

# Effects of Short-Term Macronutrient Redistribution on Performance Parameters in Resistance Trained Males





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## Abstract

The present study was designed to examine the physical performance responses associated with adoption of a one-week low carbohydrate (LC) or low fat (LF) diet in resistance trained males. Subjects (n = 10) participated in four separate testing sessions, both pre and post assessment following the LC and LF diets. Performance parameters evaluated included the vertical jump (VJ), one-repetition maximum back squat (SQ) and bench press (BP), and a repetition maximum bench press (RMBP) at 75% of the attained maximum. Prior to testing, blood was drawn via venipuncture and evaluated for Testosterone and Growth Hormone concentrations. Testosterone concentration was found to be significantly lower ( $p < .05$ ) with LC when compared to LF. No significant changes in performance were noted ( $p > 0.05$ ) across performance of all aforementioned assessments. In resistance trained males, individuals have the option of switching to either a LC or LF diet without adversely affecting acute performance. Either of these strategies can be successfully applied to a nutritional periodization scheme in accordance with the training goals of the individual.

**Keywords:** Low Carbohydrate Diet; Strength; Endurance

**Abbreviations:** RER: Respiratory Exchange Ratio; CRD: Carbohydrate Restricted Diet; VJ: Vertical Jump; 1-RM: One-Repetition Maximum; BP: Bench Press; SQ: Back Squat; RMBP: Maximum Repetition Bench Press; IRB: Institutional Review Board; ELISA: Enzyme-Linked Immunosorbent Assay; CSCS: Certified Strength and Conditioning Specialist;

## Introduction

The generally conferred health benefits of adopting a carbohydrate or fat restricted diet have been investigated and discussed in great detail [1-6]. However, with regards to athletic performance, less is known regarding the chronic effects of these types of dietary manipulations. Researchers and coaches alike have always had the impression that a diet high in carbohydrates is essential to propagate athletic potential and performance gains [7]. However, research has been performed describing this aforementioned need for carbohydrate consumption as being outdated [1-9]. Fleming and colleagues [2] examined the effects on athletic performance of adopting a high-fat, moderate-protein diet for a period of 6 weeks. From the findings, researchers concluded that carbohydrate restricted diets attenuated absolute performance on the cycle ergometer with significantly reduced respiratory exchange ratio (RER) values observed. However, when measured relative to body compositional improvements, both aerobic and anaerobic cycle performance did not decline.

Dipla and colleagues [1] determined that variation of protein content with regards to stable carbohydrate levels while on an isocaloric diet conferred no reductions in strength performance of moderately trained females. Body composition improvements and reduced body mass led to improvements in relative strength [1]. These results [10] who stated that through alteration of protein content, hypothalamic signaling patterns reduced appetite, in turn reducing body fat while promoting maintenance of lean body mass [3]. Sought to examine the effects of switching from a habitual diet to a carbohydrate restricted diet (CRD) for a period of 7 days on strength and power performance in trained men and women. Following the week-long intervention, the researchers noted a significant reduction in body mass concurrent to maintenance of strength and power outputs. These results have dramatic implications for the value of this type of diet for acute weight management objectives in weight-class specific sports.

Most recently [9] evaluated the effects of a 15-day low carbohydrate, high-fat diet on physiological and metabolic alterations in resistance trained, college-aged men. The researchers found significant decreases in body mass without noted decrements in aerobic performance. The researchers suggest the value of adopting a non-ketogenic, low carbohydrate-high fat diet for improving body composition and maintaining aerobic capacity. The primary purpose of the present study was to examine the acute effects of both carbohydrate and fat restricted dietary interventions with a highly resistance trained population. Outcomes investigated include body composition and mass, and measures of maximal strength and power. The secondary goal of the researcher was to identify the effects of these dietary interventions on anabolic biomarkers, specifically Growth Hormone and Testosterone. The researchers hypothesized that body mass would be comparably reduced in subjects following each of the two dietary interventions relative to baseline readings, with no significant changes in performance parameters. The researchers also hypothesized that there would be no differences in hormone concentration between each of the two diets.

## Methods

### Experimental Approach to the Problem

The present study was designed for two primary purposes. The first purpose was to determine changes in maximal strength and power after switching to short-term carbohydrate and fat restricted dietary protocols. The second purpose was to determine the effects of consuming each of these two diets on resting anabolic biomarkers, specifically Growth Hormone and Testosterone. The tests that were administered were the countermovement vertical jump (VJ), one-repetition maximum (1-RM) in the bench press (BP) and back squat (SQ), and a maximum repetition bench press (RMBP).

### Subjects

The subjects for this investigation included 10 resistance-trained males (age:  $22.6 \pm 4.12$  years, and height:  $174.8 \pm 7.98$  cm). All subjects were recreationally active and reported no injuries at the time of data collection. Prior to participation in the study, all participants read and signed a consent form and completed a medical history questionnaire as well as documentation of training history. The Springfield College Institutional Review Board (IRB) approved the study prior to data collection. Upon completion of all testing, body composition results and results from the exercise performance tests were provided to each of the subjects.

### Procedures

Each subject was required to meet with the primary investigator on five separate occasions. Exercise testing occurred during the last four of these sessions. Session one was an introductory meeting, where the primary investigator described the details of the study. The subjects filled out all necessary paperwork and were asked to keep a habitual diet and training log. Subjects were asked to refrain from alcohol consumption during the duration of the study and were requested to refrain from caffeine consumption a minimum

of 12 hr prior to body composition analysis. In addition, subjects were required to refrain from performing resistance exercise 48 hr before each exercise testing session.

Session two took place 1 week after the first meeting. Subjects arrived at the human performance laboratory following a 12 hr fast. Height was measured using a stadiometer (HAB910-41, Healthometer®, Erlanger, KY), while body mass and composition of each of the subjects was determined using bioelectrical impedance (Tanita, BC-418, Tokyo, Japan). After initial body composition analysis was completed, a sample of blood was taken from the subject via venipuncture for analysis of anabolic biomarker concentrations.

Blood was drawn into 10mL serum sample collection tubes using a 21-gauge,  $\frac{3}{4}$ " butterfly multi-sample syringe. Blood samples were placed in a test-tube holder at room temperature to permit clotting before centrifugation. Once fully clotted, samples were placed into a centrifuge and spun at 2000 rpm for 15 min, after which serum was aspirated and aliquotted into 1.5 ml microcentrifuge tubes. Samples were then stored at  $-80^{\circ}\text{C}$  for later analysis. Testosterone and Growth Hormone was analyzed using the enzyme-linked immunosorbent assay (ELISA) technique. All coefficients of variance (CV) values were below 10%, meaning that all readings were acceptable.

Upon completion of body composition analysis and blood draw, subjects were instructed to leave the laboratory, consume a standard habitual meal, and return 3 to 5 hr later to initiate exercise testing. Upon return, subjects were instructed to perform a 5 min warm-up using a cycle ergometer (Monark 828E Ergometer Testing Bike, Monark Exercise AB, Vansbro, Sweden) at a self-selected pace and resistance. Subjects then performed dynamic stretches for a total of 10 repetitions for each exercise. Subjects were instructed on how to perform each dynamic stretch by a Certified Strength and Conditioning Specialist (CSCS). During all testing sessions, subjects were permitted to consume water *ad libitum*.

Following completion of the designated warm-up, subjects began the testing procedure. The first test administered was the countermovement VJ test. The VJ test assessed muscular power. Each subject performed three countermovement VJs, separated by 2 min of rest. During the countermovement VJ, each subject was instructed to start in a stationary position. The downward phase of the jump consisted of the subjects flexing at the hips and knees to approximately  $90^{\circ}$ , with concurrent shoulder hyperextension. The upward phase of the countermovement VJ consisted of concurrent rapid hyperextension of the knee and hip, and flexion of the shoulder. Arm swing was permitted during performance of the VJ. VJ height was recorded using a "Just-Jump" mat (Just-Jump! Probotics Inc., Huntsville, AL). The maximum height achieved during the three trials was recorded and used for data analysis.

The 1-RM for both the SQ and the BP was determined next using the method described by Baechle et al. [11]. After completion of three warm-up sets, the weight for each of the exercises was subsequently increased for each subject until a 1-RM was performed before exhaustion. The rest between sets was 2-4 min in

length, as outlined by [11]. Following a 3-5minute rest subsequent to completion of 1-RM testing, subjects performed a RMBP using 75%, or the estimated 10-RM amount of weight, as determined via formula [11].

Once all testing had been completed, subjects were allowed to cool-down for 5 min at a volitional pace on the cycle ergometer. After completion of exercise, subjects were informed as to what dietary intervention they would be following for the ensuing week, during which time they were required to maintain a food log and training journal. Session three commenced 1 week after the completion of session two. The testing procedure was identical to that of session two with the exception of the macronutrient composition of the meal consumed prior to exercise testing. The pre-testing meal varied depending upon which dietary intervention the subject was assigned. Upon completion of session three, subjects followed a wash-out period of 2 weeks. During this time, subjects were instructed to return back to a habitual diet. Subjects were asked to follow a habitual caloric intake and energy expenditure pattern as obtained from diet and training logs prior to testing session two.

Session four took place 2 weeks after session three and followed an identical protocol as that outlined for session two. Subjects had followed a habitual diet, and new baseline data were collected. Upon completion of all testing, subjects were instructed as to the specifics of the next dietary intervention to be followed. Session five took place 1 week after session four and followed an identical protocol to that outlined during session three. Prior to initiating dietary interventions, each subject underwent dietary counseling from a certified sports nutritionist (CISSN). Diets were assigned randomly, using a counterbalanced strategy. During this time, each subject was instructed on how to maintain an individual dietary log. Subjects were required to complete a 5-day dietary log while consuming a habitual diet, including at least one weekend day, and again for both the carbohydrate and fat restricted dietary interventions. The carbohydrate restricted diet consisted of 50 g or less of carbohydrate per day. The fat restricted diet consisted of less than 25% of total calories from fat per day. A list of foods that were acceptable to consume while on either of the restricted diets was provided.

During both dietary interventions, the primary investigator contacted each subject every 24-48 hrs to answer any questions the subject had about the diet. Each subject was also required to keep a training log while consuming habitual, carbohydrate and fat restricted diets. Subjects were instructed to replicate training and activities as best they could during each of the weeks being analyzed. Following each intervention, diets were analyzed to assure compliance using The Food Process ® SQL software (ESHA Research, Salem, OR).

### Statistical Analysis

Using SPSS (Version 18.0), 10, 2 x 2 repeated measures analysis of variance (RM-ANOVA) were used to identify if there were significant interactions among the independent variables for each dependent variable. The independent variables included time, or

pre-versus post-intervention; intervention, or low carbohydrate versus low fat dietary intervention; and the interaction of time and intervention. The dependent variables included body composition and body mass; strength and power performance parameters, namely the VJ, 1-RM SQ and BP, and the RMBP; and anabolic biomarkers, or Growth Hormone and Testosterone concentration. This investigation had a statistical power of 0.80, an alpha level of 0.05, and a medium effect size ( $f = 0.40$ ).

### Results

The purpose of this study was to identify differences in body composition, strength performance, and endocrine variables in resistance trained males when they switched to a low carbohydrate or lowfat dietary intervention. A total of 10 subjects participated in the research. The mean age and height for the subjects was  $22.6 \pm 4.12$  years and  $174.8 \pm 7.98$  cm respectively. Macronutrient distribution was assessed using the completed dietary logs. From the analysis, it was determined that carbohydrate consumption was significantly lower on the low carbohydrate diet as compared to both the control and lowfat dietary intervention ( $p < 0.05$ ;  $40.8 \pm 4.84g$  vs.  $332.5 \pm 44.9g$  vs.  $316.3 \pm 10.9g$ , respectively). The analysis also revealed caloric intake from fat while following the lowfat diet to be less than 25%, as prescribed (Table 1).

**Table 1:** Descriptive Statistics for Macronutrient Distribution.

	Low Fat Diet			Low Carbohydrate Diet		
	Mean	SD	%K Cals	Mean	SD	%K Cals
<b>Total Calories (Kcal)</b>						
Pre	2403.60	252.60	100	2403.60	252.60	100
Post	2294.00	129.00	100	2271.20	105.20	100
<b>Carbohydrates (g)</b>						
Pre	332.50	44.91	55	332.50	44.91	55
Post	316.30	10.96	55	40.80	4.84	7
<b>Fat (g)</b>						
Pre	65.80	4.47	25	65.80	4.47	25
Post	50.40	4.14	20	99.60	3.74	39
<b>Protein (g)</b>						
Pre	127.10	7.03	20	127.10	7.03	20
Post	143.80	10.01	25	302.90	6.69	55

Body composition was assessed following a 12 hr fast on the morning of the performance tests. Factors considered for analysis were: bodyweight, body fat percentage, predicted fat mass, and predicted fat-free mass. Descriptive statistics for body composition measures are reported in Table 2. For body composition variables, no significant interaction ( $p > .05$ ) existed for condition and time. In addition, the main effect for condition was not significantly different. A significant ( $p < .05$ ) time effect was found in bodyweight. Pre-intervention values for bodyweight were greater for LF than for LC ( $179.2 \pm 23.9$  lbs vs.  $178.7 \pm 25.3$  lbs, respectively).

**Table 2:** Descriptive Statistics for Body Composition Measures.

	Low-fat Diet		Low Carbohydrate Diet	
	Mean	SD	Mean	SD
<b>Bodyweight (lbs)</b>				
Pre	179.20*	23.90	178.70*	25.30
Post	178.10	23.70	177.80	24.20
<b>Body Fat %</b>				
Pre	14.24	4.03	13.89	3.70
Post	13.97	3.86	13.69	3.30
<b>Fat Mass (lbs)</b>				
Pre	25.94	10.10	25.40	10.10
Post	25.28	9.47	24.78	8.80
<b>Fat-Free Mass (lbs)</b>				
Pre	153.40	17.00	153.30	16.90
Post	152.80	17.10	153.00	17.50

\*A significant ( $p < .05$ ) time effect was found in bodyweight. Pre-intervention values for bodyweight were greater for Low Fat than for Low Carbohydrate.

Subjects performed four consecutive strength and power related tests 3 hr following the body composition analysis. In order, these tests were: the VJ, 1-RM SQ, 1-RM BP, and a RMBP performed using 75% of the identified maximum. Descriptive statistics for performance measures are reported in Table 3. For all performance variables, no significant ( $p > .05$ ) interaction existed between condition and time. No significant mean difference ( $p > .05$ ) existed for condition. Significant differences ( $p < .05$ ) did exist for time with regard to the performance measures, specifically for 1-RM BP and SQ. The values for 1-RM BP and SQ were significantly greater posttest than pretest for both diets, respectively ( $286.0 \pm 18.0$  lbs vs.  $278.7 \pm 17.1$  lbs;  $356.5 \pm 16.9$  lbs vs.  $351.2 \pm 17.1$  lbs); however, no significant differences were noted in performance of the VJ or the RMBP across time ( $p > .05$ ).

**Table 3:** Descriptive Statistics for Performance Measures.

	Low Fat Diet		Low Carbohydrate Diet	
	Mean	SD	Mean	SD
<b>Vertical Jump (in)</b>				
Pre	26.68	2.92	26.56	3.40
Post	27.56	3.31	27.54	3.00
<b>1-RM BP (lbs)</b>				
Pre	281.50	56.40	276.50	54.80
Post	290.50	57.80	281.00	53.90
<b>1-RM SQ (lbs)</b>				
Pre	352.50	54.00	348.50	54.10
Post	360.50	52.30	354.00	54.50
<b>RM BP (reps)</b>				
Pre	9.40	1.71	9.70	2.30
Post	9.10	2.00	10.20	1.80

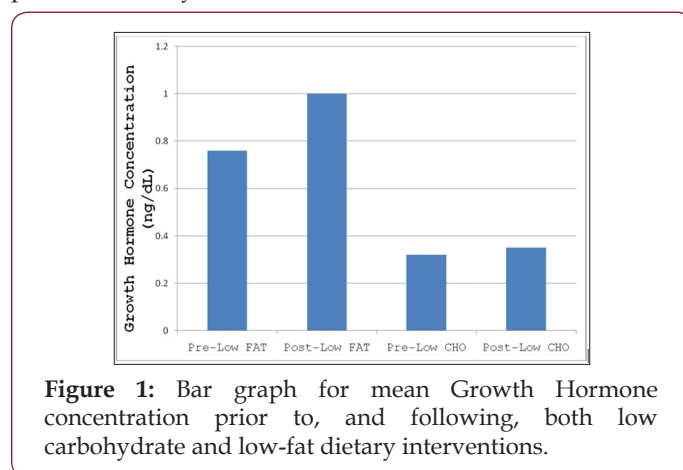
Blood samples were taken prior to, and following, each of the two interventions. No significant interactions or main effects were found for Growth Hormone (Figure 1); however, there was a significant interaction between the dietary interventions and Testosterone concentration ( $p < .05$ ; Figure 2). A simple effects test was conducted and testosterone levels declined significantly following the low carbohydrate intervention (Table 4).

**Table 4:** Descriptive Statistics for Anabolic Hormones.

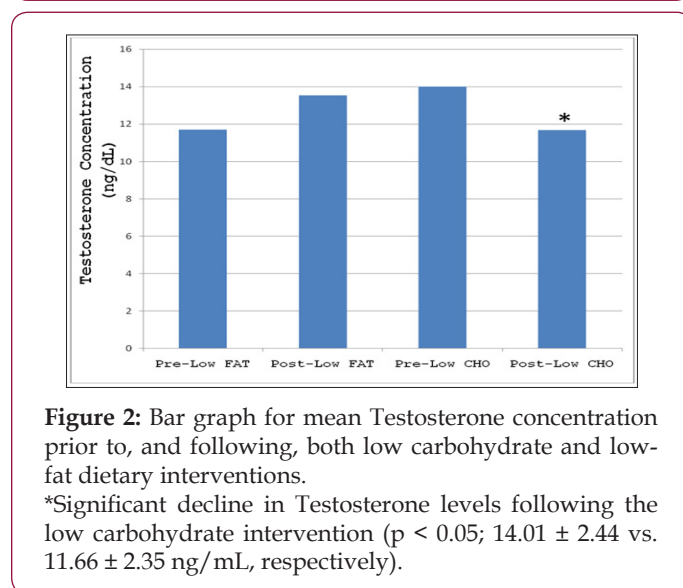
	Low Fat Diet		Low Carbohydrate Diet	
	Mean	SD	Mean	SD
<b>Growth Hormone (ng/mL)</b>				
Pre	0.76	1.89	0.32	0.49
Post	1.00	2.41	0.34	0.59
<b>Testosterone (ng/mL)</b>				
Pre	11.700	3.89	14.010*	2.44
Post	13.52	3.01	11.66*	3.45

\*Significant main effect of condition between prelow fat and prelow carbohydrate intervention.

\*Significant main effect of time and condition between pre and post low carbohydrate intervention.



**Figure 1:** Bar graph for mean Growth Hormone concentration prior to, and following, both low carbohydrate and low-fat dietary interventions.



**Figure 2:** Bar graph for mean Testosterone concentration prior to, and following, both low carbohydrate and low-fat dietary interventions.

\*Significant decline in Testosterone levels following the low carbohydrate intervention ( $p < 0.05$ ;  $14.01 \pm 2.44$  vs.  $11.66 \pm 2.35$  ng/mL, respectively).



A pos- hoc power analysis was conducted on the performance parameters to determine the appropriate sample size to find the effects for future research. The effect size was medium (.40), requiring a minimum sample size of 20 to elicit treatment effects for the strength performance parameters (assuming power = .80).

## Discussion

The purpose of the present study was to identify differences in both body composition and strength performance variables in a resistance-trained male sample following either a LC or a LF dietary intervention. From the results, the key differences found to exist were changes related to baseline variations across time for bodyweight, 1-RM BP and 1-RM SQ. In addition, a significant decline in Testosterone concentration was noted following the low carbohydrate intervention. During the control diets, macronutrient distribution was approximately 55%, 20%, and 25% for carbohydrates, protein, and fat, respectively. These numbers correspond well to the distribution [1]. During the low carbohydrate dietary intervention, macronutrient distribution was 7%, 54%, and 39% for carbohydrates, protein and fat, which is somewhat similar to the diet presented by [12]. For the lowfat diet, macronutrient distribution was approximately 55% carbohydrates, 25% protein, and 20% fat, which is similar to the control diets and the traditional western diet [1] (Table 1).

With regard to comparisons in strength performance measures related to adoption of short-term dietary interventions, the research is relatively sparse. The majority of research conducted entails alterations in resting and exercise respiratory exchange ratio (RER), a direct indication of macronutrient utilization, and of VO<sub>2</sub>max, or the assessment of maximal aerobic capacity [2]. Compared the effects of a high fat, low carbohydrate as compared to a low fat, high carbohydrate group on performance of both aerobic (30 min time trial) and anaerobic (repeated Wingate tests) cycling protocols. Researchers found that while reductions in absolute performance were observed for the high fat diet group, there were no changes in terms of relative performance between the groups, given the significant weight-loss experienced by the high fat group [2].

Most similar to this investigation [3] evaluated the effects of switching from a habitual diet to a carbohydrate restricted diet (CRD) for a period of 7 days on strength and power performance in trained men and women. Following the week-long intervention, the researchers noted a significant reduction in body mass concurrent to maintenance of strength and power outputs, corroborated by the findings of the current investigation. From the results of these two studies, one could infer that a low carbohydrate diet, while not ideal for improving absolute performance of high intensity activities, exhibits no demonstrable decline in relative strength and power performance.

In the current investigation, blood was taken from the subjects prior to performance testing on four separate occasions, to identify any potential influence the short-term dietary interventions would have on anabolic biomarker concentration. From the results, it was identified that while there were no significant changes in Growth

Hormone concentration across interventions, there did exist a significant difference in Testosterone concentration following the low carbohydrate intervention. Specifically, Testosterone concentrations were found to decline following the 1-week intervention.

Examples of factors causing elevations in Growth Hormone, the body's primary lipolytic hormone, include but are not limited to: a high protein meal, or amino acid infusion; prolonged protein calorie deprivation, or fasting; exercise, as well as additional stressors including fever and surgery; and elevations in Testosterone [12,13]. Growth Hormone levels are suppressed when exposed to chronic stress, such as protracted illness, age progression and senility, obesity, and increases in circulating insulin levels associated with a high carbohydrate meal [10]. However, despite these supposed mechanisms responsible for accelerating Growth Hormone secretion (particularly high protein diet and prolonged caloric deficit), the results of this study demonstrated no changes regardless of dietary intervention, potentially attributed to the short duration of the study.

The production and release of Testosterone, the primary male androgenic hormone, is greatly influenced by factors such as overtraining, acute and prolonged illness, sleep deprivation, and a caloric deficit, all of which are responsible for reductions in circulating Testosterone concentration and release, leading to increased Nitrogen excretion and loss of lean body mass [13]. Langfort and colleagues [12] sought to identify the relationship between adoption of a carbohydrate restricted diet and its effects on the endocrine response, specifically Testosterone concentration, to a graded exercise protocol on a cycle ergometer. Much like the present study, carbohydrate consumption was reduced to below 10% of total daily caloric intake. Utilizing a catheter for constant blood sampling, researchers found that serum testosterone was reduced slightly while on a low carbohydrate diet but increased in concert with the other metabolites while consuming a traditional, mixed diet [12]. Researchers attributed this decline in serum Testosterone levels to a decline in carbohydrate stores within the body. These findings corroborate the results of the performed investigation, supporting the hypothesis that a low carbohydrate diet will result in a short-term reduction in serum Testosterone levels. However, data does not exist regarding the effects of these types of nutritional interventions on serum Testosterone and Growth Hormone concentrations across longer periods of time, i.e., greater than one week.

In summary, the major findings of the present study were that in highly resistance trained males, consuming either a LC or LF diet for a period of 1 week will result in no changes of statistical significance in either body composition or strength performance variables. These results corroborate the research of [1] and Sawyer et al. [12], who noted no changes in strength parameters for both upper and lower body after following a control diet or an isoenergetic, high protein, low carbohydrate diet. However, with regards to endocrine factors, a slight decline was noted in serum Testosterone concentration following the low carbohydrate diet, as was previously seen in [12].

## Practical Applications

Acute weight management is often one of the most difficult aspects of the annual competitive plan for weight-class sports. Identifying safe and effective ways to promote short-term weight loss while maintain strength and power production is a top priority to coaches and athletes alike. Adopting a short-term, low carbohydrate diet for weight loss and strength preservation can potentially serve as an effective alternative to more drastic means (e.g., diuretics) of short-term weight loss during a prolonged competitive season.

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