81</td>
<td>81</td>
<td>0.286</td>
<td>0.593</td>
</tr>
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<td>No</td>
<td>15</td>
<td>12</td>
<td></td>
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<tr>
<td>Better Glucose Management</td>
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</tr>
<tr>
<td>Yes</td>
<td>177</td>
<td>67</td>
<td>56</td>
<td>1.005</td>
<td>0.316</td>
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<td>No</td>
<td>25</td>
<td>29</td>
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<td></td>
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<tr>
<td>Reduced HbA1c</td>
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<td></td>
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<td></td>
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<tr>
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<td>0.752</td>
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<td>No</td>
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<td>20</td>
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<tr>
<td>Reduced Hunger</td>
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<td>Reduced Insulin Resistance</td>
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<td>Reduced Triglycerides</td>
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<td>No</td>
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<tr>
<td>Reduced Blood Pressure</td>
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<tr>
<td>Yes</td>
<td>176</td>
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<td>1.259</td>
<td>0.262</td>
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<td>Reduced Requirement for Medication/Insulin</td>
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<td></td>
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<td>30</td>
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<td></td>
</tr>
</tbody>
</table>

Reduced Blood Pressure

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis indicated no significant differences ($\chi² = 1.259$, $p=0.262$) between the percent of dietitians who
reported that they believe reduced blood pressure to be a benefit of ketogenic diets for the
treatment of T2DM by frequency of counseling (Table 11).

**Reduced Requirements for Medication or Insulin**

Using the collapsed frequency of counseling variables, a 2x2 Chi square analysis
indicated no significant differences ($\chi^2 = 0.716, p=0.398$) between the percent of dietitians who
reported that they believe reduced requirements for diabetes medication or insulin to be a benefit
of ketogenic diets for the treatment of T2DM by frequency of counseling (Table 11).

**Summary**

The results of this survey of registered dietitians in Indiana indicate that, despite the
many cited benefits, the majority of dietitians do not recommend ketogenic diets for the
treatment of T2DM. Most dietitians indicated that they have a somewhat negative or very
negative attitude toward the ketogenic diet, while nearly half of the dietitians surveyed reported
being only moderately familiar with diets that induce nutritional ketosis. More than half of
respondents indicated that they believe the evidence supporting the use of ketogenic diets to treat
T2DM is inconclusive, however, most dietitians indicated that they believe nutritional ketosis
can result in weight loss, reduced hemoglobin A1c, better blood glucose management, reduced
insulin resistance, hunger and the need for diabetes medications or insulin. Although, the
majority of those surveyed did not believe that nutritional ketosis can result in reduced blood
pressure or reduced triglycerides.

Dietitians reported several concerns which prevent them from recommending ketogenic
diets for T2DM. These concerns include: long-term dietary adherence, palatability of the diet,
cardiovascular concerns, possible side effects of ketosis, the patient’s ability to access or afford
healthy ketogenic foods, renal concerns, hypoglycemia and the standards of care in current their workplace. Of those who reported that they do not recommend ketogenic diets because of concerns regarding diet adherence, significantly more indicated that their highest earned degree was a post-graduate degree. Additionally, significantly more of the dietitians who counsel clients with T2DM daily or weekly reported that concerns regarding possible side effects of ketosis prevent them from recommending ketogenic diets, compared to those who counsel T2DM clients less frequently.

The most commonly reported method used to teach blood glucose management was carbohydrate counting, indicating that the diabetic exchange system, which has been taught to dietitians in medical nutrition therapy classes for many years, has fallen out of favor. These results indicate that there is a discrepancy between the perceived benefits of nutritional ketosis and the number of dietitians who recommend this therapy option, highlighting the need to educate registered dietitians in Indiana about the safety and efficacy of nutritional ketosis for the treatment of T2DM.
CHAPTER 5

DISCUSSION

The purpose of this study was to examine the attitudes, beliefs, and practices of registered dietitians who are members of the Indiana Academy of Nutrition and Dietetics regarding dietary treatments for type 2 diabetes mellitus (T2DM). This chapter presents a summary of the results of this study and the implications of those findings.

Summary of Findings

The results of this survey indicated that registered dietitians in Indiana do not recommend ketogenic diets for the treatment of T2DM. Most dietitians (92.8%) indicated that they have never recommended a ketogenic diet for T2DM, and more than half (63%) reported that they do not believe they will ever recommend nutritional ketosis to a client with diabetes. More than half of the dietitians surveyed indicated that they believe that evidence to support the use of a ketogenic diet for the treatment of T2DM is inconclusive or weak. Although most dietitians correctly identified that the classic ketogenic diet (4:1) and the modified ketogenic diet (3:1) can result in nutritional ketosis, only half correctly identified the Modified Atkins diet (1:1) as a macronutrient distribution that can result in nutritional ketosis. The majority of RDs in Indiana reported having negative attitudes toward ketogenic diets, with nearly half reporting that they feel they would be judged negatively by their peers or colleagues if they were to recommend a
ketogenic diet for the treatment of T2DM. Additionally, most dietitians reported being only moderately or slightly familiar with diets that induce nutritional ketosis.

The most commonly reported method of teaching blood glucose management to clients with T2DM was carbohydrate counting. The average macronutrient distribution recommended by dietitians for the treatment of T2DM was 48.1 ± 6.9 percent from carbohydrate, 24.6 ± 7.1 percent from protein, and 27.3 ± 6.6 percent from fat. Most dietitians indicated that they “agree” or “strongly agree” that the recommendation of 45-65\% of calories from carbohydrate, a value established as the Acceptable Macronutrient Distribution Range (AMDR) by the Institute of Medicine in the *Dietary Reference Intakes* (IOM, 2002), and repeated in the *2015-2020 Dietary Guidelines for Americans* (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015), is appropriate for individuals with T2DM. Furthermore, an overwhelming majority of dietitians indicated that they believe individuals with T2DM should be discouraged from following a ketogenic diet.

No significant differences were found in the percent of dietitians who have ever recommended a ketogenic diet for the treatment of T2DM, or those who believe that they might recommend a ketogenic diet in the future for the treatment of T2DM, when compared by educational level or frequency of counseling individuals with T2DM. Similarly, no differences were found between the attitudes or beliefs of dietitians regarding the ketogenic diet, or how frequently it is recommended for the treatment of T2DM, by educational level or frequency of counseling individuals with T2DM. Finally, no significant differences were found between the perceived benefits of nutritional ketosis, or the concerns that prevent the recommendations of ketogenic diets, by educational level or frequency of counseling individuals with T2DM.
Significantly more dietitians who counsel individuals with T2DM frequently, reported that concerns regarding side effects of ketosis would prevent them from recommending a ketogenic diet for the treatment of T2DM, compared to those who counsel clients with T2DM infrequently. Additionally, significantly more dietitians who held post-graduate degrees reported that long-term dietary adherence would prevent them from recommending a ketogenic diet for the treatment of T2DM, compared to those who held an undergraduate degree.

**Methods Used to Help Manage Blood Glucose Levels**

The Diabetic Exchange System (American Diabetes Association and the Academy of Nutrition and Dietetics, 2008), taught to dietitians in medical nutrition therapy classes for years, has long been the standard method for teaching patients how to control their blood glucose through dietary measures. Recently, however, this system is, seemingly, falling out of favor, as basic and advanced carbohydrate counting is becoming more popular among RDs for the management of blood glucose. These methods teach individuals to count carbohydrate grams or “choices” with serving sizes based on those used in the exchange system (Hall, 2013).

The results of the present study indicate that registered dietitians in Indiana are more likely to use the carbohydrate counting method (75.6%) rather than the diabetic exchange system (6%), low Glycemic Index diets (1%), or ketogenic diets (1%) to help teach clients how to manage their blood glucose level. Additionally, 13% of the dietitians in this study indicated that they prefer to teach “other” methods of blood glucose management which included: individualized counseling using several methods (3.5%), whole-foods plant based method (2.5%), lower overall carbohydrate intake (2.5%), MyPlate method (1.5%), balanced portions and meal timing (1.5%), or weight maintenance (0.5%). These results shed light on the
inconsistencies between the dietary blood glucose management techniques being taught in medical nutrition therapy classes in the U.S. and those being used in the field by registered dietitians counseling clients with T2DM.

**Macronutrient Distribution Recommended to Treat T2DM**

The optimal macronutrient distribution for individuals with T2DM is an area of much debate. According to Sandouk & Lanzang (2017), no optimal dietary strategy exists for all individuals with obesity and T2DM. These authors remark that the best diet is one that achieves adherence by meeting a patient’s dietary preferences and energy needs. The results of this survey indicate that registered dietitians in Indiana recommend an average of 48.1±6.9% of calories from carbohydrate, 27.3±6.6% of calories from fat and 24.6±7.1% of calories from protein for the treatment of T2DM.

According to the Acceptable Macronutrient Distribution Range (AMDR), established by the Food and Nutrition Board of the Institute of Medicine, in the landmark *Dietary Reference Intakes* (IOM, 2002), and as included in the *Dietary Guidelines for Americans* (DGA) 2015-2020 (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015), the macronutrient recommendations (i.e., 10-35% fat, 10-35% protein, 45-65% carbohydrate) are intended to help individuals improve and maintain overall health and reduce the risk of chronic disease—the focus of the Dietary Reference Intakes, including the AMDR, is on *disease prevention*; the DRI were not intended to be used in the treatment of disease. Nonetheless, the macronutrient recommendations for the treatment of T2DM reported by dietitians in the present study fall within the AMDR (45-65% of calories from carbohydrate, 20-35% of calories from fat, 10-35% of calories from protein) recommended for healthy people. Additionally, 16% of
dietitians in this study reported that they “strongly agree” while 61% “agree” that the AMDR carbohydrate recommendations (45-65% of calories) are appropriate for individuals with T2DM. These results indicate the need to remind registered dietitians in Indiana about the intended and appropriate use of the AMDR recommendations.

**Macronutrient Distributions Associated with Nutritional Ketosis**

According to Rohel & Sewak (2017), several variations of the ketogenic diet exist, but all versions of the diet seek to reduce the intake of dietary carbohydrate and increase the intake of dietary fat. Diet variation which are known to induce nutritional ketosis include the 4:1 ratio classic ketogenic diet (90% fat, 6% protein, 4% carbohydrate), 3:1 ratio modified ketogenic diet (87% fat, 10% protein, 3% carbohydrate), 2:1 ratio modified ketogenic diet (82% fat, 12% protein, 6% carbohydrate) modified Atkins diet (typically prescribed in a 1:1 ratio-70% fat, 15% protein, 15% carbohydrate) and the medium chain triglyceride (MCT) diet (typically prescribed in a 1-2:1 ratio-71% fat, 19% protein, 10% carbohydrate) (Charlie Foundation, 2019).

The results of this survey indicate that most dietitians correctly identified the classic (4:1) ketogenic diet and modified (3:1) diet as capable of resulting in nutritional ketosis (Roehl & Sewak, 2017). However, only 53% correctly identified the modified Atkins (1:1) diet as being capable of causing nutritional ketosis (Park et al., 2019). Furthermore, most study participants reported being only slightly (25%) familiar or moderately (45%) familiar with diets which induce nutritional ketosis. The present study demonstrates that there is a poor understanding among registered dietitians in Indiana of the dietary macronutrient compositions that can result in nutritional ketosis. Additionally, the lack of familiarity among registered dietitians with diets
that result in nutritional ketosis should be addressed in order to increase their comfort with this
dietary therapy method.

**Attitudes and Beliefs concerning Ketogenic Diets for the Treatment of T2DM**

No research has been identified that investigates the attitudes and beliefs of registered
dietitians regarding nutritional ketosis as a treatment method for T2DM. The results of this study
found that dietitians in Indiana, overall, have negative attitudes toward ketogenic diets.
Participants overwhelmingly reported that they believe the evidence in support of the ketogenic
diet to treat T2DM is weak or inconclusive. When asked if they believe that ketogenic diets
should be discouraged for the treatment of T2DM, 41% of respondents indicated that they
“agree,” while 18% “strongly agree.” Many (34%) dietitians reported that they “agree” and
another 18% “strongly agree” that they would be judged negatively by their peers if they were to
recommend a ketogenic diet to treat T2DM. These results represent several factors, other than
the most recent research, that may be effecting the dietary recommendations made by dietitians
in Indiana. These should be addressed in future research to truly understand how attitudes and
beliefs effect the dietary treatment recommendations of registered dietitians.

**Benefits of Ketogenic Diets and Concerns Preventing RD from Recommending Them**

Diets that result in nutritional ketosis can provide numerous benefits for the treatment of
T2DM including weight loss, the reduction of HbA1c, blood pressure, and triglycerides as well
as an increase in HDL cholesterol (Evert et al., 2019). Additionally, nutritional ketosis may lead
to reduction in insulin resistance (Goday, et al, 2016), and the use of diabetes medications and
insulin for many individuals (Hallberg et al., 2018; Tay et al., 2015). The results of the present
study indicate that registered dietitians in Indiana correctly identified several of the benefits above as benefits of ketogenic diets. The majority of dietitians indicated that they believe weight loss, reduced HbA1c, reduced blood glucose, reduced insulin resistance, reduced need for diabetes medication or insulin, and reduced hunger can result from ketogenic diets. However, most dietitians do not perceive reduced triglycerides or reduced blood pressure as benefits of nutritional ketosis. Despite the numerous documented benefits of nutritional ketosis, and the acknowledgement of these benefits by the majority of dietitians surveyed, the results of this study indicate that most dietitians in Indiana do not recommend this dietary treatment method to their clients with T2DM.

Participants of the present study reported several concerns that prevent them from recommending ketogenic diets, including cardiovascular concerns, renal concerns, possible side-effects of ketosis, possible hypoglycemia, long-term dietary adherence, the patient’s ability to access/afford health ketogenic foods, or standards of care in the workplace. Dietitians who reported counseling individuals with T2DM frequently were significantly (p=0.028) more likely to indicate that concerns regarding the side effects of ketosis would prevent them from recommending a ketogenic diet to treat T2DM when compared to those who counsel individuals with T2DM infrequently. Additionally, among the dietitians who indicated that long-term dietary adherence concerns would prevent from recommending this dietary pattern, significantly ($\chi^2=3.953, p=0.047, A.R. 2.0$) more held a post graduate degree.

The safety and tolerability of ketogenic diets have been demonstrated in clinical trials (Hallberg et al., 2018; Goday et al., 2016; Westman et al., 2008) Though some negative side effects have been reported with the use of this diet to treat T2DM (e.g., headache, diarrhea, vomiting, muscle weakness, or cramps), when compared with a standard low-calorie diet, the
only side-effect experienced significantly more frequently among the ketogenic diet group was constipation (Goday et al., 2016). Friedman et al. (2012) demonstrated that high-protein, low-carbohydrate diets do not lead to alterations in kidney functions when compared to low-fat diets, among obese adults who followed the diet for 24-months. No significant differences were found between kidney function, as measured by estimated glomerular filtration, albumin, calcium excretion, or serum urinary solutes, between groups at the conclusion of the intervention. However, the diet is contraindicated for use in individuals with existing renal impairment (Evert et al., 2019). Additionally, clinical trials have demonstrated that dietary adherence is similar between individuals following low-carbohydrate diets, low-fat diets and low-glycemic index diets (Paoli et al., 2011; Westman et al., 2008; Yancy et al., 2004).

The results of the current study highlight the inconsistencies that exist between the beliefs of registered dietitians regarding the safety and efficacy of ketogenic diets for the treatment of T2DM, and the benefits and side effects of this dietary pattern supported by the literature. Despite the acknowledgement by dietitians that ketogenic diets can aid in reaching the most important MNT target goals of T2DM, i.e., reduced weight, lowered HbA1c, blood glucose and the need for medication or insulin, they are not recommending this dietary treatment method. Although trials have demonstrated that ketogenic diets may cause only mild side-effects, and have similar adherence rates compared to other diet strategies, the results of the present study indicate that several concerns prevent registered dietitians from recommending a ketogenic diet for the treatment of T2DM.
Summary

The results of the present study suggest that registered dietitians prefer to teach carbohydrate counting, rather than the diabetic exchange system, when providing diabetes self-management education to individuals with T2DM. Most dietitians indicated that they believe the carbohydrate recommendations (AMDR) for healthy individuals established by the Institute of Medicine’s Dietary Reference Intakes, and included in the Dietary Guidelines for Americans, are appropriate for individuals with T2DM. Additionally, the most commonly reported macronutrient recommendations made by dietitians to treat T2DM fall within the macronutrient distribution range established by the Institute of Medicine. However, the AMDR are not intended to be used in the treatment of chronic disease, indicating the need to remind registered dietitians of the proper use of these recommendations.

Current literature suggests diets that result in nutritional ketosis can provide many benefits to individuals with T2DM, including weight loss, improved glycemic control, reduced HbA1c, reduced triglycerides, blood pressure and hunger, as well as increased HDL cholesterol. Nonetheless, the present study indicates that dietitians in Indiana do not recommend these diets, and do not believe that they will recommend this dietary pattern in the future to treat T2DM. Overall, study participants were only moderately familiar with ketogenic diets, and associate nutritional ketosis with more “extreme” macronutrient distributions, with less than half of RDs accurately identifying the very popular modified Atkins diet as a macronutrient distribution capable of resulting in nutritional ketosis. The results of the present study indicate that although registered dietitians identified many benefits of ketogenic diets for T2DM treatment, their attitudes and beliefs may be affecting their practice recommendations. Education and training are
required to help registered dietitians become more familiar and comfortable with this dietary therapy method.
CHAPTER 6

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

The purpose of this study was to examine the attitudes, beliefs, and practices of registered dietitians who are members of the Indiana Academy of Nutrition and Dietetics regarding dietary treatments for type 2 diabetes mellitus (T2DM). This chapter presents the conclusions, limitations, and future research recommendations on this topic.

Conclusions

Type 2 diabetes mellitus is on the rise in the United States and around the world. In the United States alone, it is estimated that the prevalence of diabetes (both type 1 and type 2) will increase by 54% between 2015 and 2030, effecting more than 54.9 million Americans (Rowley et al., 2017). Medical Nutrition Therapy provided by a registered dietitian is an effective tool for preventing and managing T2DM (Morris & Wylie-Rosett, 2010). The goal of nutrition therapy in the treatment of T2DM is to reach and maintain healthy body weight, body mass index, and HbA1c, while stabilizing blood glucose values to avoid hyperglycemia or hypoglycemia (Chamberlain et al., 2016). Registered dietitians must use evidenced based practice to and clinical judgement when prescribing MNT for T2DM, as several dietary strategies may be effective for reaching these goals (Franz et al., 2017).
Diets that cause nutritional ketosis have been shown to be as effect as other dietary strategies for weight loss (Westman et al., 2008), and more effective than other dietary therapies for reducing blood glucose, HbA1c and the need for medications or insulin (Hallberg et al., 2018; Tay et al., 2015) for patients with T2DM. Despite these documented benefits it is still unclear if registered dietitians are utilizing this therapy method in the treatment of their diabetic clients.

For this reason, the focus of this study was to evaluate how many dietitians in Indiana recommend ketogenic diets to treat T2DM. Results indicated that only 7% of the dietitians surveyed reported ever having recommended a diet that causes nutritional ketosis for the treatment of T2DM. Additionally, 49% of dietitians reported that they do not believe they will ever recommend a ketogenic diet to treat T2DM.

This study investigated the macronutrient distributions that dietitians use to treat T2DM. These results indicate that RDs are likely to recommend a macronutrient distribution (48±6.9% calories from carbohydrate, 27.3±6.6% of calories from fat, 24.6± 7.7% of calories from protein recommended on average) similar to the AMDR, established by the Food and Nutrition Board of the Institute of Medicine in the Dietary Reference Intakes (IOM. 2002) and as included in the Dietary Guidelines for Americans (US DHHS, 2015) for the treatment of T2DM. Although these recommendations and guidelines are intended for healthy individuals, not those with chronic disease, when dietitians were asked if they believe the AMDR carbohydrate recommendations are appropriate for individuals with T2DM, 61% agreed while 16% strongly agreed with these recommendations.

This study sought to understand how dietitian’s attitudes and beliefs about this debated and controversial diet therapy might affect their practice recommendations. These result indicate
that overall, dietitians in Indiana have negative attitudes toward ketogenic diets for the treatment of T2DM. The results of the present study indicated that most dietitians (41% agree, 18% strongly agree) believe that individuals with T2DM should be discouraged from following a ketogenic diet. Most dietitians are only moderately or slightly familiar with ketogenic diets and a number of dietitians indicate that they fear judgment from colleagues if they were to recommend a ketogenic diet for the treatment of T2DM.

Finally, this study proceeded to investigate the differences in attitudes, beliefs and practices of registered dietitians based on educational level and frequency of counseling individuals with T2DM. No significant differences were found in attitudes or beliefs by educational level or frequency of counseling clients with T2DM. However, when perceived benefits and concerns regarding nutritional ketosis were evaluated by these variables, it was found that significantly more (χ²=4.839, p=0.028) dietitians who counsel individuals frequently report that side effects from ketosis would prevent them from recommending a ketogenic diet for the treatment of T2DM compared to those who counsel less frequently. Additionally, those with post-graduate degrees were significantly more (χ²= 3.953, p=0.047) likely to report that concerns regarding diet adherence would prevent them from recommending a ketogenic diet for the treatment of T2DM, compared to those with an undergraduate degree.

As more research becomes available, it is likely that more professional organizations will begin to endorse low-carbohydrate and very-low-carbohydrate ketogenic diets as safe and effective dietary therapy options for some individuals with T2DM, as the American Diabetes Association has recently done (Evert et al., 2019). As this diet therapy becomes more widely accepted, registered dietitians will be heavily relied upon to recommend and oversee ketogenic diet therapies for patients with T2DM. The results of this study indicate a lack of familiarity
with, and negative attitudes toward ketogenic diets from registered dietitians in Indiana. However, there are many documented benefits of a ketogenic diet for the treatment of T2DM, including weight loss, reduced blood glucose, and HbA1c and a reduced requirement for medications and insulin (Goday et al., 2016; Hallberg et al., 2018; Tay et al., 2015), which most registered dietitians in this study acknowledged. Therefore, more research is needed to explore why dietitians in Indiana do not recommend this diet therapy.

Strengths and Limitations of the Study

This was the first known study to evaluate the attitudes, beliefs and practices of dietitians regarding nutritional ketosis as a dietary treatment method for T2DM. Therefore, the survey instrument was created by the researcher to address these research questions. A strength of the study was the survey instrument which was evaluated for face content and validity by 2 registered dietitians and 2 experts in survey design. A major limitation of the study was the sample size (n=199) that did not achieve the 279 responses need to obtain results that are representative of the target population with a 4% margin of error as is standard. Therefore, these results are considered preliminary and should be interpreted cautiously.

Future Recommendations

The results of this study warrant further research. The following are suggestions based on the results of this study

- The present study asked a few question which ultimately were not useful to answer the research questions. In the future, it is recommended to remove survey Q 20
regarding the methods used to stay current with diabetes research as this data was not pertinent.

- The demographics section of the survey did not offer as many response options as necessary to capture all of the professional certifications/credentials, or areas of dietetics practice without requiring participants to provide a text response. If this survey instrument is used in the future, it is recommended that “outpatient counseling” be added as a response to Q24 and that “Indiana Certified Dietitian” – or if the survey is given after 2020, that “Indiana Licensed Dietitian” – be added as a response to Q25.

- The present study asked about sources of formal education which included professional conferences and webinars as possible response options. It is suggested that editing this question to ask only about the education gained in university coursework would provide useful data concerning the curriculum of undergraduate and graduate dietetics programs in Indiana.

- The present study was distributed three times through the Indiana Academy of Nutrition and Dietetics member email contact list. If this study were to be repeated, it is suggested that the survey be distributed at least one additional time in order to achieve a higher response rate.

- It is recommended that the survey be repeated at a national level to members of the Academy’s Diabetes Care and Education practice group to find out if the results observed in Indiana are representative of those who counsel patients with diabetes nationwide.
REFERENCES


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https://doi.org/10.1111/j.1528-1167.2008.01821.x


doi: 10.1016/S0140-6736(16)00618-8
APPENDIX A

INSTITUTIONAL REVIEW BOARD MATERIALS

A-1    IRB Approval Letter

A-2    CITI Certificate of Completion
APPENDIX A-1 Institutional Review Board Approval Letter

Office of Research Integrity
Institutional Review Board (IRB)
2000 University Avenue
Muncie, IN 47306-0155
Phone: 765-285-5052
Email: orhelp@bsu.edu

DATE: March 29, 2019
TO: Madison Hayes, B.S.
FROM: Ball State University IRB
RE: IRB protocol # 1406860-1
TITLE: Attitudes, Beliefs, and Practices of Registered Dietitians in Indiana Regarding Nutritional Ketosis as a Dietary Treatment for Type 2 Diabetes
SUBMISSION TYPE: New Project
DECISION: APPROVED
PROJECT STATUS: EXEMPT
DECISION DATE: March 29, 2019
REVIEW TYPE: Exempt Review

The designated reviewer for the Institutional Review Board (IRB) reviewed your protocol and determined the procedures you have proposed are appropriate for exemption under the federal regulations. As such, there will be no further review of your protocol, and you are cleared to proceed with the procedures outlined in your protocol. As an exempt study, there is no requirement for continuing review. Your protocol will remain on file with the IRB as a matter of record. All research under this protocol must be conducted in accordance with the approved submission and in accordance with the principles of the Belmont Report.

Exempt Categories:

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Research conducted in established or commonly accepted educational settings, that specifically involves normal educational practices that are not likely to adversely impact students’ opportunity to learn required educational content or the assessment of educators who provide instruction. This includes most research on regular and special education instructional strategies, and research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.</td>
</tr>
</tbody>
</table>
| 2 | Research that only includes interactions involving educational test (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met: (i) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through

Generated on IRBNet
identifiers linked to the subjects; (ii) Any disclosure of the human subjects’ responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects’ financial standing, employability, educational advancement, or reputation; or (iii) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by 46.111(a)(7).

Category 3: Research involving benign behavioral interventions in conjunction with the collection of information from an adult subject through verbal or written responses (including data entry) or audiovisual recording if the subject prospectively agrees to the intervention and information collection and at least one of the following criteria is met: (A) The information obtained is recorded by the investigator in such a manner that the identity of human subjects cannot be readily ascertained, directly or through identifiers linked to the subjects; (B) Any disclosure of the human subjects’ responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects’ financial standing, employability, educational advancement, or reputation; or (C) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects can be readily ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by 46.111(a)(7).

Category 4: Secondary research for which consent is not required.

Category 5: Research and demonstration projects that are conducted or supported by a Federal department or agency, or otherwise subject to the approval of department or agency heads, and that are designed to study, evaluate, improve, or otherwise examine public benefit or service programs, including procedures for obtaining benefits or services under those programs, possible changes in or alternatives to those programs or procedures, or possible changes in methods or levels of payment for benefits or services under those programs.

Category 6: Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed or (ii) if a food is consumed that contains a food ingredient at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

Category 7: Storage or maintenance for secondary research for which broad consent is required: Storage or maintenance of identifiable private information or identifiable biospecimens for potential secondary research use if an IRB conducts a limited IRB review and makes the determinations required by 46.111(a)(8).

Category 8: Secondary research for which broad consent is required: Research involving the use of identifiable private information or identifiable biospecimens for secondary research use, if the following criteria are met: (1) Broad consent for the storage, maintenance, and secondary research use of the identifiable private information or identifiable biospecimens was obtained in accordance with §46.116(a)(1) through (4), (a)(6), and (d); (2) Documentation of informed consent or waiver of documentation of consent was obtained in accordance with §46.117; and (3) An IRB conducts a limited IRB review and makes the determination required by §46.111(a)(7) and makes the determination that the research to be conducted is within the scope of the broad consent referenced in paragraph (d)(9)(i) of this section; and (iv) The investigator does not include returning individual research results to participants as part of the study plan. Note: This provision does not prevent an investigator from abiding by any legal requirements to return individual research results.

Ball State Specific Exempt Categories

Category 9: Research involving publicly observable online behavior. Any online behavior that requires a person’s permission to access is considered private and does not fall under this category. Information that cannot be accessed by the general population would also be considered private.
Category 10: Research involving BSU students who are under 18 but have legal authority over their FERPA protected information. Only studies that fall into another exempt category except for sampling from BSU students who are under 18 can be considered exempt in this category.

While your project does not require continuing review, it is the responsibility of the P.I. (and, if applicable, faculty supervisor) to inform the IRB if the procedures presented in this protocol are to be modified or if problems related to human research participants arise in connection with this project. Any procedural modifications must be evaluated by the IRB before being implemented, as some modifications may change the review status of this project. Please contact Grace Yoder at (765) 285-5034 or gmyoder@bsu.edu if you are unsure whether your proposed modification requires review or have any questions. Proposed modifications should be addressed in writing and submitted electronically to the IRBNet as a "Modification/Amendment" for review. Please reference your IRB protocol number 1408860-1 in any communication to the IRB regarding this project.

In the case of an adverse event and/or unanticipated problem, you will need to submit written documentation of the event to IRBNet under this protocol number and you will need to directly notify the Office of Research Integrity (http://www.bsu.edu/irb) within 5 business days. If you have questions, please contact Grace Yoder at (765) 285-5034 or gmyoder@bsu.edu.

Reminder: Even though your study is exempt from the relevant federal regulations of the Common Rule (45 CFR 46, subpart A), Ball State has elected to hold you accountable to these regulations to encourage best research practices. You and your research team are not exempt from ethical research practices and should therefore employ all protections for your participants and the data which are appropriate to your project.
Appendix A-2  CITI Certificate of Completion

This is to certify that:

Madison Hayes

Has completed the following CITI Program course:

Social & Behavioral Research - Basic/Refresher  (Curriculum Group)
Social & Behavioral Research - Basic/Refresher  (Course Learner Group)
1 - Basic Course  (Stage)

Under requirements set by:

Ball State University

Verify at www.citiprogram.org/verify/?wb349ae03-c9b2-4299-a1f5-3f3681c06fd8-28195038
APPENDIX B

SURVEY INSTRUMENT
Appendix B-1 Survey Instrument

Attitudes, Beliefs and Practices of Registered Dietitians Regarding Dietary Treatments for T2DM

Q1. Are you a Registered Dietitian/Dietitian Nutritionist?
   o Yes
   o Not yet—but I hope to be in the future!

Q2. How often do you counsel patients with type 2 diabetes (T2DM)? [Only display if answer to Q1 is yes]
   o Daily
   o A few times a week
   o A few times a month
   o Rarely or never

Q3. Which of these methods do you use when you teach clients with T2DM how to self-manage their blood glucose? [Only display if answer to Q1 is yes]
   o I do not counsel clients with T2DM
   o Carbohydrate counting (carb counting)
   o Diabetic exchange list
   o Ketogenic diet
   o Glycemic index
   o Other (please explain)

Q4. What macronutrient percent do you typically recommend for the dietary management of T2DM? [Only display if answer to Q1 is yes]
   % calories from carbohydrate
   % calories from protein
   % calories from fat

Q5. How familiar are you with diets that induce nutritional ketosis (i.e., ketogenic diets)?
   o Extremely familiar
   o Very familiar
   o Moderately familiar
   o Slightly familiar
   o Not familiar at all

Q6. Did you attend Mary Susan Spears' presentation at the 2019 annual IAND meeting entitled "Ketogenic Therapy: Expanding Beyond Seizure Control?"
   o Yes
   o No
Q7. Which of these dietary combinations can result in nutritional ketosis? (select all that apply)

- 90% fat, 6% protein, 4% carbohydrate
- 87% fat, 10% protein, 3% carbohydrate
- 82% fat, 12% protein, 6% carbohydrate
- 70% fat, 15% protein, 15% carbohydrate
- 35% fat, 25% protein, 45% carbohydrate
- I am not sure

Q8. Have you ever recommended a ketogenic diet to treat T2DM? [Only display if answer to Q1 is yes]

- Yes
- No
- Unsure

Q9. Do you believe you might recommend a ketogenic diet to a client with T2DM in the future? [Only display if answer to Q1 is yes]

- Yes
- No
- Unsure

Q10. Which of these would you recommend for the treatment of T2DM? (select all that apply)

- I would not recommend any ketogenic diet for the treatment of T2DM
- Classic Ketogenic diet -- 90% fat, 6% protein, 4% carbohydrate
- Modified ketogenic diet -- 87% fat, 10% protein, 4% carbohydrate
- Modified ketogenic diet-- 82% fat, 12% protein, 6% carbohydrate
- Modified Atkins diet -- 70% fat, 15% protein, 15% carbohydrate

*For the remainder of the survey, “ketogenic diet” will be defined as any diet that induces nutritional ketosis

Q11. Would any of the following prevent you from recommending a ketogenic diet for the treatment of T2DM?

<table>
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<tr>
<th>Concern</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular concerns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term adherence to the diet</td>
<td></td>
<td></td>
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<tr>
<td>Palatability of ketogenic foods</td>
<td></td>
<td></td>
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<tr>
<td>Renal concerns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palatability of ketogenic foods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible side effects of ketosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient’s ability to access or afford healthy ketogenic foods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible hypoglycemia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard of care in current workplace prevents me from recommending this diet</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q12. Do you believe that a ketogenic diet can provide any of the following benefits for the treatment of T2DM?

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Better blood glucose management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced hemoglobin A1c</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced hunger</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced insulin resistance</td>
<td></td>
<td></td>
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<tr>
<td>Reduced blood pressure</td>
<td></td>
<td></td>
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<tr>
<td>Reduced triglycerides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced requirements for oral glucose lowering medications or insulin</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q13. In your opinion, how strong is the evidence to support the use of a ketogenic diet in the treatment/management of type 2 diabetes?

- Very strong
- Strong
- Inconclusive
- Weak
- Very weak

Q14. How safe do you consider nutritional ketosis to be for the treatment/management of type 2 diabetes?

- Very safe
- Somewhat safe
- Neither safe nor unsafe
- Probably not safe
- Definitely not safe

Q15. Which response best represents your attitudes towards the ketogenic diet?

- Very positive
- Somewhat positive
- Neither positive nor negative
- Somewhat negative
- Very negative

Q16. In your opinion, the ketogenic diet is:

- Recommended too frequently by RD/RDNs for the treatment/management of type 2 diabetes
- Not recommended frequently enough by RD/RDNs for the treatment/management of type 2 diabetes
- Recommended appropriately by RD/RDNs for the treatment/management of type 2
Q17. To what extent do you agree or disagree with this statement: “I believe that patients with T2DM should be discouraged from following a ketogenic diet.”
   o Strongly agree
   o Agree
   o Neither agree nor disagree
   o Disagree
   o Strongly disagree

Q18. To what extent do you agree or disagree with this statement: "I feel that I would be judged negatively by my peers/colleagues if I recommend a ketogenic diet to a client with T2DM."
   o Strongly agree
   o Agree
   o Neither agree nor disagree
   o Disagree
   o Strongly disagree

Q19. Have you received formal education about nutritional ketosis (e.g., ketogenic diets) from any of the following sources? (select all that apply)
   o I have never received any formal education about nutritional ketosis
   o Continuing education courses (i.e., webinars, presentations) (select all that apply)
   o Dietetic internship
   o Undergraduate coursework
   o Graduate coursework
   o Professional conference (e.g., FNCE)

Q20. Which of these resources do you use to stay current about research regarding dietary treatments for T2DM? (select all that apply)
   o Peer reviewed studies/papers
   o Publications from professional organizations (American Diabetes Association or Academy of Nutrition and Dietetics)
   o Continuing education material or expert presentations
   o Media sources (Social media, news sources, TV, radio, podcasts)


   To what extent do you agree or disagree with this recommendation for people with T2DM?
   o Strongly Agree
   o Agree
   o Neither agree nor disagree
   o Disagree
   o Strongly disagree
Demographic Characteristics:

Q22. To which generational category do you belong?
   - Silent Generation (born between 1928-1945)
   - Baby Boomer (born between 1946-1964)
   - Generation X (born between 1965-1980)
   - Millennial (born between 1981-1996)
   - Generation Z (born between 1997-2012)

Q23. What is your highest earned degree?
   - Associate’s
   - Baccalaureate
   - Master’s
   - Doctorate

Q24. Primary area of dietetics practice?. (Select all that apply) [Only display if answer to Q1 is yes]
   - Acute or long-term healthcare (clinical)
   - Public health
   - Community nutrition
   - Education
   - Private practice
   - Industry
   - Research
   - Government
   - Food systems management
   - Other (please explain)

Q25. Which professional credentials do you hold? (Select all that apply) [Only display if answer to Q1 is yes]
   - RD(N)- Registered Dietitian (Nutritionist) (CDR)
   - CDE- Certified Diabetes Educator (National Certification Board for Diabetes Educators)
   - CLC- Certified Lactation Counselor
   - IBCLC- International Board Certified Lactation Consultant (International Board of Lactation Consultant Examiners)
   - CNSC- Certified Nutrition Support Clinician ( ASPEN)
   - CSG- Certified Specialist in Gerontological Nutrition (CDR)
   - CSO- Certified Specialist in Oncology Nutrition (CDR)
   - CCSP-Certified Specialist in Pediatric Nutrition (CDR)
   - CSR- Certified Specialist in Renal Nutrition (CDR)
   - CSSD- Certified Specialist in Sports Dietetics (CDR)
   - Other (please specify)

Q26. How many years have you been practicing as a dietitian? [Only display if answer to Q1 is yes]
   Grab the slider and pull
Q27. Current employment status:
   o Part-time
   o Full-time
   o Unemployed
   o Retired
   o Student
APPENDIX C

LETTERS OF PERMISSION AND CONSENT

C-1 Letter of Permission to Distribute Survey

C-2 Letter of Informed Consent
Appendix C-1 Letter of Permission to Distribute Survey

To: Madison Hayes, Graduate Student
   mhayes@bsu.edu

Re: Attitudes, Beliefs, and Practices of Registered Dietitians Regarding Dietary Treatments for Type 2 Diabetes

Date: March 14, 2019

The Indiana Academy of Nutrition and Dietetics (IAND) is willing to send out the email blurb to all members of the Indiana Academy. We understand that the email will include the link to your online survey entitled “Attitudes, Beliefs, and Practices of Registered Dietitians Regarding Dietary Treatments for Type 2 Diabetes.”

Once you send us the email blurb, we will be happy to distribute it three times as requested.

Sincerely,

Mark McInerney, DHSc., RD, CD
President
Indiana Academy of Nutrition and Dietetics
2860 W. Shore Drive
Crawfordsville, IN 47933
land_exec@eatrightin.org
Appendix C-2 Letter of Informed Consent

The purpose of this study, *Attitudes, Beliefs, and Practices of Registered Dietitians in Indiana Regarding Nutritional Ketosis as a Dietary Treatment for Type 2 Diabetes*, is to examine the attitudes, beliefs, and practices of members of the Indiana Academy of Nutrition and Dietetics regarding dietary treatment recommendations for type 2 diabetes mellitus (T2DM). To be eligible to participate in this study, you must be 18 years of age or older and a member of the Indiana Academy of Nutrition and Dietetics.

Participants will be asked to complete an anonymous survey containing multiple choice questions about nutrition practices and dietary recommendations for individuals with T2DM. The survey should take less than 7 minutes to complete. All data will be collected anonymously; you will not be asked to provide any identifiable information other than your professional credentials. The data will be stored on a password protected computer and flash drive for three years.

There are no anticipated risks or discomforts associated with taking this survey. This survey is completely voluntary. You are not required to answer all of the questions. You may quit the survey at any time.

For questions about your rights as a research subject, please contact the Director, Office of Research Compliance, Ball State University, Muncie, IN 47306, (765) 285-5070, orihelp@bsu.edu

*Researcher Contact Information:*  
Madison Hayes, mhayes@bsu.edu  
Dr. Carol Friesen, cfriesen@bsu.edu

By selecting the "I agree" button you acknowledge that you have read the information above and agree to participate in the survey by giving your informed consent. If you do not wish to participate in the survey, please select the "I do not agree" button

Do you agree to participate in this research study?

- I Agree
- I do not agree
APPENDIX D

RECRUITMENT EMAILS BY WAVE

D-1 Initial Email

D-2 Second Wave Email

D-3 Third Wave Email

D-4 QR Code Linked to Survey
Appendix D-1 Initial Email Survey

Email #1: Study Description and Link to Qualtrics Survey

Dear Colleague,

My name is Madison Hayes. I am a graduate student in Nutrition and Dietetics at Ball State University. I am working with Carol Friesen, PhD, RDN, CD and Christy Tunnell, MBA, RD, CD, to complete my thesis. The purpose of my study is to identify the attitudes, beliefs and current practices of registered dietitians regarding dietary treatments for type 2 diabetes.

To access this brief survey (less than 7 minutes), click on (or copy) this link: https://bsu.qualtrics.com/jfe/form/SV_elX5JRv6izqqPKB

Your participation in this anonymous survey is completely voluntary. No personally identifiable information will be collected. The Ball State University Institutional Review Board has approved this survey as exempt (Study #1406960-1). Should you have any comments or questions about this survey, please contact me at mhayes@bsu.edu.

Thank you for your assistance.

Sincerely,

Madison Hayes, RDN
Graduate Assistant
mhayes@bsu.edu

IAND | www.eatrightin.org
Appendix D-2 Second Wave Email

Email #2: Thank You and Additional Request for Participation

Dear Colleague,

If you have already completed the *Attitudes, Beliefs, and Practices of Registered Dietitians Regarding Dietary Treatments for T2DM* survey, please except my thanks and disregard this email.

If you have not completed the survey, please consider taking a few minutes do so now. Simply click or copy this link [https://bsu.qualtrics.com/jfe/form/SV_etXsJRVglZqPKB](https://bsu.qualtrics.com/jfe/form/SV_etXsJRVglZqPKB) to complete the brief (less than 7 minute), anonymous survey.

Ball State University Institutional Review Board has approved this survey as exempt (Study # 1406860-1). Should you have any comments or questions, please contact me at [mhayes@bsu.edu](mailto:mhayes@bsu.edu).

Thank you for your assistance.

Sincerely,

Madison Hayes, RDN
Graduate Assistant
[mhayes@bsu.edu](mailto:mhayes@bsu.edu)
Appendix D-3 Third Wave Email

Email #3: Thank You and Repeated Request for Participation

Dear Colleague,

If you have already completed the *Attitudes, Beliefs, and Practices of Registered Dietitians Regarding Dietary Treatments for T2DM survey*, please except my thanks and disregard this email.

If you have not completed the survey, please consider taking a few minutes do so now. Simply click or copy this link [https://bsu.qualtrics.com/jfe/form/SV_etX5IRv6ZcqPKB](https://bsu.qualtrics.com/jfe/form/SV_etX5IRv6ZcqPKB) to complete the brief (less than 7 minute), anonymous survey.

Ball State University Institutional Review Board has approved this survey as exempt (Study # 1406860-1). Should you have any comments or questions, please contact me at mhayes@bsu.edu.

Thank you for your assistance.

Sincerely,

Madison Hayes, RDN
Graduate Assistant
mhayes@bsu.edu

IAND | [www.eatrightin.org](http://www.eatrightin.org)
Appendix D-4 QR Code Link to Survey