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The High Protein/Low Carbohydrate Diet: A Literature Review of it's Effectiveness for Weight Loss

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Dedication

I would like to take this opportunity to thank my PA school classmates for supporting my complaints about balancing this scholarly project with clinical rotations. Looking back…we were always able to have a steady balance of work, and play! The Morse Center also contributed to my sanity in the last two years. I would also like to thank my close friends, roommates, and family for their support throughout my two short years of PA school. And most of all I want to thank Kyle for his overwhelming support and interest in this project and my experiences, as I become a clinician.

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Chapter 1

Introduction

Obesity in Today's Society

It would be difficult for one to live in America today and not be aware of the high numbers of overweight people. Obesity seems to be an epidemic in today's society and causes both medical and financial problems. The National Health and Nutrition Examination Survey from 1999 reported that approximately 120 million adults are overweight or obese. (Flegal, Carroll, Ogden, & Johnson, 2002). The measures of obesity and being overweight are determined by a classification system developed in 1998 by the National Heart, Lung, and Blood Institute (NHLBI) (NHLBI Guidelines, 1998) and the World Health Organization (WHO) (WHO,1997). This measure is based upon the Body Mass Index (BMI) of the individual that is calculated using Formula 1. Table 1 showing the NHBLI Classification of BMI can be found in the appendix. Weight circumference is also a measure of obesity, but it is based upon abdominal fat content. Measurement of greater than 40 inches for a male and greater than 38 inches for a female are indicators that an individual is at higher risk for health problems (Centers for Disease Control, 2004).

Now that the reference range for obesity is understood, it is important to identify the risks associated with being obese. Obesity can lead to much morbidity and some mortality as well, if not corrected. Obesity increases the risk of developing co-morbid conditions ranging from hypertension to Type II diabetes mellitus. Table 2 is a complete list of the health risks associated with obesity. According to the American Obesity Association, obesity is involved in the cause of 300,000 deaths per year (American Obesity Association, 2003).

Not only is obesity associated with morbidity and mortality, but also the health problems that result from obesity are contributing to the increased cost of medical care. More people are being diagnosed with the illnesses listed in Table 2 and the cost of treatment is ever increasing. The most recent reports indicate that approximately $100 billion per year is spent on adults with obesity related illnesses. (Colditz, 1999).

This leads us to two very important questions. First, what has been causing this steady increase in the prevalence of obese people? The second and more critical question, is what are we to do about it? Over the past several decades' lifestyles have changed. An increase in technology has led to people spending more time in front of a computer screen at work, and more time in front of the television at home. More people are also relying on automobiles for transportation than ever before. Technology has also led to a decrease in the cost of unhealthy fast and processed food choices (Spence-Jones, 2003). The focus at the dinner table has even changed from the traditional balanced meal of meat, potatoes, and a vegetable to one that is more time efficient and less health conscious. The focus has changed from meals that include protein and minimal carbohydrates to one that is loaded with carbohydrates, such as spaghetti with garlic bread. The fat content before was probably still high because of hamburger and pork, but now includes carbohydrates and fat.

Current Weight Loss Options

Because of the increase in obesity there has also been the advent of many weight loss strategies. There are numerous fad diets, exercise strategies, weight loss pills, surgical interventions, and even therapy groups to aid in weight loss. Some of the popular diets that seem to work for people are based upon the consumption of fewer calories. This strategy makes sense,

because physically the only way to lose a pound of body fat is to have a 3500-calorie deficit (Roth & Townsend, 2003). That means that either one needs to eat less calories or burn more calories by increasing physical activity. The Weight Watchers diet is based upon consuming a specified point value for each day (Weight watchers, 2003). There has also been Richard Simmons that put out workout videos, such as "Sweatin' to the Oldies" that were focused on aerobic activity that enabled one to burn more calories. The most recently advertised diet is The Atkins Diet. Dr. Robert Atkins developed the Atkins diet and it has been shown to be successful. The diet is based on a very low carbohydrate, high protein and high fat diet. If followed correctly the diet takes off pounds quickly, and people are more encouraged and further, more satisfied (Atkins, 2003).

It is unclear whether the ratio of carbohydrate to proteins is a determinant of weight loss in humans. There is some evidence that shows a diet high in protein, as opposed to a diet high in carbohydrates can essentially help one lose weight. This diet differs from the Atkins diet, because it is not as strict and it deals with the *ratios* of protein to carbohydrates. A diet high in carbohydrate tends to drive up post-prandial insulin levels and eventually promote excess energy consumption, leading to obesity (Hu, van Dan, & Liu, 2001). On the other hand a diet high in protein has been shown to satisfy the feeling of hunger faster than carbohydrates and fat (Skov et al, 1999b). The high protein diet is also beneficial because it allows one to lose more body fat and maintain lean body mass (Layman et al, 2003a).

PURPOSE

The purpose of this paper is to review the literature and to assess the efficacy of the high protein diet in nutritional weight loss. If it can be safely applied in today's society, we may see

more weight loss, less weight gain, and therefore, less co-morbidities associated with obesity. The conclusions drawn from this paper are relevant to the Physician Assistant profession. If a new diet is shown to be successful and safe then it is one more option to help patients lose weight and live a better quality of life.

SCOPE AND LIMITS

The literature will involve available and published studies that include information about high protein diets and low carbohydrate diets. These studies will be compared to studies done about high carbohydrate diets. Published works will only be taken from 1975-2003. Trial studies will involve both men and women. Also examined will be both sedentary and exercising individuals. This should be acceptable as long as each variable is controlled throughout the study. National and international papers will be reviewed. Medline and OhioLink will be searched for the following keywords: protein, carbohydrate, diet, weight loss, Atkins, kidney and protein, osteoporosis and protein.

REVIEW OF LITERATURE PLAN

In this paper the goal will be to exhaust the literature and seek clarity about whether the ratio of carbohydrates to protein is a determinant of weight loss. Literature will be reviewed to find studies and elaborate on the pathophysiology behind why a high protein, low carbohydrate diet works. Also encompassed will be relevance of the study, which will be based upon the statistical analysis. Any flaws associated with the study will be examined. The conclusion should engage a recommended diet for weight loss. Another goal will be to find negative health implications of a high protein diet, and finally to comment about the effect of a high protein diet

on the serum lipid profile. Although it is important to establish conclusions about the efficacy of a high protein diet, it is essential that the opposite, a high carbohydrate diet, be examined as well. The problems associated with a high carbohydrate diet will be further examined in order to write a thorough paper.

Chapter 2

Discussion

Weight loss and diets

As mentioned above, America has a problem with obesity. The number of overweight and obese children is increasing. As these numbers increase it begins a domino effect. The prevalence of overweight teenagers is increasing and so is the number diagnosed with Type II diabetes mellitus (Hay, Hayward, Levin, & Sondheimer, 2003). Carrying unnecessary weight may also increase the chances of developing heart disease, hypertension, and hyperlipidemia (Spence-Jones, 2003). As the number of health related problems increases, so does the cost of medical care. Billions of dollars are spent each year on obesity related illnesses (Colditz, 1999). According to a published journal article the burden of obesity on the American economy is estimated at $100 billion (Thompson, Edelsberg, Colditz, Bird, & Oster, 1999). So, that leads to the purpose of this article; to find out if and why popular diets, such as “The Atkins Diet”, “The Zone Diet”, “The SouthBeach Diet,” and “Weight Watchers” work. Is it the foods eaten in the diet that cause people to lose weight or does it essentially once again come down to the amount of calories eaten per day?

The American Heart Association (AHA) has published guidelines for weight loss and maintenance on their website. The AHA suggests setting a realistic goal of losing 1-2 pounds per week. That means, women should eat a 1,200 calories/day and men at least 1,500 calories per day. The AHA also recommends physical activities, such as jogging, walking, or riding a bike. Most people should do approximately 30-60 minutes of moderated physical activity 6-7 days a week. The AHA stresses the importance of making weight loss and maintenance a lifestyle change, rather than repeatedly losing and gaining weight (American Heart Association,

2004). Despite the AHA recommendations Serdula et al published a study in 1999 that showed that Americans do not follow these guidelines for weight loss. This study consisted of a random-digit telephone survey conducted by 49 state health departments and the District of Columbia. Although the results may be skewed because it is a telephone survey, they found that 28.8% of men and 43.6% of women reported trying to lose weight. Among those attempting to lose weight only about 50% reported doing so by reducing calories and 35-40% reported consuming less fat. As for increasing physical activity only 36-42% reported doing 150 minutes of physical activity per week. And, not surprisingly, only about 20% of respondents increased physical activity in combination with eating fewer calories (Serdula et al, 1999). So, what went wrong? Is it a lack of knowledge about how to lose weight or are Americans attracted by diet fads? In this next informative section we will attempt to conclude the effectiveness of certain popular diets.

As stressed earlier, the AHA recommends losing weight by increasing physical activity and decreasing calories eaten. Weight Watchers follows a similar plan to help customers lose weight. They have the "POINTS^{R} Weight-Loss System" that allows an individual to eat what they want based on a calculated number of points/calories per day. Their sales pitch is that it, "teaches you how to lose weight without sacrificing any of the essentials of a great life" (Weight Watchers. 2003). Essentially it is a structured commercial program and in a paper by Heshka, et al, commercial programs seem to have a higher success rate for losing weight when compared with self initiated weight loss. Participants in Weight Watchers also have weekly weigh-ins, structured menus, and support groups that may help to increase success rates (Heshka et al, 2003). Weight Watchers seems to be one of the closest *diets* to mimic the recommendation by the AHA.

The Atkins diet is currently one of the most recognized diets on the market. Atkins is now putting it's name on popular restaurant menus, such as T.G.I. Friday's and Subway. Supermarkets also sell a variety of "Atkins's approved" food items. The Atkins diet has actually been around since the 1970's, but is not new. Anthropologic studies suggest our ancestors consumed a diet with approximately 30% of energy from protein found mainly in animal products (Eaton, Eaton III, & Konner, 1997). The Atkins Diet restricts carbohydrates and has four phases. The first phase is the introduction of the diet and restricts carbohydrates to less than 20grams/day. The only allowed carbohydrates should come from salad and other non-starchy vegetables. Phase 2 adds back some carbohydrates in the form of foods high in fiber and nutrient. Carbohydrate allowance increases from 20 to 25 grams/day the first week then to 30gram/day the second week and continues increasing until weight loss is halted. Then it is advised to subtract 5 grams/day from the last number and moderate weight loss should occur. Phase 3 is the transition from weight loss to weight maintenance. Carbohydrate intake should be increased by 10-grams/week and a very gradual weight loss should be maintained during this period. Phase 4 consists of lifestyle maintenance and allows a wide variety of foods rich in nutrients, while still maintaining carbohydrates in moderation. Unlike a diet, that Atkins Nutritional Approach™ is a lifetime nutritional philosophy, focusing on the consumption of nutrient-dense, unprocessed foods and vitamin and nutrient supplementation (Atkins, 2004).

A study published in 2002 supports low carbohydrate diets, like The Atkins diet. This study examined a six-month adherence to a very low carbohydrate diet and found that the diet program led to sustained weight loss. The majority of the weight lost was fat mass, which means that participants are maintaining their lean muscle mass. Also, it is important to note that most participants improved their serum lipid profile (Westman, Yancy, Edman, Tomlin, & Perkins,

2002). People like the Atkins diet because they can eat meat and eggs, they lose weight fast, and it reduces constant hunger (Stein, 2002). Although The Atkins diet seems to be a current fad diet, there are still experts that criticize the very basic assumption of the Atkin diet. The AHA advocates against high protein diets, like the Atkins diet. The AHA says that high protein diets "restrict healthful foods that provide essential nutrients and don't provide the variety of foods needed to adequately meet nutritional needs". They also comments that too much protein can increase health risks and high saturated fat in the diet leads to increased risk of coronary heart disease (American Heart Association, 2003). So, as one can see, The Atkins diet remains controversial.

One of the most recent spin-offs of the Atkins diet is the South Beach Diet. The South Beach diet was founded by Dr. Agastson. The South Beach diet is divided into three phases. The first phase does not allow any carbohydrates or alcohol for 14 days. It allows eating any amount of food until hunger is diminished, claiming that carbohydrate cravings will decrease. Phase 2 introduces carbohydrates in moderation, claiming that the body has now corrected the way it reacts to being overweight. Weight loss should be 1-2 pounds/week during this phase. Phase 3 involves eating healthy foods in small size portions and increasing physical activity to enhance the cardiovascular benefits of weight loss (South Beach Diet, 2004).

The Zone diet is another diet that emphasizes high protein. This diet is not low-carbohydrate. From the start the diet follows a 40/30/30 protein/carbohydrate/fat intake pattern for each meal. Dr. Barry Sears developed The Zone diet with the idea that it changes the body's insulin to glucagon ratio. Essentially, it prohibits large fluctuations in insulin and glucagon, which may contribute to weight loss (Cheuvront, 1999).

As one can conclude, there are many diets out there that advocate high-protein/low-carbohydrate eating patterns. There are some that involve counting calories. There are also the diets that advocate the law of energy by decreasing the amount of calories consumed and increasing the calories used through physical activity. In the following sections the task will be to present the literature regarding published studies on high-protein/low-carbohydrate diets in comparison to the high-carbohydrate/low-fat diet.

High-Protein/Low-Carbohydrate vs. High-Carbohydrate/Low-Protein

The high protein/low carbohydrate diet is very popular throughout the world right now, but what most people do not understand is that the diet has been around for decades. Dr. Robert Atkins first developed his diet in the 1970's (Atkins, 2001). As a result of the resurgence of the Atkins diet, many scientists are studying the risks and benefits associated with a low-carbohydrate diet/high fat and protein diet. In this section we will look at the physiology of the low-carbohydrate diet, why it is effective and any adverse effects associated with this diet. Dr. Atkins believed in his diet and followed the recommendations for over forty years. (Atkins, 2001). The question is, did his own diet recommendations contribute to his death?

The Physiology

Many studies suggest that a diet high in protein reduces hunger better than a high carbohydrate diet (Skov et al, 1999a). Foods high in protein, such as steak, chicken, and fish, also seem to be more substantial and satisfying in comparison to high-carbohydrate foods, such as cereal and pasta (Baron, Schori, Crow, Carter, & Mann, 1986). The previous statements clarify some logical reasons why the high-protein/ low-carbohydrate diet may work for weight

loss, but the physiology of ketosis is the real reason scientists believe the diet is beneficial. Within three to four days of minimal carbohydrate intake the state of ketosis occurs because without carbohydrates, the liver is depleted of its glycogen stores. In the absence of glycogen and low dietary intake of carbohydrates, the body metabolizes fat at an increased rate to maintain energy levels. During this process, the liver releases ketone bodies into the blood stream and hence many studies use ketonuria as a measurement that the carbohydrates in the diet are low enough for effective weight loss. The resulting ketone bodies are muscle sparing and cause the body to use fat as an energy source and therefore lean muscle mass is maintained, while adipose tissue is lost (Manninen, 2004). One study indicates that a steady carbohydrate-restricted diet decreases resting levels of insulin. They believe that the significant reduction in insulin may have allowed body fat to be released and as a result lean body mass was maintained (Volek et al, 2002).

Volek et al also found a role for thyroid hormone in carbohydrate-restricted weight loss. In their study healthy, normal-weight men, were restricted to 8% carbohydrates for six weeks. Not only did these subjects lose a significant amount of weight in comparison to men on a 48% carbohydrate diet, but their hormone levels changed as well. The results showed a significant decrease in serum insulin and an increase in total thyroxine (T4) (Volek et al, 2002). The author did not mention whether thyroid-stimulating hormone (TSH) was measured. If TSH were measured it may explain that the patient was in a state of hyperthyroidism and therefore had an increase basal metabolic rate (Tierney, McPhee, & Papadakis, 2003). Hyperthyroidism is defined as increased T4 with decreased TSH, occurring because of a negative feedback loop associated with the hypothalamus, the anterior pituitary, the thyroid gland, and the level of T4 hormone produced (Tierney et al, 2003). In contrast, Layman et al, did a study involving

overweight and obese women, comparing a moderate-protein diet to a high-carbohydrate diet for 10-weeks. Each diet was equal in energy intake. In this study Layman et al noted the same changes in body composition (maintain lean muscle mass), but stated that the levels of thyroid hormone (T3 and T4) were maintained. They also noted a decrease of insulin response to a low-carbohydrate meal (Layman, Shiue, Sather, Erickson, & Baum, 2003b). Layman also mentions that increased protein intake during catabolic conditions helps maintain protein synthesis, due to the presence of amino acids in the protein (Layman et al, 2003b)

Satiety, decreased insulin, and ketosis do offer an explanation for a more significant weight loss with a low-carbohydrate diet, but another author questions energy intake as the reason for weight loss. In a 12-month trial comparing a high-carbohydrate diet to a low-carbohydrate diet, the author presented the logical idea that the difference in weight loss can be attributed to an overall decrease in energy intake in the low-carbohydrate group. Foster et al, admits that he is unsure of the mechanism behind the lower energy intake on a low-carbohydrate diet. He suggests it may be related to the lack of food choices involved with a low-carbohydrate diet (Foster et al, 2003). For example, a meal may include, chicken or fish and a non-starchy vegetable, such as green beans. Even tasteful sauces (BBQ, teriyaki) contain sugar as do carrots and corn. That leaves the dieter with plain foods, such as meats, cheese, and non-starchy vegetables.

Effect on Weight Loss

Many of the articles from MEDLINE examined the effectiveness of a low-carbohydrate diet for weight loss. Most studies did demonstrate that a low-carbohydrate diet is effective for weight loss, but the amount of weight loss and the length of the study may not have always been

significant. Once again Foster's study is the most relevant because it cover the longest span of time, twelve months. At three months and six months the low-carbohydrate, high-protein, high-fat diet subjects had lost significantly more weight than the low-calorie, high-carbohydrate, low-fat diet. At twelve months the subjects evened out and the weight loss between the groups was not significant. This trial seemed to be an effective, well-disciplined study, but the low number of subjects, sixty-three, may have limited the effectiveness of the results. The subjects included 63 participants, male and female, 44-years old, and were obese with non-medicated elevated cholesterol levels. They met with a registered dietitian at the beginning of the diet and again at 3, 6, and 12 months to review any dietary issues. The low-carbohydrate dieters followed the Atkins diet program, limiting carbohydrates to less than 20-grams per day in the first two weeks. The high-carbohydrate dieters were instructed to eat a 1200-1500 cal/day or 1500-1800 cal/day diet, females and males, respectively. The high-carbohydrate diet consisted of 60% carbohydrate, 25% fat, and 15% protein calories. In summary, Foster's study was well disciplined, but limited by the number of participants. Although it has it's limitations it can be concluded that people lose weight on a low-carbohydrate diet and often lose it faster than they might on a high-carbohydrate diet, but the end result is the same. Therefore, it depends on each individual's dietary preference, motivation, and perseverance (Foster et al, 2003).

Yet another study with forty-one overweight and obese, healthy males and females, found that a low-carbohydrate (very similar to the Atkins diet) diet is effective for weight loss. This six-month study did not limit calorie intake and encouraged exercise. The mean recommended caloric intake for the subjects was approximately 1900 kcal/day. Ninety-five percent of the participants in the study lost 10% of their body weight and decreased their body mass index by 3.2. Mean fat mass also decreased by 2.9% (Westman et al, 2002). Although this

study demonstrates weight loss on a carbohydrate restricted (not calorie restricted) diet, it has several flaws. First, the number of participants was limited and it was only a six-month trial. Second, the study was funded by The Atkins Center for Complementary Medicine. Third, the low-carbohydrate diet was not compared to another diet and therefore there was no control. It could have been improved if some of the subjects ate 1900 calories/day, while allowing carbohydrates. Also, fifty-one percent of participants admitted exercising three or more times per week and that may have added to the dieter's ability to lose weight (Westman et al, 2002).

As mentioned above Layman et al, et al did a 10-week trial in which women increased the amount of protein in their daily diet and decreased carbohydrates. The author was interested in the change in insulin levels on weight loss. One group consumed less than 40% of energy from carbohydrates, while the other group consumed greater than 55% of carbohydrates daily. Both groups lost weight, 7.53kg and 6.96kg, respectively. The results of the study also illustrate that postprandial insulin response was reduced and blood glucose levels were stable with added protein in the diet (Layman et al, 2003b). These conclusions suggest that maintaining stable levels of blood glucose may contribute to weight loss. This may also provide a basis for a low carbohydrate diet in a diabetic patient. As with all studies this one had some limitations. It only involved twenty-four participants, all women. Both diets were actually designed for a weekly weight loss of 0.6kg/wk based on energy restrictions and subjects were instructed to keep their activity level constant throughout the day. Another issue with the study is that it was very structured. Participant meals were either prepared for them at a laboratory or they were given certain meals to prepare at home. It is important to note that this diet was not a ketogenic diet, like that of the Atkins. They measured urinary ketones and there was no reported significant difference between the high-protein and high-carbohydrate groups (Layman et al, 2003b).

Another six-month trial examined the effectiveness of replacing carbohydrates with protein on weight loss. Unlike the Atkins diet, this study also restricted fat to 30% of total energy intake. The subjects were obese men and women, randomly assigned to a high-protein, high-carbohydrate diet, or a control group. The high-protein group consumed 25% protein and 45% carbohydrates for energy per day. The high- carbohydrate group consumed 12% protein and 58% of daily energy from carbohydrates. The results of the study revealed that the high-protein dieters lost more weight at three and at six months than the high-carbohydrate group. 35% of high-protein dieter lost greater than 10 kg (22-lbs) and only 9% of high-carbohydrate dieters lost that much. Body fat was also reduced, respectively (Skov et al, 1999b). The weight loss in this study must be due to the decreased fat intake because the control subjects did not lose weight. The results of this study may be skewed due to food availability. Subjects were allowed to choose foods allotted by their diet at a food shop, free-of charge (Skov et al, 1999b). The strict control of food intake may have had an influence on adherence to the diets. Another major flaw in this study is that the high-protein group had greater energy deficits over the high-carbohydrate group. In the discussion the author notes that he is unsure of the mechanism for the weight loss in the high protein group, but possibly attributes it to decreased calorie intake and an increased thermogenic effect of protein. In contrast, he attributed decreased energy intake in the high-protein group to earlier satiety (Skov et al, 1999b).

Lean et al did a study examining 110 overweight and obese women on 1200 kcal/day diet. The women were divided into two groups: high-carbohydrate (58% energy) and low carbohydrate (35% energy). After six months, the results of the study indicated that the low-carbohydrate group lost more weight than the high-carbohydrate group, but the difference was not statistically significant. This study was good because it did have a larger number of

participants than most studies, and concentrating on only female subjects allowed for better control. It was also conducted in an outpatient clinic setting, therefore it can be concluded that each diet is amendable to real life. The study was limited to only postmenopausal women, so the basil metabolic rate (BMR) may be different in comparison to the average population. BMR is the rate at which the body burns calories (Lean, Han, Prvan, Richmond, & Avenell, 1997).

Another study examined the body's hormonal response to a carbohydrate-restricted diet. This study was very limited because it only spanned six weeks and included twenty healthy, normal weight men. Only twelve of these men participated in the carbohydrate restriction (8% of daily energy intake), the other eight men served as controls. They also varied the activity level from sedentary to aerobic and weight training routines among those eight subjects, once again adding another variable. Although the results of the study did not demonstrate a significant weight loss, there was a significant decrease in total body fat percentage at both three and six weeks. The result indicates that a carbohydrate-restricted diet can change body composition from body fat to lean body mass, which supports thoughts by Skov et al, 1999b (Volek et al, 2002). As mentioned above in the physiology section, Volek et al attributes the change in body composition to the body's response to decreased insulin levels on the carbohydrate-restricted diet. He thinks that a significant reduction in insulin allows body fat to be mobilized and therefore excreted (Volek et al, 2002). Also, when the body reaches ketosis it has circulating ketones in the blood, one of which is β-hydroxybutyrate, and this ketone has been shown to reduce the breakdown of protein during starvation (Sherwin, Hendler, & Felig, 1975). In conclusion, Volek et al found that restricting carbohydrates and calories leads to a decrease in body fat, while maintaining lean muscle mass (Volek et al, 2002).

A 1986 study conducted in the United Kingdom varied slightly from the other studies here, but still has substantial evidence to support the low carbohydrate diet. This study compared a low-carbohydrate/low-fiber diet to a high carbohydrate/higher fiber diet and found that the low-carbohydrate dieters lost more weight at three months. The problem is that the weight was regained within one year (Baron et al, 1986). Regaining weight after the diet, really questions the long-term viability of this lifestyle change. In fact many of the dieters found both diets difficult to adhere too and in general the low-carbohydrate dieters complained of hunger more than the other group. The feelings of these dieters seem to be in contrast too many other studies that suggest the high protein diet induced satiety (Skov et al, 1999b) (Layman et al, 2003a). The reason for increased hunger may be attributed to calorie restriction (1000 kcal/day). Baron et al's study was of good quality because it included a large number of overweight subjects (135) and they were randomly assigned to groups. Once again, the study was too short to make long-term conclusions about a low-carbohydrate diet. Also, it was one of the few studies to restrict to less than 1000 kcal/day and also have awareness for fiber content in the diet (Baron et al, 1986). In fact, they concluded that a high-fiber diet, which is encouraged by the AHA, might not be the most beneficial for weight loss (American Heart Association, 2003) (Baron et al, 1986).

Some of the diets above have been similar to the Atkins diet and others have been high in protein, low in carbohydrate, but not necessarily carbohydrate restricted, like Atkins. Johnston et al did a study involving college campus volunteers who were divided into two groups, a high-protein/low fat (30% energy from protein) group and a high-carbohydrate/low-fat diet (60% energy from carbohydrate). The fat content is the main difference between this diet and Atkins. The results concluded that both diets contributed to equal weight loss, body fat loss, and a reduction in total cholesterol. There were a few differences in the results of the two groups.

Urinary calcium excretion was increased in the high protein group, but attributed to the increased dietary intake of calcium. This study also concluded that the low fat/high protein dieters had a higher satisfaction because they were not as hungry. Other lab values, such as creatinine clearance (kidney function) and nitrogen balance (kidney function) did not vary between the groups. Both groups were also restricted to 1700 calories per day (Johnston, Tjonn, & Swan, 2004). In contrast to Skov et al, this study did not show an increase in glomerular filtration rate, the rate at which blood filters through the kidney (Skov et al, 1999a). More about this will be discussed later. There was also very little difference between the groups with the reduction of insulin in the blood, but they both experienced a decrease in insulin levels. This may demonstrate that weight loss can improve insulin sensitivity and not be dependent on the intake of protein or carbohydrate. There are a few problems associated with this study. The study was a short six-week trial and limited to nine subjects in the high-protein group and seven in the high-carbohydrate group (Johnston et al, 2004).

In addition to all of the studies described above, there has been one that covers all aspects of diet. Although this study can be critiqued because it was only for 10-weeks and had only 11 women in each group, it did look at weight reduction under three different conditions: 25%, 45%, and 75% carbohydrate diets, with variations in protein and fat. The variables were controlled because the subjects were adult, sedentary, and overweight women. The diets were also restricted to 1200 kcal/day. The results of the study did not show a significant difference in weight loss among the groups, but once again the lowest carbohydrate group lost the most weight. In contrast to Volek et al, 1999, Skov, 1999b, and Layman, 2003a there were no significant differences in body loss of body fat percentages. In fact, all subjects lost some lean

body mass throughout the study (Alford, Blankenship, & Hagen, 1990). Overall this was a good idea, but the study would need to be longer and include more women in order to be conclusive.

Effect on Cholesterol Levels

The other positive effect of a high-protein/low-carbohydrate diet is on serum cholesterol levels. Common knowledge about fat intake and cholesterol levels makes one think that a low-carbohydrate/high-fat and protein diet will increase cholesterol because of increased fat intake, but several studies have shown that cholesterol levels actually improve with this diet. In some cases improvement is more significant than cholesterol levels in dieters on a high-carbohydrate diet.

In the Layman et al study, although only 10-weeks in duration, the total amount of triglycerides was reduced by 20% in the high protein group. In contrast, with double the cholesterol intake in the high-protein verses the high-carbohydrate diet, there was an approximately 10% reductions in total and LDL cholesterol in both diets (Layman et al, 2003b).

Foster found the opposite to be true in another study. Not only did his 12-month study show differences in weight loss, but also at three months low-density lipoprotein (LDL) cholesterol and total cholesterol were significantly lower than that of the conventional diet subjects. High-density lipoprotein (HDL) cholesterol and triglycerides increased more in the low-carbohydrate dieters than in the conventional dieters, but was not statistically significant (Foster et al, 2002).

In yet another study, Wolfe and Gieovannetti found that in subjects with a normal baseline lipid level, substituting protein for carbohydrate resulted in significant reductions of total cholesterol and triglycerides. The results of this study may be skewed because the fat

intake was not elevated as it is in most low-carbohydrate diets. Although the results of this particular study did not show a statistically significant increase in HDL-cholesterol, Wolfe's 1991 study did demonstrate that HDL-levels may be increased by substituting protein for carbohydrates in hypercholesterolemic subjects (Wolfe & Gieovannetti, 1991).

In the six-month low-carbohydrate study by Westman et al, (low-carbohydrate/high-fat and protein) LDL cholesterol levels were reduced in 71% of participants. Ninety percent of the subjects experienced an increase in HDL. The author did not report the amount of change, so the significance of these values cannot be measured (Westman et al, 2002).

The trial by Skov et al, published in 1999, demonstrated weight loss with a high-protein, low fat diet. It also exhibited evidence of decreased triglycerides in the high-protein group and an increase in levels of triglycerides in the high-carbohydrate group (Skov et al, 1999b). This result is consistent with the above-mentioned studies by Foster et al, and Wolfe and Gieovannetti (Foster et al, 2003) (Wolfe & Gieovannetti, 1991).

There is a study that contradicts the cholesterol reduction found with the low carbohydrate diet. In a randomized, controlled study among 110 postmenopausal women, Lean et al found that those on the high carbohydrate diet significantly lowered their total plasma cholesterol at three and six months. In the same study at three months the LDL was lowered and the HDL cholesterol had increased in the high carbohydrate group. The low carbohydrate group only showed a significant reduction in triglycerides at three and six months, while the high carbohydrate group decreased triglycerides at six months only. In summary, this study showed that the high carbohydrate diet is better for lowering plasma lipid levels (Lean et al, 1997).

Overall, it seems that the low-carbohydrate/high-protein diet had an impact on lowering blood LDL-cholesterol levels and increasing HDL-cholesterol levels, regardless of the fat intake.

The lowering of LDL also seems to occur faster in the low-carbohydrate diets as compared to the high-carbohydrate diets. It is important to note, that the lower cholesterol levels in the low-carbohydrate/high-protein groups may also be attributed to a greater amount of weight loss in the low-carbohydrate/high-protein groups. The only contradiction to the above mentioned conclusions it the study involving postmenopausal women with lowered LDL and increased HDL-cholesterols being attributed mostly to the high-carbohydrate diet. This may be due to older age of these participants or even different hormones (less estrogens). Further studies controlling age and hormone levels would need to be done to confirm the results.

Adverse Effects of High Protein/Low Carbohydrate Diet

As with any diet or lifestyle change, the good and the bad effects need to be examined. The evidence above suggests that a high-protein/low-carbohydrate diet can allow for weight loss, but what are the adverse effects of this type of diet? Several criticisms of the high-fat and protein/low-carbohydrate diet have been made. The first is allowance of saturated fat with no limitations, which has been linked to heart disease (Americian Heart Association, 2004). Increasing the amount of dietary fat and cholesterol intake has been shown to lead to the onset of atherosclerosis, which is the build up of fatty plaques in arteries ("Expert panel," 2001). In contrast, Layman et al point out that both low-carbohydrate/high-protein and high-carbohydrate diets lowered total cholesterol and LDL cholesterol, but the high protein group ingested greater than twice the cholesterol (Layman et al, 2003a). According to several authors, this finding suggests that cholesterol intake is not the sole contributor to the lipid profile (Layman et al, 2003a), (Wolfe & Gieovannetti, 1991), (Wolf & Grundy, 1983). Some scientists conclude that a high-carbohydrate diet will actually lower HDL cholesterol (Zimmerman et al, 1986), (Brinton,

Eisenberg & Breslow, 1990) and raise plasma triglycerides (Wolf & Grundy, 1983), (Truswell, 1994).

The Atkins diet does not allow fruits and vegetables in moderation. The author of Harvard Health Letter suggests that this goes against all previous evidence of the nutritional value of fruits and vegetables (Wehrwein, 2003). The other common adverse effects of the Atkin's diet are well documented in several journal articles; constipation, bad breath, headache, and hair loss (Westman et al, 2002). A common controversy about the Atkins diet is its effect on kidney function due to the ketones that are produced. For the first three months of one study the low-carbohydrate dieters had a significantly greater amount of ketones in their urine, but that evened out after three months (Foster et al, 2003). Increased ketones in the urine are indicative of the state of ketosis, which as stated earlier signifies that the low carbohydrate diet is working and the body is using body fat as an energy source (Manninen, 2004).

In order to understand any adverse effects of protein on the kidney, it is important to have some background physiology of the kidney. The kidney filters blood continuously throughout the day and night. This filtration is called the glomerular filtration rate (GFR). GFR determines the kidney function and is influenced by age, gender, body size and pregnancy, all of which slow GFR (Skov et al, 1999a).

Skov et al did a study examining renal function of healthy subjects on 25% and 12% protein diets over six months. With an increase in dietary protein intake, GFR also increased and with a decrease in dietary protein intake, GFR was subsequently decreased. Also, the high protein diet caused kidney volume to increase and the opposite for the low protein diet. But, Skov et al also notes that the specific GFR (expression of filtration rate per unit kidney volume) did not vary between the groups, rather it adapted to the amount of protein load and weight loss

or gain. They also found that albumin excreted in the urine was not altered on a high protein diet. In conclusion, they stated that they did not find adverse effects of a high protein diet on the kidney function of those without prior history of renal problems (Skov et al, 1999a). In contrast, Brenner feels that increased GFR causes hyperfiltration and glomerulosclerosis (Brenner, Meyer, & Hostetter, 1982). Another study by Riley and Dwyer specifically examined the association between microalbuminuria, dietary protein and saturated fat intake. This study was useful because it has been shown that microalbuminuria is associated with increased renal disease and increased mortality in insulin-dependent diabetes mellitus, non-insulin-dependent diabetes mellitus, and non-diabetics. The results of the Australian population questionnaire concluded that there was a direct relationship between saturated fat intake and microalbuminuria, but an indirect relationship between protein intake and microalbuminuria. Therefore, those who consumed high amounts of protein did not experience high levels of microalbuminuria, but those who consumed high amounts of saturated fat did (Riley & Dwyer, 1998). These results are still troubling in relation to the Atkins/ketogenic diet because the diet is high in saturated fat, and high in protein, so one would suspect that the incidence of microalbuminuria would even out. It also indicates that a diet low in saturated fat and high in protein will not contribute to increased mortality in those with diabetes mellitus.

Wolfe and Piche pointed out that men who took in high amounts of animal protein had a higher incidence of kidney stones (Wolfe & Piche, 1999). There have been several studies to investigate the effects of a high protein diet (1.2-2.0g/kg body weight) on kidney function. A study by Poortmans and Dellalieux did not report any negative effects of long-term daily protein intake in healthy individuals (Poortmans & Dellalieux, 2000). The study also showed that the subjects rapidly adapted to the increase in urea nitrogen. There was a positive correlation

between the amount of protein intake and amount of blood urea nitrogen and urea nitrogen excreted in the urine (Layman et al, 2003a). In the body, protein is broken down and generates nitrogenous waste, which becomes blood urea nitrogen (BUN). BUN is freely filtered by the glomerulus, the kidney's filtration apparatus. Increased levels of BUN indicate glomerular dysfunction. If BUN is increased (>20mg/dL) then it may contribute to a condition called, azotemia (increased BUN and creatinine). When azotemia starts to manifests specific signs and symptoms, it is termed uremia, which is urine in the blood (Sacher & McPherson, 2000). In conclusion of this paragraph, it is important to point out that although some studies do not show evidence of protein induced renal dysfunction, most of the studies are short term and the kidneys may not show evidence of a challenge in less than one year.

In addition to GFR, studies have also examined the increase in kidney stones due to the increased amount of urinary calcium. The pathogenesis behind the formation of calcium-oxalate stones is still not fully understood. Fifty percent of patient with calcium-oxalate stones have hypercalemia due to increased calcium intake or absorption of calcium from the small intestine in excessive amounts. Increased blood calcium may contribute to supersaturation of the urine filtered resulting in kidney stones (Kumar, 2003). Because many of the foods rich in protein (dairy products) are also high in calcium, it is important to examine the effect of increased dietary calcium. It has been thought that a diet rich in calcium (milk, cheese, yogurt) can contribute to an increased incidence of kidney stones, because they are most commonly derived from calcium oxalate (Drach, 1986). But, in contrast to popular belief, many studies are being published, suggesting that it's actually the oxalate that causes an increased incidence of kidney stones, rather than the increased calcium. A study published in the New England Journal of Medicine in 1993 was a mailed survey to 45,619 men ages 40 to 75 that showed an inverse

relationship between dietary calcium intake and increased risk of kidney stones. In fact, they found that an increased intake of dietary calcium actually decreases the risk of developing kidney stones. The study results also showed that the intake of animal protein did not have an effect on the risk of kidney stones. Some scientists have hypothesized an explanation for the above finding. They think that the inverse relationship between kidney stones and calcium intake may be due to the oxalate. Restricting dietary calcium actually increased gastrointestinal absorption of oxalate, leading to an increase in urinary oxalate excretion. Therefore those patients that decreased their calcium intake may have actually increasing their absorption of oxalate, contributing to the formation of calcium-oxalate kidney stones (Curhan, Willet, Rimm, Stampfer, 1993).

There has also been some association or controversy in regards to a high-protein/low-carbohydrate diet and osteoporosis/osteopenia. Wolfe & Piche feel that increased calcium excreted in the urine does not decrease bone reabsorbtion of calcium and therefore does not cause osteoporosis (Wolfe & Piche, 1999). Another study indirectly examined the effects of increasing protein intake on bone metabolism. This study took a small number of postmenopausal women and gave them a high meat (20% energy as protein) or a low meat (12% energy as protein) diet for eight weeks. The diets did not seem to differ in the amount of calcium lost in the urine and therefore it was concluded that a high-protein diet did not affect bone metabolism in postmenopausal women. This and other studies also suggest that the intake of phosphorus with the increased intake of protein (resulting in hypercalcuria) balances the calcium loss (Roughead, Johnson, Lykken, & Hunt, 2003). This may be related to a parathyroid hormone-mediated mechanism (Yuen, Draper, & Trilok, 1984). This is because parathyroid hormone, phosphorous, the kidneys, and bone are all connected. When phosphorous is increased

it decreases plasma calcium, which then causes the parathyroid glands to increase the amount of parathyroid hormone (PTH) released. Increased PTH causes the bones to release calcium, leading to more calcium in the plasma. Increased PTH also causes decreased phosphorous reabsorption by the kidney and increased calcium reabsorption by the kidney. In summary, the balance of calcium mentioned above is due to increased plasma calcium which causes the increase in PTH and an increase in bone calcium release. When phosphorous is involved it decreases the amount of plasma calcium, thus they balance (Kumar, 2003). Once again, this evidence supports Wolf and Piche in their conclusion that a high protein diet does not lead to osteoporosis. Skov et al did another relevant study for the effects of increased protein intake on osteoporosis in 2002. This study was a randomized, placebo-controlled, six-month trial comparing a low-protein group to a high-protein group and examined weight loss and bone mineral content. Both groups lost weight, but there was not a significant difference between the groups. The results concluded that a high-protein diet does not decrease bone mineral content and it is thought that this is due to an increased calcium intake because many high-protein products are dairy and contain calcium. Therefore, reducing the risk of osteoporosis. In fact the study actually showed a positive correlation between body fat mass and bone mineral content. As body fat decreased so did bone mineral content (Skov, Haulrik, Roubro, Molgarrd, & Astrup 2002). In conclusion, this study advocated a high-protein diet that is rich in calcium for weight loss and preventing osteoporosis.

The longest trial to date studying the efficacy of a high-protein/low-carbohydrate diet is 12 months. Because there are no published studies spanning longer than one year it is difficult to make conclusions about the safety and efficacy of ketogenic diets. There does not seem to be severe adverse effects of the diet within the first twelve months, but the question remains as to

how the kidney's handle years of increased GFR and kidney volume (Foster et al, 2003). One would conceive that eventually they would begin to fail.

Chapter 3

Conclusion

Most of the studies above have supportive evidence that low-carbohydrate/high-protein diets contribute to weight loss. Some even conclude that this weight loss is greater than compared to a high-carbohydrate diet. Only the study by Johnston actually examined the effect of both, while maintaining a low-fat diet as well. The most commonly reported benefits of the high-protein/low carbohydrate diet were early satiety, decreased calorie intake, and increased compliance because of these two reasons. It was also concluded in most studies that this diet lowered total and LDL cholesterol as well as decreasing postprandial insulin increase and stabilizing plasma glucose levels. Although most of the subjects enrolled in the low-carbohydrate/high protein diet lost weight, they also usually had a decrease in calorie intake due to becoming full easier and because foods high in protein also tend to be lower in calories than high-carbohydrate foods. So, it can be concluded that the high-protein/low-carbohydrate diet is effective for weight loss, but more than likely the mechanism is still a reduction in total energy intake. Therefore, the composition of the diet may not matter but rather the quantity of calories taken in per day or week.

Although it seems that the carbohydrate intake of the diet may not have a solid affect on weight loss, the question regarding the fat intake is still at stake. As stated earlier, the AHA recommends a diet low in fat because it decreases the risk of building atherosclerotic plaques in arteries, that may eventually contribute to a heart attack. Increased plasma cholesterol levels also contribute to the build-up of these plaques. As noted above, a low-carbohydrate/high-protein diet seems to lower total and LDL cholesterol in the first twelve months. But, Foster et al showed that the same was true for a high-carbohydrate diet, but the low-carbohydrate diet

lowered the cholesterol faster (within the three months). In conclusion, one must ask, "does it matter how fast the cholesterol is decreased as long as it decreases within the first year?" A recent article published in the Journal of American College of Cardiology looked at various studies comparing the Atkins type diet to that recommended by AHA and concluded that they still support the AHA diet over the Atkins diet. The authors state that the attrition rate of the Atkins type diet is low (20-43%) and there are deficiencies of many important micronutrients and dietary fiber. As with many other conclusions they recommend that further studies be done before clinicians advocate the Atkins type diet because evidence still shows that a high fat diet leads to atherosclerosis (Kappagoda, Hyson, & Amsterdam, 2004).

Much controversy has risen in the last year since Dr. Atkins death. Because Dr. Atkins followed his diet/lifestyle change for 40 years before he died, most people want to know if he had clogged arteries from the years of increased fat intake. I could not find a credible journal source regarding this issue, but a peer-reviewed medical education journal, Resident & Staff Physician article seems to be a source. Dr. Feinberg says that Dr. Atkins died at the age of 72 years old after falling on the ice and hitting his head. He then sustained bleeding in his head and eventually death (Feinberg, 2004). It is important to note, that Dr. Atkins did not die from coronary artery disease (CAD) or other heart related factors. This article also states that an autopsy was not performed, so there is no way of knowing whether he had CAD other than his medical records, which also were not released to the public (Feinberg, 2004). A Wall Street Journal article from February 2004 noted Dr. Atkin's cardiologist, Dr. Patrick Fratellone as saying Dr. Atkins fluctuated within ten pounds of 195 from 1999-2002. Dr. Fratellone denied the medical examiner's report that stated Dr. Atkins had a history of a heart attack, congestive heart failure, and hypertension. He stated that Dr. Atkins had cardiomyopathy that he acquired

from a viral illness. One other comment that Dr. Fratellone mentioned was that in 2002, Dr. Atkins had a coronary angiography and they found, “mild narrowing of the arteries that didn’t cause any symptoms” (Winslow & McLaughlin, 2004). Once again, this leaves us with more inconclusive evidence about the *long-term* safety and efficacy of the Atkins diet.

I also believe that when people think of the Atkins diet, a low-carbohydrate diet, or a high-carbohydrate diet, they automatically think of a short-term diet. Everyone is looking for a quick fix to weight loss. Most people do not think of weight loss or weight maintenance as a lifestyle change. This common though process seems to be the problem. The Atkins diet may be useful to people because it has been proven to provide fast weight loss, which motivates people to continue on the diet and lose more weight. The problem arises when people lose 10, 20, 30 pounds and then start adding back *all* of the carbohydrates that they ate before beginning the diet. The ketogenic diet does work, but people need to understand that a low carbohydrate diet is a lifestyle change. Once the weight is lost, one must still remain on a low-carbohydrate diet, but not necessarily a no-carbohydrate diet. For instance, eat spaghetti once a week or oatmeal for breakfast, but do not eat a large amount of carbohydrates everyday or you *will* gain the weight back. Also, people must follow ADA/AHA recommendation and increase daily physical activity. Not only is exercise good for losing and maintaining weight, but also the cardiovascular benefits are endless.

So, this paper raised another question. Do the risks of being overweight or obese outweigh the unknown risks associated with a high-protein/low-carbohydrate diet? It has been shown that obesity leads to several morbid diseases, such as diabetes mellitus, coronary artery disease, hypertension, and hyperlipidemia. But, without long-term studies of high-protein/low-carbohydrate diets there is inconclusive evidence that it has adverse effects on the kidneys and

the arteries. Some studies show that the high protein diet may increase the glomerular filtration rate and increase the volume of the kidney, therefore making the kidney work harder. Also, it has been shown that during a ketotic state the body produces ketones in the blood and urine that may also harm the kidneys. The only conclusion to this controversy is to conduct long-term (10-year) trials of people on a high protein diet trying to maintain and not lose weight. Based on all the evidence above I would recommend a high protein diet because it does decrease hunger and most foods are lower in calories, but some carbohydrates are still needed to provide an adequate source of fiber and nutrients. I would recommend a diet low in fat, high in protein, and carbohydrate restricted for two weeks to initially lose weight, but because the long-term effects of a high-fat/high-protein/low-carbohydrate diet remain to be seen I do not recommend this for long periods of time. The lower fat diet can still provide calcium to prevent bone demineralization (low-fat dairy) and also not contribute to atherosclerotic plaques.

Relevance the the physician assistant profession

This review of literature may be helpful to healthcare professionals because it encompasses the results of many studies on the best composition of a diet for weight loss. As a clinician I would recommend a low carbohydrate diet as long as the protein intake was moderate and fat intake was still low. Although I am convinced that the high protein/low carbohydrate diet lowers total cholesterol, I am not convinced that it needs to be lowered within three months, especially when the high-carbohydrate diet also lowers the cholesterol, it just takes a little more time. The quandary I have with the high fat part of the Atkins diet is that it has been shown that a diet high in fat does lead to atherosclerosis and coronary artery disease. I agree with the American Heart Association that a persons diet should be low in fat, but I don't agree that we

need as many carbohydrates as they recommend on the food pyramid. Also, the type of carbohydrate may be influential. Some studies recommend a diet with carbohydrates from whole grain and higher fiber as opposed to sugary, processed carbohydrates. This way one could get fiber and also nutrients from the grain, without adding lots of calories. The diet that has carbohydrates from a grain source, high protein, and low in fat may actually be the best diet and is currently recommended to prevent the Type II Diabetes Mellitus (Hu et al, 2001).

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NHBLI Classification	BMI
Underweight	<18.5
Normal	<18.5-24.9
Overweight	<25.0-29.9
Obese I	<30-34.9
Obese II	<35.0-39.9
Obese III	> or = 40.0

Table 1. NHBLI BMI Classification System (From "Overview of obesity," by Spence-Jones, G. (2003). *Critical Care Nurs Q, 26,* 85)

Coronary heart disease	Hypertension
Gallbladder disease	Dyslipidemia
Stroke	Chronic joint pain
Hypercholesterolemia	Several cancers
Sleep apnea/respiratory problems	Type II Diabetes
Osteoarthritis	Back injury

Table 2: Health risks associated with obesity
From "Overview of obesity," by Spence-Jones, G. (2003). *Critical Care Nurs Q, 26*, 85-86

BMI= Weight (kg)/[Height (m^2)]

Figure 1: Body mass index formula (from "Overview of obesity," by Spence-Jones, G. (2003). *Critical Care Nurs Q, 26,* 85)

Abstract

Objective

To review published literature about high-protein/low carbohydrate diets and determine their effectiveness for weight loss and also examine adverse effects associated with a high protein/low carbohydrate diet.

Method

Search engines such as MEDLINE, OhioLink, PubMed, and newspaper sources were used to find relevant literature

Results

It was found that a high-protein/low-carbohydrate diet is effective for losing weight if followed correctly. It can also aid in lowering blood lipid levels at a faster rate than that of a high-carbohydrate diet. It has been shown that a high-protein/low-carbohydrate diet does have side effects such as constipation, bad breath, and headaches, but the adverse effects on the kidneys has not been fully studied.

Conclusion

Although it has been shown that a high-protein/low-carbohydrate diet is effective for weight loss short term, the long-term effects of the high-protein on the kidneys and high-fat on the body's arteries remains to be seen.