Weight Loss in Obese Adults on the Ketogenic Diet

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Obesity is an epidemic that has increased in prevalence over the past several years according to the Centers of Disease Control and Prevention [CDC] (2020). Nearly half of the United States population is obese at a staggering 42.4% obesity rate- a rate that has tripled from 1975 to 2016. Obesity is the number one cause of mortality in adults (CDC, 2020). The mortality rate from obesity as an underlying factor is higher than for people who are underweight. Contributing factors for obesity include poor dietary patterns, education and inactivity. In 2016, obesity-related healthcare costs in the United States was $260.6 billion (Cawley et al., 2021).

According to the World Health Organization [WHO] (2021), obesity is defined as excessive fat accumulation that may impair health as a result of an imbalance of caloric intake and caloric output. WHO (2021) defines a body mass index (BMI) of 30 or higher as obese. Furthermore, it is reported the pervasiveness of diseases which are due to obesity, to include, cardiovascular disease, adult onset diabetes, musculoskeletal disorders, some forms of cancer and even psychological effects (WHO, 2021). There are countless physical and mental attributes that reversing obesity can unearth in an individual ranging from increased energy, improvement or resolution of type II diabetes, sleep apnea to decreasing gastrointestinal reflux (“Seven Benefits of Losing Weight,” n.d.). Piay et al. (2021) found a direct positive correlation found with weight loss with improved mental health. They reported psychological distress in obese adults decreased from 83.6% to 63.3% supporting the positive effects of weight loss.

Healthy People 2030 is the next decade’s campaign to improve health by following data-driven national objectives and goals. The corrective nature of Healthy People

2030 for obese adults highlights behavior modifications. The Mayo Clinic (2021) further explores dietary choices to treat obesity as a behavior modification by suggesting making healthier food choices and restricting particular food groups such as carbohydrates. Modius (2019) highlights the ketogenic diet's embrace for healthier food choices such as healthy omega 3 fats and the restriction of food groups such as carbohydrates to 20-50 grams per day to put the body into a state of ketosis and therefore lose weight. Weight loss can be attained by expelling more calories than intake which will show in decreased pounds by body weight ("Weight Reduction," n.d.).

As there are many weight loss options, the ketogenic diet has become a popular choice in the management for weight loss. The ketogenic diet has been the most popular Google search from 2016 to 2018 and had nearly 10 million searches in the year 2020 alone (Hunt, 2021). This diet has been credited with its success for rapid weight loss without restricting taste nor allowing the feeling of starvation following a low calorie diet. Hunt (2021) defines the ketogenic diet as high in fats, low in carbohydrates and moderate in protein intake. These ratios contribute to ketone produced in the body which uses this as fuel for energy or fat loss, rather than carbohydrates. Because ketones deplete stored energy (excess fat) rather quickly, it can be understood why the ketogenic diet has boomed in popularity in the past few years as a choice to lose weight (Hunt, 2021).

Problem Statement

Obesity is a worldwide endemic nearly tripling in rate since 1975. In 2016 it was reported that over 650 million people worldwide were not only overweight, but obese (WHO, 2021). Obesity is preventable and treatable with behavior modifications like dietary changes to lose weight and leads to improved overall health both physically

and psychologically (Mayo Clinic, 2021). The ketogenic diet is a viable option for obese adults to achieve their weight loss goals which overall improve physical and psychological distress from obesity (Piya et al., 2021).

Thesis and Aims

The ketogenic diet is a successful and sustainable diet for obese adults to lose weight. One aim of this project is to provide evidentiary support for the ketogenic diet. An additional aim is to disseminate up to date literature to primary care providers in order to offer the ketogenic diet as a sustainable option for weight loss, to reverse disease risk, and, essentially, regain optimal health.

PICO Question

In obese adults does the ketogenic diet as compared to a low caloric diet decrease weight?

Background and Significance

The body mass index (BMI) is a value based on height and weight in order to classify one's weight. It is obtained by an individual's weight in kilograms divided by the square of their height in meters (WHO, 2021). A healthy BMI is considered between 18.5 to 24.9, a BMI greater than 25 is considered overweight, and a BMI over 30 is obesity (CDC, 2021). As the BMI climbs upward, the risk of developing disease increases, for example diabetes. The risk of developing diabetes quadrupled worldwide since 1980 (CDC, 2021). As weight decreases improves insulin sensitivity, this often reverses type II diabetes where patients no longer need medication (Park, 2017). Beyond physiological benefits of weight loss, the CDC (2021) mentions that even a modest 5 to 10 percent decrease in body weight promotes psychological health benefits such as improving general mood and self-confidence.

There are many popular diets that claim to reverse obesity quickly and efficiently without restricting calories such as the Atkins Diet (O'Connor, 2019). The Atkins Diet is similar to the ketogenic diet by restricting carbohydrate and protein percentages of dietary intake, however, the Atkins Diet gradually increases carbohydrate intake over time which results in initial weight loss but not sustained as in the ketogenic diet. The ketogenic diet has been successful for losing weight due to the benefit of blood sugar level stability as a result of low carbohydrate intake. Ultimately, by stabilizing blood sugar levels, lowers the hormone insulin which is attributed to weight gain (O'Connor, 2019).

The ketogenic diet started in the 20th century as a way to control epilepsy through following a diet seventy percent rich in healthy omega-3 fatty acids and the remaining thirty percent of protein and carbohydrates, enabling the body to burn ketones instead of glucose for energy (Harmon, 2020). Essentially switching the body's energy source to ketones from fats instead of glucose demonstrated rapid weight loss by keeping the human body in a state of ketosis (Harmon, 2020). Ketosis occurs when carbohydrates are very low, the body breaks down excess fat because of the carbohydrate restriction which results in ketone production that becomes the body's new form of energy (Higuera, 2018). With the ketogenic diet, high quality omega-3 fats and wholesome foods such as avocado, pure butter, wild-caught salmon or 60% fat ground beef are tasteful and sustainable for dieters (Modius, 2019). However, certain side effects may make the ketogenic diet difficult to adhere to given a common case of "keto flu" (Holland, 2021). The "keto flu" is a side effect from the body's transition from the carbohydrate cycle to ketosis which include symptoms such as fatigue, irritability, and mental fogginess (Holland, 2021).

Evidence in Support of the Intervention

The following are current studies examining the question whether the ketogenic diet is effective in lowering weight in obese adults. Saslaw et al. (2017) conducted a randomized method study design following 34 adults with HbA1c levels above 6% and BMIs above 25. Two participant groups included the first group on a very low-carbohydrate ketogenic (LCK) diet and the second group of participants followed a moderate-carbohydrate, calorie-restricted, low-fat (MCCR) diet. The authors followed the patients over twelve months measuring HbA1c levels, body weight and diabetic medication use. The authors reported that those following the LCK diet demonstrated more weight loss found as compared to the MCCR diet participants. At the twelve month mark, the HbA1c levels for the LCK group was lower at 6.1% while the MCCR group was 6.7% and body weight was 92 kilograms for LCK and 95.8 kilograms for MCCR. The need to take diabetic medication in the LCK group decreased from 10 participants to six participants still taking the medication at the end of the 12 month study while the MCCR group demonstrated no change of their six participants still taking diabetic medication at the 12 month mark. These results suggest that not only does the ketogenic diet lead to weight loss, but lower HbA1c levels which decreases the chances of developing Type2 diabetes.

Perticone et al. (2019) conducted an open controlled design study with a sample size of 56 outpatient obese adults. Two groups were formed: a very low calorie ketogenic diet and a standard low calorie Mediterranean diet over 12 months. The aims of the study were to quantify if vitamin D levels increased in the ketogenic diet group. There was a statistical decrease in weight loss and waist circumference in the group following a ketogenic diet while significant anthropometric parameters were not observed in the standard low caloric group. Results also showed 95% of the participants proved positive adherence to the ketogenic diet as supported by greater

weight loss by the ketogenic group as compared to the Mediterranean diet group. The results also showed the ketogenic diet group had an increase in vitamin D levels. The authors concluded the ketogenic diet was one of the most effective diet regimens that has demonstrated effectiveness for rapid weight loss as well as increasing serum vitamin d levels.

Moreno et al. (2016) conducted a random controlled trial and followed 45 obese adults for 24 months to evaluate the long term effects of excess adiposity following a very low-calorie-ketogenic (VLCK) diet. The 45 obese adults were randomly placed into two groups: the VLCK diet group and the other in a standard low-calorie diet group. At the end of the 24 months, the VLCK demonstrated greater weight loss of 12.8kg as compared to the standard-low calorie diet group which lost 4.4kg overall. At the end of the 24 months, the VLCK group had an average waist circumference of 11.6cm lost while the standard-low calorie diet group was lower at 4.1cm lost. These results infer that the very low-calorie-ketogenic diet was the more effective diet in this study after 24 months as demonstrated by greater weight loss and concluding this decreases the risk of individual potential disease burden.

Potential Barriers to Implementing the Intervention

One of the barriers to implementation of the ketogenic diet is adhering to the strict low-carbohydrate diet ratio of 20-50g per day (“Weight Reduction,” n.d.). This stresses the importance of taking the time to plan ahead because 20g of carbohydrates can add up rather quickly in one meal or snack if the allocated carbohydrate intake throughout the day is not set beforehand (Holland, 2021). Another barrier to the diet is the side effect referred to as the “keto flu.” It can be a deterrent from continuing with the diet (Holland, 2021).

Weight loss management for obese adults can arguably provide improved health, increased energy, and an overall higher quality of life. Diet is the key whether that is either hindering or helping to achieve weight loss. The ketogenic diet has been popularized over the few years as it is quite successful. As supported by the referenced evidence-based studies, the ketogenic diet is a favored and successful diet intervention for greater weight loss. The provided evidence suggests the ketogenic diet a viable option for primary care providers to recommend to obese adult patients for weight loss.

Introduction of Theory

The relationship between the human body and external environment influences both the human mind and physical state. Whether these influences introduce stress and anxiety from an occupation or diet choices and weight, essentially these can be viewed as modifiable factors. By adjusting diet, it can be assumed that weight can also be adjusted by increasing or decreasing. This can be analyzed and supported by how it promotes health due to the relationship of different diets and decreasing weight in obese populations. Next, this idea will be discussed with a theoretical model and an analysis on its influence on the advanced practice registered nurse (APRN) profession.

The Health Promotion Model

The interaction of diet and this population can essentially be supported by a 1982 model structured to help individuals achieve improved well-being by encouraging positive health behaviors (Pender, 1982). The positive changes through the interaction of an individual and their environment result in behavioral outcome and positive well-being. The change an obese individual can make through diet change can be viewed as controlling their environment. This interaction between diet, the human mind and body overall promotes self-efficacy. Pender's model provides the framework as suggested by decreasing weight in obese adult populations via diet change and overall

improved well-being.

The health promotion model is structured by how an individual interacts with their environment and aims toward health-promoting behavior (Pender, 1982). Overall, this model's goal is to increase an individual's well-being through major concepts such as health behavior, goal-directed self-care, environment, and self-efficacy. Pender suggests these major concepts ultimately demonstrate that modifiable factors can positively or negatively affect health promoting behavior. This model cohesively conveys that individuals have the potential to exhibit behavior that either promotes or deters health through their own cognitive-perceptual factors and self-will (Pender, 1982).

Theory's Influence on the Advanced Practice of Nursing

The health promotion model focuses on the individual's control or behavior that promotes or negatively impacts health (Pender, 1982). This model has recently influenced advanced practice nursing as seen throughout the COVID-19 pandemic because it aims to holistically evaluate an individual and self-promoting health behavior. For example, in relation to the COVID-19 pandemic, these behaviors include education and awareness of the disease as demonstrated by social distancing, appropriate use of public areas and use of personal protective equipment (Madran & Ocakçı, 2022). These behaviors all advocate positive health promoting behavior. Nurse to patient education on these factors positively promotes health behavior in an epidemic where health promotion starts at the individual level before healing a population. These interventions by proper education as influenced by this model are still relevant and powerful today for general health promotion in not only individuals, but a population as seen through this pandemic.

Another example of more recent influence of advanced practice nursing from the health promotion model is demonstrated by a 2017 study on improving nutritional

behavior of overweight and obese women through influencing modifying factors such as eating habits (Khodaveisi et al., 2017). This study closely monitored and introduced nutritional behavioral changes to an experimental and control group based on Pender's model and resulted in a positive change by improvement of nutritional behaviors. This introduction and encouragement of healthy nutrition via diet, portion control and cooking methods are all positive health promotion practices that demonstrate and encourage prevention of obesity as framed by Pender's health promotion model. The application of this theory to a weight loss project ultimately promotes positive engagement of health promoting behavior.

Theoretical Framework Analysis

In adult obese populations, does the ketogenic diet as compared to a low caloric diet decrease weight? The health promotion model is directed toward how an individual interacts with their environment with the ultimate goal of increasing an individual's well-being (Pender, 1982). This model's design is able to structure weight loss in obese populations because weight loss is a modifiable lifestyle factor reflective of how an individual directly interacts with their environment.

If diet adherence psychology is considered an individual's environment, this is a modifiable lifestyle factor example that the health promotion model is structured by. For example, Oh (2021) studied social support and health promoting behavior. The most crucial aspects of Pender's theory are that cognitive-perceptual factors influence health promotion behavior and that these components are not static but may be modified by interventions that can promote healthy behavior. Additionally, weight-related experience avoidance is one psychological aspect that may have an impact on the quality of a diet among people with obesity (Wooldridge et al., 2022). Applying this model to weight loss in obese populations based on diet intervention can demonstrate the success or failure

of how the ketogenic or low caloric diet structures health promoting behavior.

Theoretical Contribution to APRN Profession

Due to its negative effects on quality of life and mental health, obesity is a significant condition with prevalence in the United States at a staggering 41.9% among adults (Centers for Disease control, 2022). Additionally, the estimated medical cost of obesity in the United States was $173 billion in 2019 which averaged an increase of $1,861 more in medical costs than adults of healthy weight (Centers for Disease Control, 2022). Nutritional intake is attained via diet and weight loss among obese adults is dependent on this intake. In the 2019, twelve-month study distinguishing the ketogenic diet and a Mediterranean or low-caloric diet among obese individuals, the result was a distinct decrease in obesity level (Perticone et al, 2019). With nearly 355,000 licensed nurse practitioners in the United States, 88.9% are certified in providing primary care (AANP, 2022). If obesity levels decrease by introducing diet adherence in primary care, this can increase well-being of individuals as structured by the health promotion model. Nurse practitioners can encourage weight loss in the primary care setting by diet intervention and provide a new standard of practice and care of overall health by preventing further medical complications as seen in untreated obesity.

Theory Implication to Guide Personal APRN Practice

The health promotion model identifies modifiable nursing actions that can enhance quality of life by focusing on individual characteristics, behavior-specific cognitions and behavioral outcomes (Pender, 1982). If individuals are able to regulate their own choices and behavior, the nurse practitioner can utilize this model in encouraging health promoting factors and provide resources.

In APRN practice, the analysis of patients regarding any potential preventing factors to facilitate weight loss can be initialized. Are there any factors hindering an obese patient to lose weight such as acute or chronic medical conditions, psychological factors, finances or other resources? APRN practice can benefit from the evaluation of these factors with the ultimate goal of promoting health by decreasing obesity. This will uphold the dialogue of the health promotion model and its influence on overall well-being.

The APRN profession can be viewed as sustaining the foundation to promote overall health. Finding a cure for illness and disease is not a guaranteed path in the practice of medicine but rather a journey. Instead of just the absence of sickness, the health promotion model defines health as a positive dynamic state (Pender, 1982). This model influences the APRN practice by conveying that the goal of health promotion is to raise a patient's level of well-being by changes in behavior. However, the sole application of this model by diet intervention and weight loss among obese adult populations can demonstrate either positive or negative health behavior. Are the ketogenic diet or low-caloric diets recommended by the APRN practice as an appropriate intervention for obese adults and weight loss? Further investigation and external factors can be considered as far as decreasing weight in obese adults. Rather than mere diet, other hindering factors may be of issue such as access to food, psychological or other medical comorbidities that may affect successful weight loss through these diets alone.

Literature Search

In order to determine whether the ketogenic diet decreases weight loss as compared to a low caloric diet among obese adults, a literature search was conducted for this project. The databases PubMed, Cumulative Index to Nursing and Allied Health

Literature (CINAHL) and Clinical Key for Nursing were used in this search. The following search terms were used: “ketogenic diet, low calorie and weight loss” yielded 446 results. The addition of the search term “obese” narrowed the results to 176 articles. From these search results, the studies that were ultimately used were those that included methods for analyzing quantitative weight loss within the targeted diet among the study population in comparison to another diet to compare and cohort studies due to the limitations in primary studies for the exact search terms such as “the ketogenic diet” and “low-caloric diet.” Among the search result criteria, there were no direct articles that compared these two diets directly, however, similar such as weight loss and low-caloric ketogenic diet. Other criteria included current studies within the past five years and access to the full text of the article(s). The criteria were (then expanded to the past seven years in order to obtain additional information. Overall, there were seven total number of studies selected as a result of these search results. This review will provide evidence from seven studies to include two cohort studies (Moreno et al., 2016; Saslaw et al., 2017) and four randomized controlled trials (Bruci et al., 2020; Cunha et al., 2020; Di Rosa et al., 2022; Schiavo et al., 2020) and an open controlled study (Perticone et al., 2019).

Definitions

1. The ketogenic diet consists of diet restricted food groups- healthy omega 3 fats and carbohydrates limited to 20 to 50g per day therefore putting the body into a state of ketosis (Modius, 2019). Hunt (2021) defines the ketogenic diet as high in fats, low in carbohydrates and moderate in protein intake.
2. A low calorie diet - is a restriction of caloric intake by an individual. According to Di Rosa et al. (2022), a hypocaloric dietary plan was individualized according to participants’ nutritional needs and preferences.

3. Obesity - defined as excessive fat accumulation that may impair health as a result of an imbalance of caloric intake and caloric output (WHO, 2021).
4. Body mass index (BMI) of 30 or higher is defined as obese and calculated from an individual's weight in kilograms divided by their height in centimeters (squared) (WHO, 2021).
5. Another tool used as weight measurements in two studies (Di Rosa et al., 2022; Schiavo et al., 2020) is known as a bioelectrical impedance analysis (BIA) was used which runs a small electrical current through the body and determines quantities of fat mass.

Literature Review

There were several principal themes that were recognized as a result of the literature review. These themes included the intervention of the ketogenic diet which dominated in success compared to other diet interventions, how the ketogenic diet improved weight loss and how this success was measured based on improved BMI. These themes were essential in supporting the PICO question of how the ketogenic diet decreases weight among obese adults.

Theme #1 Intervention of the Ketogenic Diet

There were a variety of different intervention designs among the studies selected. Among the total seven studies in this search, all the studies used the ketogenic diet as the intervention, however, some studies had additional groups (Cunha et al., 2020; Di Rosa et al., 2022; Moreno et al., 2016; Perticone et al., 2019; Saslaw et al., 2017; Schiavo et al., 2020). For example, the studies conducted by Di Rosa et al. (2022) and Perticone et al. (2019) had the ketogenic intervention group as well as the

Mediterranean diet. Furthermore, the studies conducted by Cunha et al. (2020); Moreno et al. (2016); Schiavo et al. (2020) used the ketogenic intervention group as well as low caloric diets. The cohort study conducted by Saslaw et al. (2017) used a moderate low caloric restricted diet. The remaining study conducted by Bruci et al. (2020) did not have an additional intervention group but encompassed comparing the ketogenic diet results among obese adults and those with mild kidney failure. Although the studies all used the ketogenic diet, the studies by Bruci et al. (2020); Di Rosa et al. (2022); Perticone et al. (2019); Saslaw et al. (2017) specifically did not compare the ketogenic diet to a low caloric diet as posed in the PICO for this capstone.

A total of 582 subjects were enrolled in these studies presented. They were enrolled either from university units, a clinical trial website or access centers for obesity treatment. The studies where the subjects were enrolled through university settings were (Cunha et al., 2020; Di Rosa et al., 2022; Moreno et al., 2016; Perticone et al., 2019). One study enrolled subjects through a clinical trial website (Saslaw et al., 2017). Two studies enrolled via hospital access centers for obesity treatment (Bruci et al., 2020 and Schiavo et al., 2020). The subjects were enrolled anywhere from two months (Cunha et al., 2020), three months (Bruci et al., 2020; Di Rosa et al., 2020), four months (Schiavo et al., 2020), one year (Perticone et al., 2019; Saslaw et al., 2017) and two years (Moreno et al., 2016).

Based on the authors' conclusions of the designs, there were common conclusions that can be drawn. The four random controlled trials shared similar conclusions on their design together, commenting that the ketogenic is an effective method to achieve significant weight loss despite the generally small samples sizes (Bruci et al., 2020; Cunha et al., 2020; Di Rosa et al., 2022; Schiavo et al., 2020).

However, according to Cunha et al. (2020), the ketogenic diet's popularity among obese adults is effective short term but not sustainable long term. All studies commented that additional, larger clinical trials are needed for confirmation on the effectiveness of the ketogenic diet on weight loss. Additionally, the cohort studies concluded the design shared remarks on the effectiveness of the ketogenic diet on BMI (Di Rosa et al., 2022; Moreno et al., 2016; Saslaw et al., 2017). According to Moreno et al. (2016), while not mentioning obesity specifically, the study concluded that the ketogenic diet decreases adipose tissue and, ultimately, weight that is sustainable two years after the conclusion of the study. The ketogenic diet demonstrated greater weight loss than in a moderate calorie diet (Saslaw et al., 2017). Perticone et al. (2019) concluded that the ketogenic diet over one year demonstrated significant weight loss as well as increased vitamin D levels in obese adults.

The appraisal of the intervention study designs shows that the data may be weak because power analysis were not submitted for six of the seven studies (Bruci et al., 2020; Cunha et al., 2020; Di Rosa et al., 2022; Moreno et al,. 2016; Perticone et al., 2019; Saslaw et al., 2017) whereas a power analysis was submitted for one. According to Schiavo et al. (2020), priori power analysis was used and concluded that a sample of 21 patients could detect a difference in the primary outcome with 90% power and an alpha error of 5%. Schiavo et al. (2020) also explained how they selected their subjects while the other studies did not, other than stating subjects were enrolled in already existing institution groups such as obesity or metabolic clinics of which they met criteria (Bruci et al., 2020; Di Rosa et al., 2022; Moreno et al., 2016; Perticone et al., 2019; Saslaw et al., 2017).

Theme #2 Improved BMI

All seven studies reviewed reported the positive finding of weight loss as a result of using the ketogenic diet as an intervention (Bruci et al., 2020; Cunha et al., 2020; Di Rosa et al., 2022; Moreno et al., 2016; Perticone et al., 2019; Saslaw et al., 2017; Schiavo et al., 2020). Three studies reported statistical significance (Di Rosa et al., 2022; Moreno et al., 2016; Schiavo et al., 2020). Two of these three studies did not offer additional evidence to support their results (Di Rosa et al., 2020; Moreno et al., 2016). A power analysis as well as statistical significance with an effect size of Pearson's correlation of $r = 0.95$ was submitted for only one study (Schiavo et al., 2020). Among these studies, statistical significance, effect size and/or power analysis were not reported (Bruci et al., 2020; Cunha et al., 2020; Perticone et al., 2019; Saslaw et al., 2017). One of these articles (Cunha et al., 2020) specifically mentioned the lack of power analysis while.

According to Schiavo et al. (2020), there was statistically significant evidence supporting a ketogenic diet that contributed to increased weight loss despite a small sample size and effect size of $r = 0.95$. A $p < .05$ was considered statistically significant and a positive finding was demonstrated by a reported $p = 0.0260$ for the group that lost body weight (Schiavo et al., 2020). These values support strong evidence ~~robust study of statistical significance~~, however, a larger clinical trial is needed to confirm this preliminary data (Schiavo et al., 2020). ~~The~~ Schiavo et al. (2020) ~~study~~ provided stronger evidence by reporting effect size and power analysis in comparison to Bruci et al. (2020), Cunha et al. (2020), Perticone et al. (2019) and Saslaw et al. (2017) which offers weaker evidence due to the lack of providing effect size and/or power analysis.

Theme #3 Measurements

All studies measured body mass index (BMI) by calculating an individual's weight

in kilograms divided by their height in centimeters squared (Bruci et al., 2020; Cunha et al., 2020; Di Rosa et al., 2022; Moreno et al., 2016; Perticone et al., 2019; Saslaw et al., 2017; Schiavo et al., 2020). Two of the studies measured their outcomes by calculating both BMI and a bioelectrical impedance analysis (BIA), which runs a small electrical current through the body and determines quantities of fat mass (Di Rosa et al., 2022; Schiavo et al., 2020). The statistical outcomes of the BMI measurements were positive as all seven studies reported a decrease in BMI as a result of the ketogenic diet as the intervention (Bruci et al., 2020; Cunha et al., 2020; Di Rosa et al., 2022; Moreno et al., 2016; Perticone et al., 2019; Saslaw et al., 2017; Schiavo et al., 2020). Additionally, the measurement of BIA reported positive decreases respectively by a portion of 5% weight loss (Di Rosa et al., 2022) and while the exact BIA percentage was not reported, the study concluded a positive Pearson's correlation $r = 0.95$ (Schiavo et al., 2020).

A limitation that can be considered in measurements is exactly how the measurements were taken. While seemingly BMI and BIA were reported throughout the results discussion of each study, five of the seven studies explained the anthropometric parameters taken as a result of this thought. For example, the same calibrated scale and height measurement was used for all subjects (Bruci et al., 2020; Di Rosa et al., 2022; Moreno et al., 2016; Perticone et al., 2019; Schiavo et al., 2020). According to Bruci et al. (2020), subjects were measured while fasted and with an empty bladder. According to Shiavo et al. (2020), additional anthropometric parameters were taken including measuring the subjects' weight while fasted and wearing light clothing with an empty bladder. These inconsistencies in how measurements were obtained can be a determining factor in whether strong supporting evidence can be used if the respective diet interventions used were appropriately measured and therefore affecting the efficacy

of results.

Limitations and Strengths

There were limitations noted among the studies presented in this literature review. For example, sample sizes were small n < 60 (Bruci et al., 2020; Cunha et al., 2020; Moreno et al., 2016; Perticone et al., 2019; Saslaw et al., 2017; Schiavo et al., 2020) with the exception of one study with a sample size of 268 subjects (Di Rosa et al., 2022). A small sample size can arguably pose greater issues with variability such as undermining validity within a study in comparison to larger studies, especially if a power analysis was not discussed. Additionally, statistical significance, effect size and/or power analysis were not reported which would have bolstered results and strengthened evidentiary support (Bruci et al., 2020; Cunha et al., 2020; Perticone et al., 2019; Saslaw et al., 2017).

Additional thoughts that can be considered into providing limitations among the studies would be the consideration of dropouts or missing data. According to Di Rosa et al. (2022) there were 106 of 268 dropouts. The other studies that mentioned dropouts did not expand but only vaguely commented on whether there were (Moreno et al., 2016; Saslow et al., 2017) or made the assumption that dropouts were considered in their statistical findings giving a respective 15% drop out rate without confirming this value was true (Schiavo et al., 2020). These are a few factors that could pose as outliers in the concluding evidence and ultimately be a consideration in affecting the reliability of outcome of the studies.

As far as strengths determined among these studies, Perticone et al. (2019) was confident in reporting the ketogenic diet was a powerful tool in improving not only weight loss, but vitamin d status in obese patients. According to Moreno et al. (2016) their

strength was determining a decrease in body fat mass. According to Saslow et al. (2017) and Di Rosa et al. (2022) their studies' strength was in very few dropouts. Bruci et al. (2020) did not report strengths other than stating their study was performed in a real life setting. Contrary to these articles, Cunha et al. (2020) and Schiavo et al. (2020) did not report any strengths included in their respective studies.

Gaps in Literature

There were limitations in finding current literature because the initial search to include published studies within the past five years had to be expanded to the past seven years. Nearly all of the studies had small sample sizes and more studies with larger sample sizes are needed. While all studies generally reported a positive change to BMI by the intervention of the ketogenic diet (Bruci et al., 2020; Cunha et al., 2020; Di Rosa et al., 2022; Moreno et al., 2016; Perticone et al., 2019; Saslaw et al., 2017; Schiavo et al., 2020), there was not a universal intervention to compare this to as posed in the PICO question comparing the ketogenic diet to a specifically low calorie diet. More research on specifically lower calorie diets in comparison to the ketogenic diet and larger studies can be beneficial in addressing this.

Conclusion

Obesity is an epidemic affecting nearly half of the United States population by 42.4% and is the number one cause of mortality in adults (CDC, 2020). The physiological health costs such as the high risk of developing diabetes causing more comorbidities, obesity-related healthcare costs in the United States were $260.6 billion (Cawley et al., 2021). The popularity of the ketogenic diet may be a tool in weight loss without compromising seemingly bland foods that are often included in standard low calorie diets. While research is limited in the benefit of weight loss from the ketogenic

diet as compared to standard low calorie diets, evidence does suggest that successful weight loss has been attained through the ketogenic diet. The improvement of obesity in the current state as an epidemic in the United States can contribute to preventing diabetes and other comorbidities such as heart disease and improved mental health. According to Moreno et al. (2016), the ketogenic diet can decrease adiposity in obese subjects and is a beneficial effect which can be maintained two years later.

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