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COMPARISON OF THE IMPACTS OF A LOW-FAT AND A HIGH-FAT, DIET PLAN ON BODY WEIGHT AND ATHLETIC ACHIEVEMENT IN RECREATIONALLY YOUNG MEN AND WOMEN

[1]Maitri Hathi [2] Dr. Sudesh Kumar

[1] Research Scholar of OPJS University, Churu, Rajasthan

[2]Associate Professor, OPJS University, Churu, Rajasthan

ABSTRACT

Athletes often adjust dietary carbs, and one nutritional method is the ketogenic diet, which consists of a low-carbohydrate, high-fat diet (KD). The goal of this study was to assess the effects of a ketogenic diet (KD) and a control diet (CD) on body composition and athletic performance in trained men and females.39 individuals (23.44 years old; 75.8 15.5 kg; 169.4 8.3 cm) exercised for 9 weeks while eating either a KD or a CD in a parallel-arm, longitudinal, diet- and exercise-controlled design. The energy intake of the two diets were equal. The KD (percent energy as carbohydrate, fat, and protein, 5:72:23) had different non-protein macronutrients than the CD (53:24:23). Pre- and post-testing were done in the weeks leading up to and after the intervention. Dual X-ray absorptiometry (DXA) assessed bone mineral content (BMC) and fat mass (FM), bioelectric impedance spectroscopy (BIS) determined intra- (ICF) and extracellular fluid (ECF), and scale weight data were used to build a 5-component (5C) model of body composition. Vertical jump (VJ), 1-repetition maximum (1RM) in the back squat and bench press, repeated Wingate sprints, and a 5 km time trial (5k) run were among the athletic performance tests.

Keywords: diet plan, athletes, ketogenic diet, control diet

1. INTRODUCTION

A ketogenic diet (KD) is a low-carbohydrate, high-fat diet that creates a unique metabolic state that may lead to a variety of health benefits, including better blood lipids, higher glucose tolerance, and, most importantly, decreased body fat (Volek et al., 2009). Most athletes, particularly those playing in weight-class-restricted sports, seek a low body fat content, and a KD promotes lipolysis and fatty acid oxidation while lowering body fat mass (Volek et al., 2016; Volek et al., 2009). Athletes have lately indicated that ingesting a KD has a self-perceived advantage (Volek et al., 2016). However, few studies have evaluated the physical adaptations to exercise in those who follow a KD against those who follow a traditional low-fat diet.

Traditional athlete parameters provide a broad variety of energy requirements based on the sport and the athlete's unique qualities. 175–300 KJ • kg-1 body weight is the minimum energy requirement. • 5–12 grams of carbohydrate per kg-1 body weight on day 1 • 1.2–2.0 grams of protein per kg-1 body weight on day 1 On day 1; the rest as fat (usually 15–25 percent of calories after carbohydrate adjustments) (Burke, 2001; Burke, Kiens, & Ivy, 2004). Carbohydrate consumption is directly proportionate to the diet's energy content, often 50–70% of total calorie intake, while staying within body weight adjusted levels. Because of their specific function in high-intensity physical exercise and accompanying anaerobic glycolysis, they are the most plentiful macronutrient in an athlete's diet (Brooks & Mercier, 1994). When you swap carbs for protein or fat, your cardiovascular function suffers (Macdermid & Stannard, 2006). The bulk of published investigations, on the other hand, have not used carbohydrate restriction to induce ketoadaptation. Ketoadaptation is still diet-induced and measured using whole blood betahydroxybutyrate (BHB) or total ketones, despite the fact that it differs from the presence of ketones in the blood (ketonemia).

Non-fasting BHB > 0.3 mmol • L-1 (or total ketones [acetone, acetoacetate, and BHB] > 0.5 mmol • L-1) indicates keto-adaptation in people who do not have diabetes. This is based on identical concentrations seen during fasting and after the beginning of moderate acidosis in diabetic patients (Guerci et al., 2005; Robinson & Williamson, 1980). Degrees of keto-adaptation are still poorly characterized. Increased lipolysis, increased fatty acid oxidation, decreased glucose oxidation, increased ketone body synthesis, and reduced amino acid catabolism are all metabolic consequences that may alter athletic performance and body composition (Cox et al., 2016; Douris et al., 2015; Volek et al., 2016). The goal of this study was to evaluate the effects of a KD on body composition and performance to a more traditional isocaloric, isonitrogenous, low-fat, moderate-carbohydrate control diet (CD).

2. Hypotheses

After 9 weeks of supervised, periodized resistance and cardiovascular exercise, recreationally trained, healthy men and women, ages 18 to 30, will have substantial decreases in body fat mass, body weight, and anaerobic fatigue. The KD and CD will have the same cardiovascular endurance, strength, vertical jump performance, muscle size, and muscular hypertrophy.

3. Specific Objectives

1. To compare the effects of a KD versus a CD on changes in cardiovascular exercise performance as measured by a 5-kilometer time trial, time to complete two 250-meter hill segments occurring at 1.00 to 1.25 kilometers and 4.00 to 4.25 kilometers within the time trial, and a 6-set repeated Wingate cycle ergometer sprint protocol after a standardized, 9-week exercise program.

2. To assess the effects of a KD with a CD on changes in strength and power, as measured by 1RM in the barbell back squat and bench press activities, as well as VJ height, power, velocity, and force after a standardized 9-week exercise program.

3. To compare the effects of a KD versus a CD on changes in body composition, such as body weight, DXA-determined LST, FM, BF percent, and BMC, as well as ultrasound-determined cross-sectional area (CSA) of the rectus femoris and combined muscle thickness (MT) of the vastus lateralis and vastus intermedius, after a standardized, 9-week exercise program.

4. Literature Review

Understanding the three primary energy systems is essential for determining the relative relevance of macronutrients in a physically active person's diet. The phosphagen, anaerobic, and aerobic routes are the three energy pathways that are important to exercise, and each is a main source of energy at various exercise intensities and durations. Maximum exercise intensities are ultimately determined by the availability of high-energy phosphate molecules and the pace at which they regenerate. The macronutrients serve as a source of adenosine triphosphate (ATP) (ATP).

For urgent energy demands, the phosphagen system makes use of the readily accessible ATP and creatine phosphate pool. During a bout of activity, the system does not depend on ATP synthesis from macronutrient substrate, but it is restored by macronutrient substrate between bouts. High-intensity (> 90% maximal) and short-duration (6–10 seconds) exercise are linked to this route (Baechle & Earle, 2008). For whatever level of activity, ATP pools are inadequate, and exercise cannot deplete ATP pools by more than 60%. (ConstantinTeodosiu, Greenhaff, McIntyre, Round, & Jones, 1997). Because the creatine phosphate pool is around 5-fold higher than the ATP pool, ATP is largely produced by creatine phosphate and adenosine diphosphate (ADP) through creatine kinase (McArdle, Katch, & Katch, 2010). Adenylate kinase, an enzyme that transfers a phosphate from one ADP to another ADP to make ATP and adenosine monophosphate, may also replenish ATP (Baechle & Earle, 2008). A 1RM test and short-duration or short-distance sprints are examples of physical exercise that predominantly rely on the phosphagen system for energy.

Only glucose or glucose produced from glycogen as the macronutrient precursor may be used to resynthesize ATP in the anaerobic system glycolysis. Glycolysis replaces ATP at a slower pace than the phosphagen system, but it has a higher capability for ATP production owing to bigger levels of glucose storage as muscle or liver glycogen and blood glucose (Baechle & Earle, 2008; Creer, Ricard, Conlee, Hoyt, & Parcell, 2004). Although glycolysis creates 2–3 ATP and 2 pyruvate • molecule-1 of glucose, it has a lower overall ATP production capacity than the phosphagen system, the anaerobic system, in comparison to the oxidative route. Pyruvate is a byproduct of glycolysis that may be converted to lactate or enter the mitochondria and tricarboxylic acid cycle. Pyruvate's destiny is determined by the workout circumstances, oxygen availability, and energy needs. Pyruvate is converted to lactate if exercise intensity is high and stays high (70 percent of max for 15 seconds or more), whereas pyruvate enters the oxidative route and the tricarboxylic acid cycle for increased ATP synthesis if exercise intensity is low to moderate (up to 65 percent of max) (Baechle & Earle, 2008). Maximum effort is not the same as maximum intensity; maximum effort signifies that the person is putting out their utmost effort despite the fact that maximum intensity is likely to fall (workload). Glycolysis is the principal energy system when a person exerts maximum effort for a period of time spanning from 10 to 60 seconds. When glycolysis is the dominant energy source, however, peak effort no longer equals maximal workload since ATP is progressively exhausted, and maximal effort physical activity corresponds to an intensity of 75–90% max (Baechle & Earle, 2008). Weightlifting workouts conducted to volitional failure at 65–80 percent 1RM (8–15 RM), intermediate distance (e.g., 400m) sprints, or intermittent high intensity efforts, such as repeated maximum effort sprints, are examples of activities predominantly dependent on glycolysis.

Glycolysis continues to supply up to 50% of the ATP necessary to power activity after 60 seconds and up to 3 minutes of prolonged maximum exertion. The aerobic, oxidative route, on the other hand, becomes the predominant energy system as time goes on. All macronutrients may be used as precursors in the aerobic route, however each macronutrient enters the tricarboxylic acid cycle at a different point. The alpha keto-acid pyruvic acid is formed from glucose, and it may be converted to acetyl-CoA to join the tricarboxylic acid cycle. Acetyl-CoA is the end product of beta oxidation of fatty acids. However, depending on which amino acid is metabolized, amino acids might enter as acetylCoA through pyruvic acid, alpha-ketoglutarate, succinyl-CoA, fumarate, or oxaloacetate, affecting the net ATP production. Proteins and amino acids, on the other hand, are normally exclusively used for ATP production during hunger or long-duration (> 90 minutes) fasting exercise (Baechle & Earle, 2008; Dohm, Williams, Kasperek, & van Rij, 1982; Graham, Rush, & MacLean, 1995; Lemon & Mullin, 1980). Depending on numerical rounding, the net ATP production from one acetyl-CoA is about 15 ATP (Baechle & Earle, 2008; Brooks, Fahey, & White, 1996). At rest (30 percent intensity), the aerobic energy system produces virtually all ATP, and it is the dominant energy source during long-duration activity. Glycolysis will continue to add to energy needs, with the amount varying according to the individual's fitness level and the intensity of the activity (Baechle & Earle, 2008). Individuals who have been properly trained may be able to exercise for long periods of time at or over 75% of their maximum oxygen intake. Untrained people, on the other hand, will use 50–60% of their maximum oxygen when reaching lactate threshold (McArdle et al., 2010). Increased lactate clearance and dependence on fatty acid metabolism through the oxidative system are two processes that allow well-trained people to endure higher workloads (Baechle & Earle, 2008; Brooks & Mercier, 1994). A 5km run or a triathlon are examples of largely aerobic activities.

5. RESEARCH METHODOLOGY

Participants

Eligible participants were between the ages of 18 and 28, had consistently exercised at least two days per week for the previous two years, had participated in both cardiovascular and resistance exercise at least once per week for the previous two years, reported themselves to be healthy, and were willing and able to follow study protocols. Tobacco usage in any form, a history of medical problems, disclosing any supplement or prescription use that would impact research results, and consistently drinking > 12 alcoholic drinks were all grounds for exclusion. By week one, seeming unable to manage the training program, being unable to complete baseline testing, having a BMI > 35 kg (m2)-1, or being less than 80% adherent with training or nutritional treatments. A power analysis from similar study was used to establish sample size (Joy et al., 2015). The participants came from the Denton, Texas region. The Texas Woman's University IRB granted approval for human subject research, and all participants gave signed informed permission before to participation.

Designing Experiments

The current diet- and training-controlled, parallelarm, semi-randomized trial involved 57 men and women. Prior to recruitment, participants were assessed and informed of the study's criteria. Prior to determining groups and improving compliance, participants completed food preference surveys and interviews with the researchers. Participants who were strongly in favor of or opposed to the KD or CD were divided into groups based on their choice (KD: n = 6; CD: n = 5). Individuals who researchers believed would firmly stick to one diet or the other were categorized accordingly (KD: n = 0; CD: n = 2), while those who had real ambivalence were randomly allocated (KD: n = 15; CD: n = 11). After being rated in decreasing order by squat 1RM, individuals were randomly allocated to KD or CD by even or odd numbers after being ranked in descending order by squat 1RM. The intervention consisted of a 9-week fitness and nutrition plan, with testing taking place both before (Week 0) and after (Week 9). (Week 10).

Diets were given for each participant based on their personal energy needs as measured by the Mifflin-St. Jeor equation, which was increased by 1.625 for the study's activity level. For all groups, a protein intake of 2.0 g • kg-1 was recommended (23 percent of Calories). In the CD, the remaining calories were given as 24 percent fat and 53 percent carbohydrate, while in the KD, they were recommended as 72 percent fat and 5 percent carbohydrate. On training days, all participants received a portion of their daily protein intake in the form of commercially available whey protein powder (protein: 25 g men, 20 g females; ISO100, Dymatize Enterprises LLC, Dallas, TX) mixed with water.

To promote enough vegetable intake as part of a more optimal KD composition, the KD group only included "net" carbs as part of the 5% amount in grams; fiber and erythritol were removed from the total grams of carbohydrate that participants were allowed to ingest. Other sugar alcohols (such as maltitol) were discouraged since they absorb and metabolize in larger levels than erythritol, but stevia and artificial sweeteners were allowed (Grembecka, 2015). Participants in the KD group were instructed to consume > 18 g (males) or 15 g (females) of fiber per day, with nuts, seeds, avocado, coconut, olives, and low-carbohydrate vegetables such as broccoli, celery, peppers, onion, salad greens, and mushrooms serving as major contributors to net carbohydrates. Other items included higher-fat meats (e.g., chicken thigh opposed. breast), fish, oils (especially coconut and olive oil), eggs, and full-fat, unsweetened dairy (excluding milk). Nut and seed flours, dark chocolate not sweetened with sugar and > 70% cacao, berries, and low-carbohydrate protein bars were also included in the KD to a lesser degree.

The CD stressed the intake of vegetables, fruits, whole grains, and other carbohydrates in equal measure. The CD group's fiber intake goal was > 30 g (males) or 25 g (females) (females). Participants in CD were encouraged to eat leaner meats, low-fat dairy, and salad dressing, use more egg whites than whole eggs, cook with just the bare minimum of vegetable oil, avoid potato chips and similar snack items, and keep track of how much nuts and seeds they ate.

All participants were advised to refrain from drinking alcohol throughout the trial and to limit their intake to no more than three servings per day if it was unavoidable. Those in the KD group were told that they could only drink wine or liquor in such situations. To measure dietary intakes, all participants utilized commercially available online and app-based software (MyFitnessPal, Baltimore, MD). CD participants were requested to monitor their dietary information for 7 days From week-1, however compliance was only needed for 3 days (2 nonconsecutive weekdays, 1 weekend).

Due to the increased degree of restriction, KD participants were asked to track 7 days From week-1. Diet records were sent weekly to investigators for dietary coaching in order to maintain consistency, meet nutritional goals, and ensure accuracy. Investigators evaluated food records every week once participants were consistently able to meet specified nutritional goals, but only met with them for coaching if the report indicated a divergence from the planned diet. Diet records were also utilized to figure out how much energy and macronutrients were consumed.

Prior to each training session, all participants underwent a standardized dynamic warmup that lasted 15–20 minutes. The active warmup also acted as a transition between drinking the beverage and starting the workout. With two exceptions, the training routine consisted of three days of weight training and two days of cardiovascular exercise Starting week-1 for nine weeks. Week 5 served as a deload week, with three days of reduced-volume resistance training and one day of reduced-volume cardiovascular training, and Week 9 tapered exercise volume down with two days of reduced-volume resistance training and one day of cardiovascular training in preparation for the testing week. • week-1: Cardiovascular exercise consisted of one steady state and one high-intensity interval training day (see Appendix B).

The Karvonen technique ((220 – age – resting HR) • intensity + resting HR) was used to do steady state exercise at 70–80 percent HR reserve, with the duration increasing from 45 to 75 minutes each week. Treadmills were suggested, but participants were also allowed to utilize a spin cycle or stepmill. All interval sessions began with 2–5 minutes of pedaling at 55–65 rpm with light resistance set at 6. Interval training sprints were completed on an upright exercise bicycle (Life Fitness, Rosemont, IL), and all interval sessions began with 2–5 minutes of pedaling at 55–65 rpm with light resistance set at 6. During the sprints, which lasted 10–30 seconds, participants were encouraged to pedal as hard as possible. Each week, the total sprint volume increased from 155 to 260 seconds, with 0.5–2 minutes of recovery in between.

Unless otherwise stated, each week included one or two days dedicated to increasing muscular strength and hypertrophy, respectively. Strength days were mostly low-volume, high-intensity (85–100% 1RM), longer-rest (3–5 minutes) schemes, whereas hypertrophy days were mostly high-volume, moderate-intensity (6–15 RM), short-rest (1–2 minutes) schemes. On strength days, the aim was to effectively move the weight through the appropriate range of motion in the back squat and bench press. The purpose of all other resistance training exercises was to completely contract the primary muscle(s) over a full range of motion with little involvement of other, aid muscles, while maintaining consistent tension in the target muscle(s) until physical failure. A training partner or an investigator aided until the goal number of repetitions was attained, up to a maximum of 2 forced repeats, if participants suffered muscle failure before completing the needed number of repetitions. The weight was gradually raised from set to set until a load was determined that caused muscle failure. Furthermore, all participants were told to concentrate mentally on the exercise's target muscle(s). With verbal signals and hard tapping of the participants' target muscle(s) during movement execution, the study staff would foster this link.

Drop sets were introduced to the participants' resistance training days in the second half of the training program. Drop sets were used as the last set for a muscle group and consisted of the participant executing repetitions until physical failure, dropping the weight by 10%, and repeating the process until muscular failure was achieved three times.

During the deload week, one session was dedicated to dynamic effort, speed training, focusing on the back squat and bench press movements. The speed workout employed a low-volume, low-intensity (40–60 percent 1RM), moderate-rest (2–3 minutes), high-velocity strategy with the objective of increasing power output and strength without putting too much strain on the body.

During the speed session, resistance band tension was applied as previously indicated (Joy, Lowery, Oliveira de Souza, & Wilson, 2016). Except for the speed session, back squat and bench press intensities were prescribed as a percentage of 1RM, with 85 percent equivalent to a prescription of 5 repetitions and every 5% change in intensity followed by a matching change of 2 repetitions. All other exercises were performed at the specified number of repetitions as a "rep max."

Each week, researchers analyzed records and suggested training weights for the first set of each exercise for the next week. All of the workouts were held at the Texas Woman's University Fitness and Recreation Center and were overseen by a National Strength and Conditioning Association Certified Strength and Conditioning Specialist. All resistance and interval training sessions were accompanied by strong verbal support from the study team.

6. FINDINGS

Individuals that underwent dietary treatments comparable to a KD had worse mineral status and BMC as a result of calorie restriction (Hahn, Halstead, & DeVivo, 1979). When energy intake is adequate and people participate in weight-bearing activity, the current findings show that a KD does not pose an immediate hazard to bone health.

Although there were substantial differences in BMC, the discrepancies seem to be related to an increase in BMC in the CD group's men. In the KD group, both sexes showed a non-significant positive directional shift in BMC (+0.01 kg).

Furthermore, lactate assessment during Wingate sprint testing would have aided in elucidating the processes behind the current findings. Extensive body composition estimation techniques, a range of practically relevant exercise performance tests spanning all three energy systems, a monitored dietary intervention, a generalizable population sample of physically fit individuals, a supervised concurrent exercise intervention more common in real-world practice than exclusive resistance or cardiovascular exercise, and the inclusion of female participants, for whom a supervised concurrent exercise intervention is more common in real-world practice than exclusive resistance or cardiovascular exercise, are all strengths of the study.

7. CONCLUSION

The problem of carbohydrate restriction in athletes is presently dividing the area of sports nutrition. While opinions and beliefs favor either the long-established importance of carbohydrates or the more recent fat-adaptation strategy, the current dissertation sheds light on the debate. The current findings show that dietary carbohydrate restriction, which causes ketosis, has no deleterious effects on exercise performance while also improving overall body composition. With the KD, there were greater decreases in body weight as compared to the FM, but no discernible variations in skeletal muscle measurements. The only characteristic in which those who followed the CD outperformed those who followed the KD was first-set sprint power output, which recovered considerably by the sixth set. Even in people conducting high-intensity exercise, the difference between first and last sets suggested that a KD enhances fatigue resistance. During the first 30 seconds of most sports events, fatigue resistance may take precedence over performance. Furthermore, there is no evident, consistent advantage to either diet in the current situation, based on strength, VJ, and 5k speed trial data.

Because the greatest relationships were seen when performance data was reported in terms of body weight, a KD may provide a distinct advantage to athletes participating in weight-class limited sports.

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