

**Effect of Whey Protein in Conjunction with a Caloric-Restricted Diet and
Resistance Training**

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Running Head: Whey and Caloric Restriction

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Whey and Caloric Restriction

Abstract: Caloric-restricted weight loss, especially rapid weight loss, results from a decrease in both lean and fat mass (FM). The goal for many is to lose FM while retaining lean body mass (LBM) and muscular performance thus many turn to supplements. Sixteen resistance trained males (24± 1.6 years of age) completed a 4 d/wk body building style split resistance training program for eight weeks in conjunction with a pre, peri-, and post-exercise ingestion of whey protein (WHEY) nutritional supplement or carbohydrate (CON) based nutritional supplement. There were no differences in body mass change between the WHEY and CON groups even though both groups lost body mass ($p < .05$), however WHEY group maintained LBM while the CON group lost ($p < .05$), and the WHEY group lost FM ($p > .05$) and the CON group did not, though the change in FM between groups was not different. Both the WHEY and CON ($p < .05$) groups significantly increased lower body strength.. The WHEY group increased upper body strength ($p < .05$) while the CON did not change. Both groups ($P < .05$) increased lower body repetitions to fatigue with the increase greater in the CON group ($p < .05$). The CON group also increased upper body repetitions ($P < .05$) while WHEY did not. WHEY group lost body mass, composed of FM while CON also experienced a loss in body mass, but this loss was due to decrease in LBM. Neither group experienced a loss in muscle performance, with the WHEY group tending to show improvement in strength and CON group in endurance. These data indicate WHEY supplementation; compared to CHO supplementation, during a caloric-restricted "cut" diet can assist in maintaining LBM while allowing for the loss of FM.

Keywords: "cut" diet
muscular performance
body composition

INTRODUCTION

Lean tissue mass is an important determinant for performance in athletes and a predictor of health in recreationally active adults (8,9,18). Individuals attempting to gain or maintain lean body mass while concurrently losing fat mass often utilize a caloric-restricted or "cut diet". "Cut diets" are typically 6-12 week protocols in which caloric intake is decreased and energy expenditure is increased in an attempt to reduce body fat mass. The type of exercise training performed, and the magnitude of the energy deficit influence the tissue lost during the course of the diet, where greater deficits yield a greater body mass loss. Volek et al. (2004) reported that a

Whey and Caloric Restriction

hypocaloric (very low carbohydrate) diet may result in a preferential loss of total and regional fat mass when compared to a hypocaloric low-fat diet (18,19). Caloric-restricted diets are often used by athletes participating in aesthetic sports, such as dance, diving, gymnastics, and bodybuilding, or in weight class sports, such as wrestling, boxing and martial arts. Non-athletes and recreationally active adults tend to emphasize the importance of reduced weight for general health and fitness, as data routinely show that lowered body fat and BMI are associated with better health outcomes (9,12).

One of the primary concerns that both athletes and non-athletes face during weight loss interventions is maintaining or increasing lean mass, while decreasing fat mass. Oftentimes, individuals partaking in a caloric-restricted diet, in addition to a vigorous resistance-training regimen, risk creating a negative protein balance, where the rate of protein catabolism exceeds the rate of protein synthesis (6,23). This may lead to muscle degradation, reduced muscle adaptations, performance, function, and recovery if left uncorrected. The expedient ingestion of nutrients after the cessation of exercise is required to help ensure the transition of net muscle protein balance from negative to positive (23). Protein supplementation increases muscle protein synthesis without a corresponding increase in protein degradation, which results in net positive protein balance, allowing for maximal recovery, hypertrophy, and strength gains (6). Therefore, in addition to fat loss, muscle maintenance is of primary concern throughout the duration of the “cut diet”, and requires adequate dietary protein consumption in both athletes and non-athletes (22). Increased consumption of dietary protein during weight loss interventions promotes a greater loss of fat mass and retention of muscle mass, the latter of which directly contributes to elevated resting metabolic rate (8).

Whey and Caloric Restriction

There is a wide range of protein products available for consumers with most claiming to provide enhanced body composition and lean muscle mass. An increasingly popular supplement is whey protein, a high quality complete protein with a high proportion of essential amino acids and branched chain amino acids (e.g. leucine, isoleucine, valine) that results in a more pronounced increase in muscle protein synthesis in response to exercise (3,4,20). However, what is not fully understood is the impact of whey protein supplementation in conjunction with a caloric-restricted diet. The results of this study could have an impact on the supplementation protocol for athletes who need to meet specific weight guidelines (e.g. wrestlers, mixed martial artists, boxers, etc.) and physique athletes. Therefore, the purpose of this study was to determine the effectiveness of a whey protein supplement on body composition, metabolism and muscular fitness in young adult males utilizing a “cut diet” while maintaining regular participation in resistance training.

METHODS

Experimental Approach to the Problem

In a single-blind, matched group design, resistance trained males participated in a four day/week body building style split resistance training program for eight weeks in conjunction with the pre-exercise, and post-exercise ingestion of a whey protein nutritional supplement (Scivation Whey, Scivation, Inc.) or carbohydrate based nutritional supplement (POWERADE®). In addition, all subjects were provided with a custom designed caloric-restricted diet specifically based on each subject’s individual pre-training body composition. Subjects were instructed that they must follow the diet provided to them for the entire program. Body composition and muscular performance were assessed before and after the eight-week progressive resistance training

Whey and Caloric Restriction

intervention period. This design allowed for the determination of the effectiveness of the “cut diet” in reducing mass across subjects, while also testing whether the whey supplement differed from the control treatment in regards to body composition and muscle performance.

Subjects

Sixteen apparently healthy, resistance trained (regular, consistent resistance training for at least two years prior to the onset of the study, and currently engaging in whole body resistance training) males between the ages of 21-28 years volunteered to participate in the study. Subjects were excluded if they had less than two years of prior resistance training experience, lower or upper extremity surgery within the past year, recent musculoskeletal injury, epilepsy, or another medical condition that would be exacerbated by the consumption of protein (i.e. excessive consumption of alcohol, diabetes, Lou Gehrig’s disease, or branched-chain keto acidura). All participants completed a confidential Physical Activity Readiness Questionnaire (Par-Q) to ensure that the current health status and physical activity habits for participation in this research was met. Prior to any data collection, all eligible subjects were made aware of the potential risks and benefits of the study and signed university-approved written informed consent documents. The Institutional Review Board of the College of Charleston granted approval of all study procedures.

Procedures

Body composition and muscular performance testing sessions were performed for all subjects prior to the first dose of supplement and initiation of resistance training and diet program, and within 3 days after the conclusion of the eight-week intervention/training period. Every attempt was made to schedule pre and post testing at the same time of day to avoid variability due to

Whey and Caloric Restriction

time. Subjects visited the Human Performance Laboratory in the Silcox Center at the College of Charleston for approximately two hours each visit to complete all testing procedures in the same order and were observed by the same research assistants.

Body Composition Assessment

Total body mass was measured on a digital medical scale (Tanita, Tokyo, Japan) and height was measured using a standard medical stadiometer (Seca, Chino, CA). Percent body fat, fat mass, and fat free mass were determined using hydrostatic weighing. Subjects were asked to enter the tank and remove any air bubbles that appeared in or on their clothes, hair, and/or skin. Subjects were then instructed to sit in the submerged chair that was attached to the load sensor. After the subjects were totally submerged, and had exhaled as much air as possible from their lungs, a mass reading was recorded. This was repeated until two measures were within 100 g. Body volume was determined using Archimedes principle, accounting for estimated lung volumes, and body density was determined (body mass/body volume) and entered into the Siri equation for estimation of fat mass and fat free mass (2)

Muscle Performance

Upper and lower body muscular strength was determined using the National Strength and Conditioning Association (NSCA)(14) protocol for a one-repetition maximum (1RM). Each subject performed a 1RM bench press to measure upper body muscular strength, and a 1RM parallel back squat to measure lower body muscular strength. To assess local muscular endurance, 80% of the subject's 1RM on each lift was used for load and subjects were instructed

Whey and Caloric Restriction

to complete as many repetitions as possible while retaining proper form. Trained research assistants spotted and supervised all lifts.

Resting Metabolic Rate

Resting metabolic rate (RMR) was assessed prior to and following the eight week intervention period using a ParvoMedics TrueOne® metabolic cart after a 45-minute resting period in which participants were instructed to remain as quiet and motionless as possible in a dimly lit room. Participants were instructed to freely inhale and exhale throughout the test. Oxygen uptake was measured from expired air and required the use of a plastic canopy, preventing the need for a facemask or mouthpiece, which may artificially elevate resting metabolic rate. Research assistants remained in the room to ensure that participants did not fall asleep.

Caloric-restricted diet

All subjects were provided with an individualized caloric-restricted diet based on individual data (body mass, body composition, resting metabolic rate, etc.). Diets were designed by an industry consultant with prior experience consulting with physique athletes during pre-contest preparation. The caloric-restricted diet was designed as an eight-week “cut diet” for reducing body fat, and used a modified carbohydrate-restricted diet approach (percent of total calories for workout days were 30% carbohydrates, 35% protein and 35% fat and for off days were 25% carbohydrates, 40% protein and 35% fat). Each individual’s daily caloric and macronutrient intake was determined using the Harris Benedict formula with an activity factor of 1.35 (lightly active individual engaging in light exercise 1-3 days/week) for workout days and 1.125 (sedentary individual) for off days. Subjects were given a diet card (See Figure 1) for work out days and off days that listed the total caloric goal with three meal options per meal to attain the desired intake. The dietary intake needs were re-calculated after four weeks of the study to

Whey and Caloric Restriction

account for any changes in body mass. Subjects were required to maintain the diet provided for them for the entire eight-week study period and weekly interviews with subjects were incorporated to help achieve compliance.

Figure 1 here

Supplementation Protocol

In a single-blind design, each participant was randomly assigned an eight-week supplementation protocol in one of two groups. Participants assigned to the protein supplement group consumed 28 g of a whey protein nutritional supplement (Scivation Whey, Scivation, Inc.) prior to and following each workout for a total of 56g. Subjects in the control group ingested 28g of a carbohydrate based nutritional supplement (POWERADE ®) prior to and following each workout, for a total of 56g per workout. Each subject was given a 4-week supply of their supplement with specific instructions on how to mix and when to consume. Subjects returned to the lab every four weeks to receive additional supplement. Subjects had to agree to refrain from consuming any other nutritional supplements during the study period.

Resistance training protocol

Participants engaged in a supervised progressive bodybuilding split style resistance-training program consisting of 60-90 minutes of training four days per week for eight weeks (Day 1: Chest/Triceps, Day 2: Legs, Day 3: shoulders, Day 4: Back/Biceps). Although the body parts trained remained consistent throughout the eight weeks, the specific exercises used for each body part alternated and repeated every other week. Subjects performed 3-4 sets per exercise with two-minute rest periods. During weeks 1 & 2 subjects completed 4-5 reps per set and every two

Whey and Caloric Restriction

subsequent weeks two reps were added per set resulting in subjects performing 10-11 reps per set during weeks 7 & 8. Subjects were provided and instructed to maintain their training log throughout the eight-week training period and returned to the lab every four weeks to have their individual training logs reviewed. Subjects (both treatment and control) not progressing through their program or complying with the stated nutrition and supplement requirements were dismissed from the study.

Statistical Analyses

Data are expressed as means \pm SE. To determine if the whey protein provided an additive benefit to the caloric restricted diet and resistance training program data was analyzed (SigmaSat 3.5) using *a priori* paired and unpaired t-tests to assess changes over time and between group means, respectively. Tukey's Test was used for post hoc analysis. Intraclass correlation coefficients (ICC) were performed to examine the test-retest reliability of the performance tests. The significance level was set at $\alpha = 0.05$.

RESULTS

Body Composition

There were no differences in body mass change between the whey and CON groups, however both groups lost body mass (2.4 ± 0.7 kg; $p < .05$) during the trial period, suggesting the calorie restricted diet was successful. (See Figure 2) The whey group maintained lean body mass during the trial while the CON group had a $1.4 \pm 0.1\%$ (pre: 67.8 ± 2.5 kg vs. post: 66.9 ± 2.5 kg) loss in lean body mass ($p < .05$). (See Figure 3) Finally, the whey group lost $20.9 \pm 3.3\%$ (11.9 ± 2.1 kg vs 9.4 ± 1.6 kg) fat mass ($p < .05$) and while the CON group non significantly lost 1.4 ± 0.7 kg fat mass

Whey and Caloric Restriction

($p > .05$) the difference in fat mass lost between groups post study was not different ($p = .20$). (See Figure 4)

Place Figures 2-6 here.

Metabolism

Resting metabolic rate, in terms of calories burned per minute, decreased in the whey group ($p < .05$) but not in the CON group ($p > .05$), though the difference in changes between the groups was not significant ($p = .19$). Not surprisingly, this trend held when translating these data to a 24-hr period (whey: 2002 ± 101 vs. 1286 ± 34 kcals/day; CON: 1898 ± 261 vs. 1586 ± 49 kcals/day).

Muscular Strength & Local Muscular Endurance

Both muscular strength and local muscular endurance were measured for the lower body (squat) and upper body (bench press). There was no difference ($p = .22$) in lower body strength changes following the study between the groups, as both the whey (pre: 133 ± 5 vs. post: 144 ± 3 kg; $p < .05$) and CON (pre: 124 ± 10 vs. post: 128 ± 12 kg; $p < .05$) groups showed significant improvements. Upper body tests showed a different result, as there was a difference in how the groups responded ($p < .05$), with the whey group increasing strength (pre: 103 ± 3 vs. post: 107 ± 4 kg; $p < .05$) while the CON did not change (pre: 101 ± 3 vs. post: 97 ± 2 kg; $p > .05$). (See Figure 7) Both groups increased squat repetitions ($p < .05$) compared to pre (whey: 12 ± 2 vs. 15 ± 2 reps; CON: 14 ± 1 vs. 19 ± 1 reps) and the increase was greater in the CON group ($p < .05$). Differences were found with upper body muscular endurance, with the CON group having a greater increase in repetitions (whey: 9 ± 0.3 vs. 9 ± 0.3 reps; CON: 7 ± 1 vs. 9 ± 0.2 reps; $p < .05$). ICCs for the lower body 1RM squat test was $R = 0.999$, 80% 1RM squat test for reps was $R = 0.991$, upper body

Whey and Caloric Restriction

1RM bench press test was $R = 0.684$, and 80% 1RM bench press test for reps was $R = 0.756$.

(See Figure 8)

Place Figures 7 & 8 here.

DISCUSSION

The aim of this study was to determine the effectiveness of a whey protein supplement in conjunction with a hypocaloric diet, on body composition, resting metabolic rate, and muscular fitness in healthy resistance trained males. Prior reports suggest maintaining muscle mass while reducing fat mass is difficult, yet we hypothesized that the whey supplement would elicit an effect on muscle recovery from exercise and maintain muscle mass and muscular fitness (5,18).

Both whey and CON groups engaged in identical, supervised resistance training programs, and received individualized hypocaloric diets for eight weeks; therefore, changes in body composition and muscular fitness are most likely the result of the protein supplement, compared to the ingestion of the carbohydrate placebo supplement. This is an important discovery because protein supplements such as whey are often relied upon to maintain or improve muscle mass, in order to aid muscle recovery, enhance athletic performance, and to reduce the risk of sarcopenia, especially in older adults (5,18).

Body Composition

Both the whey and CON groups reduced overall body mass after the eight-week intervention, attesting to the effectiveness of the hypocaloric diet. However, the whey group experienced a decrease in fat mass that was significantly different from pre-trial values, and from the CON group, indicating that the whey supplement was more effective than the carbohydrate supplement

Whey and Caloric Restriction

at promoting fat loss. This finding is consistent with previous studies that demonstrated a decrease in overall body mass and fat mass when comparing the consumption of a whey protein supplement with a carbohydrate supplement within a group of healthy, resistance-trained men (3). It is possible that the CON group did not lose fat mass because carbohydrate supplementation stimulated a greater insulin release, which is not as effective as protein supplements in stimulating muscle anabolic pathways (7).

We anticipated an increase in lean muscle mass after the conclusion of the resistance training and whey supplementation period, however; only the whey group maintained lean body mass (0 ± 0.8 kg) whereas the CON group decreased lean body mass (0.9 ± 0.1 kg). It is possible that the decrease in lean mass can be attributed to decreased myofibrillar synthesis in the CON group, potentially a result of a lower consumption of dietary protein, combined with a muscle-damaging resistance-training program. Hector et al. (2015) found that whey protein supplementation post-exercise attenuated the decline in post-prandial rates of myofibrillar protein synthesis after weight loss, which was important in preserving lean mass during weight loss interventions (8). Similarly, Joy et al. (2013) found that a whey protein supplement, in addition to a resistance-training program, in resistance-trained males was effective in optimizing muscle protein accretion and muscle fitness (9). Further, it is also possible that the WHEY decreased muscle protein degradation by providing enough available amino acids that the body didn't have to break muscle down to provide the necessary amino acids (16). Thus, the lack of a whey protein supplement may have allowed the post-exercise decline in myofibrillar protein synthesis in the CON group.

Whey and Caloric Restriction

Previous studies using whey protein supplements have demonstrated that protein supplementation is more effective than carbohydrate supplementation at maintaining lean body mass and improving overall body composition (3,4,13,22). Willoughby et al. (2007) found that a combined protein supplement (whey and casein) was effective in improving muscle mass and strength, and improving overall body composition (22). Similarly, Candow et al. (2006) found that a thrice-daily consumption of a whey protein supplement in healthy, young males and females was effective in increasing lean tissue mass and improving body composition (3).

Protein quality is also an important determinant of lean body mass responses to resistance training (20). Numerous researchers have demonstrated the ergogenic effects of whey protein on lean muscle mass in both untrained and trained individuals. Candow et al. (2006) illustrated that whey protein supplementation increased the ratio of protein synthesis to degradation post-exercise in young untrained males and females. In a study conducted on healthy young resistance-trained males, a whey nutritional intervention increased protein accretion and lean muscle mass while also improving muscle function (4). Further, researchers have found that daily supplementation of soy lowered circulating testosterone levels, whereas whey supplementation blunted cortisol response post-exercise. Therefore, whey may provide a more anabolic environment than soy because of its rapid rate of absorption and ability to blunt the cortisol response post-exercise (10).

The preservation of or increase in lean mass continues to be an important research topic, especially for athletes trying to improve body composition while maintaining performance and for older adults who risk obesity or age-onset sarcopenia and other age-related diseases (5).

Whey and Caloric Restriction

Providing these persons with adequate and high quality protein, such as whey protein, can stimulate myofibrillar protein synthesis, influence anabolic hormones and in turn preserve lean body mass (5,18). Our data suggest that whey protein supplementation in individuals attempting to lose weight via caloric restriction can achieve maintenance of lean tissue mass while experiencing a loss of fat mass.

Metabolism

Eight weeks of resistance training combined with a whey protein supplement did not elicit a significant increase in RMR. Interestingly, the whey group decreased RMR compared to baseline values, whereas the CON group maintained RMR over the same time span. Variation in RMR is largely determined by muscle mass, where increases in muscle mass increases RMR because the muscle consumes a greater amount of energy at rest, compared to fat tissue (7). The CON group demonstrated a decrease in lean mass without a concurrent decrease in RMR, possibly due to the fact that they only decreased their lean mass by 0.9 kg, which is only 0.5% of total mass (mean = 179.1 kg). Therefore, the decreased lean mass would not contribute to the change in RMR to a significant degree.

Other researchers have shown that protein supplementation in conjunction with resistance training is effective in increasing RMR above baseline values. Hambre et al. (2012) demonstrated that after a 12-week resistance- training and protein supplementation (33g whey protein/day) program in healthy males, both RMR and lean tissue mass were increased similarly (7). However, the use of a hypocaloric diet in our study makes our findings unique, and can partially explain the lack of observed changes in RMR.

Whey and Caloric Restriction

Muscle Strength and Endurance

There is a growing research interest into the anabolic benefits of protein supplements compared to a carbohydrate supplement during resistance training. Willoughby et al. (2007) indicated that whey/amino acid supplementation resulted in greater increases in upper body (bench press) and lower body (leg press) strength, when compared to a carbohydrate supplement (22). However, both of the aforementioned studies utilized multiple-ingredient protein supplements and caloric neutral diets, whereas the current study utilized a whey protein supplement in conjunction with a hypocaloric diet. After an eight week period, the whey group showed small improvements in both upper body and lower body strength, whereas the CON group only showed improvements in lower body strength. Interestingly, the strength values in the whey group were not significantly greater than the values from the CON group in lower body strength despite the change in the whey group being twice that of the CON group.

These results may be attributed to the specific effect of whey protein on muscle fibers. Ingestion of whey protein and its constituent amino acids stimulates anabolic hormone release and promotes the synthesis of muscle fibers, especially Type II muscle fibers, which enables powerful movements that promote strength rather than endurance outcomes (2,18). It should be noted that placebo groups were consuming protein in their diets, so they too would be able to promote muscle fiber hypertrophy, though to a lesser extent. Further, these subjects were already experienced in weight training, so the type of training (this was not assessed as an inclusion criteria) they were accustomed to could explain the presence or absence of strength/endurance changes.

Whey and Caloric Restriction

Other studies have demonstrated that a combination of whey with other protein supplements, such as casein and free amino acids (i.e. leucine) is more effective than an isolated whey supplement or an isocaloric carbohydrate supplement in promoting muscle anabolism and muscle strength, though with inconsistent results (2,3,11,17,18). A study by Cornish et al. (2009) illustrated the muscular strength benefits of a conjugated linoleic acid/creatine/whey (CCP) protein supplement when compared to creatine/placebo (CP) and whey/placebo (P) supplement groups. Increases in bench press strength, leg press strength, and lean tissue mass were greater in the combined group (CCP) than the isolated creatine (CP) or whey (P) groups (6). Burke et al. (2001) compared a whey/creatine monohydrate supplement against an isolated whey supplement, and reported that the subjects who consumed the whey/creatine supplement experienced greater increases in lean tissue mass and muscular strength than the whey or placebo group (3). Andersen et al. (2005) illustrated that the ingestion of a protein supplement blend (whey, casein, egg white, glutamine) one hour before and after exercise combined with a 14-week resistance program was more effective than an isocaloric carbohydrate in improving muscle performance as tested by a vertical jump (1).

Some researchers contend that a whey supplement combined with amino acids elicits the greatest beneficial effects on muscle protein synthesis and strength. Verreijen et al. (2015) found that a supplement with high whey protein, leucine, and vitamin D enriched content preserved muscle mass during intentional weight loss (defined as training in addition to a hypocaloric diet) in obese older adults (18). However, in contrast to the aforementioned study conducted by Verreijen et al (2015), Mielke et al. (2009) compared muscular strength benefits from a

Whey and Caloric Restriction

whey/leucine supplement against a carbohydrate placebo and non-supplement group, and found that the gains in muscular strength were equivalent between the carbohydrate and the whey/leucine groups (12). Similarly, Spillane et al (2014) found that the peri-exercise ingestion of a multi-ingredient protein nutritional supplement (39g maltodxtrose, 7g whey, 4g creatine monohydrate) was not effective in preferentially improving body composition, muscle performance, or muscle protein synthesis (17).

The variability in experimental factors such as the quantity of the supplements, the type of supplements, the timing of ingestion, training status, intensity of training, and external dietary intake (iso-, hyper- or hypo-caloric) make direct comparisons of these studies difficult (12). In this study, an isolated whey protein supplement promoted a greater loss in fat mass and preservation of lean body mass and (lower body) muscular strength than a carbohydrate placebo after eight weeks of heavy resistance training and a reduced-calorie diet. While it is not novel that a protein supplement can be more effective than a carbohydrate supplement at maintaining muscle mass and performance, what is unique is realizing these changes during a reduced calorie diet.

PRACTICAL APPLICATIONS

The data from this study can be directly implemented by sports performance coaches, athletic trainers, sport coaches, fitness trainers, athletes and active adults who engage in resistance training and are concerned with body composition. Many times athletes are asked to lose body mass in an attempt to improve performance, but this often leads to a loss of muscle mass, and hence poorer performance. The results of this study indicate that an eight-week progressive strength-training program performed in conjunction with a hypo-caloric diet and a whey protein

Whey and Caloric Restriction

supplement can maintain lean body mass while promoting loss of fat mass. While applicable to many athletes, this information may be especially valuable to wrestlers, boxers, mixed martial artists, and physique athletes (i.e. body builders, fitness competitors, etc.) who need to maintain lean mass and performance while still “making weight.”

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Whey and Caloric Restriction

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22. Willoughby, DS, Stout, JR, and Wilborn, CD. Effects of resistance training and protein plus amino acids supplementation on muscle anabolism, mass, and strength. *Amino Acids* 32: 467-477, 2007.
23. Witard, OC, Cocke, TL, Ferrando, AA, Wolfe, RR, Tipton, KD. Increased net muscle protein balance in response to simultaneous and separate ingestion of carbohydrate and essential amino acids following resistance exercise. *Appl Phys Nutr Met* 39(3): 329-339, 2014.

ACCEPTED

Example Meal Plan OFF Days

1604 Calories

| Meal 1 | | | | | | | | | | | | | | | | | | |
|--------|--------|----|----|--------|---|---------------------|-------|------|----|--------|---|----------------------|-------|-----|----|--------|---|-----------------------|
| # Serv | Meal 1 | | | | | | | | | | | | | | | | | |
| 5 | 10.00 | Ea | or | 335.00 | G | Egg Whites | 1.25 | C | or | 285.00 | G | NF Cottage Cheese | 1.65 | C | or | 50.00 | G | Whey Protein Pwdr |
| 2 | 2.00 | Oz | or | 56.70 | G | Avocado | 12.00 | Each | or | 17.20 | G | Almonds | 20.00 | Ea | or | 1.87 | G | Peanuts |
| 1 | 2.25 | Oz | or | 64.00 | G | Banana | 3.50 | Oz | or | 95.00 | G | Blueberries | 6.50 | Oz | or | 184.00 | G | Strawberries |
| 1 | 0.25 | C | or | 20.00 | G | Oatmeal (Dry/Plain) | 0.13 | C | or | 20.00 | G | Steel Cut Oats (Dry) | 1.25 | Tbp | or | 15.60 | G | Barley (Pearled)(Dry) |

| Meal 2 | | | | | | | | | | | | | | | | | | |
|--------|--------|------|----|--------|---|--------------------|------|----|----|--------|---|-------------------|------|-----|----|--------|---|---------------------|
| # Serv | Meal 2 | | | | | | | | | | | | | | | | | |
| 4 | 4.00 | Oz | or | 113.40 | G | Lean Turkey Breast | 4.00 | Oz | or | 113.40 | G | Tuna (cnd in H2O) | 4.00 | Oz | or | 113.40 | G | Grid Chicken Breast |
| 3 | 18.00 | Each | or | 25.80 | G | Almonds | 3.00 | Oz | or | 85.05 | G | Avocado | 6.00 | Tsp | or | 31.80 | G | Peanut Butter |
| 1 | 3.25 | Oz | or | 92.00 | G | Apple | 3.50 | Oz | or | 95.00 | G | Blueberries | 0.00 | Oz | or | 28.25 | G | Raspberries |

| Meal 3 | | | | | | | | | | | | | | | | | | |
|--------|--------|----|----|--------|---|---------------------|------|-----|----|--------|---|------------------------|-------|------|----|--------|---|---------------------|
| # Serv | Meal 3 | | | | | | | | | | | | | | | | | |
| 5 | 5.00 | Oz | or | 141.75 | G | Grid Chicken Breast | 3.75 | Oz | or | 106.25 | G | Grid Lean Sirloin | 5.00 | Oz | or | 141.75 | G | Grilled Halibut |
| 2 | 2.00 | Oz | or | 56.70 | G | Avocado | 4.00 | Tbp | or | 60.00 | G | Salad Dressing (Light) | 12.00 | Each | or | 17.20 | G | Almonds |
| 2 | 5.50 | Oz | or | 156.00 | G | Steamed Broccoli | 6.00 | C | or | 330.00 | G | Chppd LetTomCuc | 3.50 | Oz | or | 100.00 | G | Steamed Green Beans |
| 1 | 2.25 | Oz | or | 63.80 | G | Baked Potato | 0.33 | C | or | 64.35 | G | Brown Rice (Ckd) | 1.00 | Slc | or | 32.00 | G | Ezekial Bread |

| Meal 4 | | | | | | | | | | | | | | | | | | |
|--------|--------|------|----|--------|---|---------------------|------|----|----|--------|---|---------------------|------|-----|----|--------|---|--------------------|
| # Serv | Meal 4 | | | | | | | | | | | | | | | | | |
| 4 | 4.00 | Oz | or | 113.40 | G | Tuna (cnd in H2O) | 4.00 | Oz | or | 113.40 | G | Grid Chicken Breast | 1.32 | C | or | 40.00 | G | Whey Protein Pwdr |
| 2 | 12.00 | Each | or | 17.20 | G | Almonds | 2.00 | Oz | or | 56.70 | G | Avocado | 4.00 | Tsp | or | 21.20 | G | Peanut Butter |
| 2 | 8.80 | Oz | or | 250.00 | G | Steamed Spinach | 3.50 | Oz | or | 100.00 | G | Steamed Green Beans | 5.50 | Oz | or | 156.00 | G | Steamed Broccoli |
| 1 | 0.25 | C | or | 20.00 | G | Oatmeal (Dry/Plain) | 0.33 | C | or | 46.00 | G | Whole Grain Pasta | 2.00 | Oz | or | 56.70 | G | Baked Sweet Potato |

| Meal 5 | | | | | | | | | | | | | | | | | | |
|--------|--------|-----|----|--------|---|-------------------|------|----|----|--------|---|---------------------|------|-----|----|--------|---|------------------------|
| # Serv | Meal 5 | | | | | | | | | | | | | | | | | |
| 5 | 3.75 | Oz | or | 106.25 | G | Grid Lean Sirloin | 5.00 | Oz | or | 141.75 | G | Grid Chicken Breast | 5.00 | Oz | or | 141.75 | G | Grilled Halibut |
| 3 | 3.00 | Tsp | or | 13.50 | G | Olive/Enova Oil | 3.00 | Oz | or | 85.05 | G | Avocado | 6.00 | Tbp | or | 90.00 | G | Salad Dressing (Light) |
| 2 | 8.00 | Oz | or | 226.00 | G | Steamed Asparagus | 8.80 | Oz | or | 250.00 | G | Steamed Spinach | 6.00 | C | or | 330.00 | G | Chppd LetTomCuc |

Figure 1 is found in accompanying PowerPoint file.

Figure 1: Sample diet card provided for subject. Each individual's daily caloric and macronutrient intake was determined using the Harris Benedict formula with an activity factor of 1.35 (lightly active individual engaging in light exercise 1-3 days/week) for workout days and 1.125 (sedentary individual) for off days.

ACCEPTED

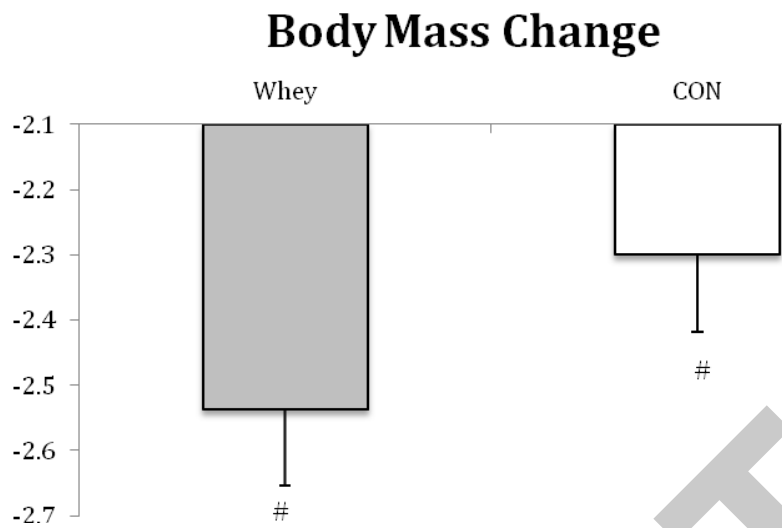


Figure 2: Change in body mass between whey and control groups following 8 week study period. # Different from pre within group, $p < 0.05$.

Lean Body Mass Change

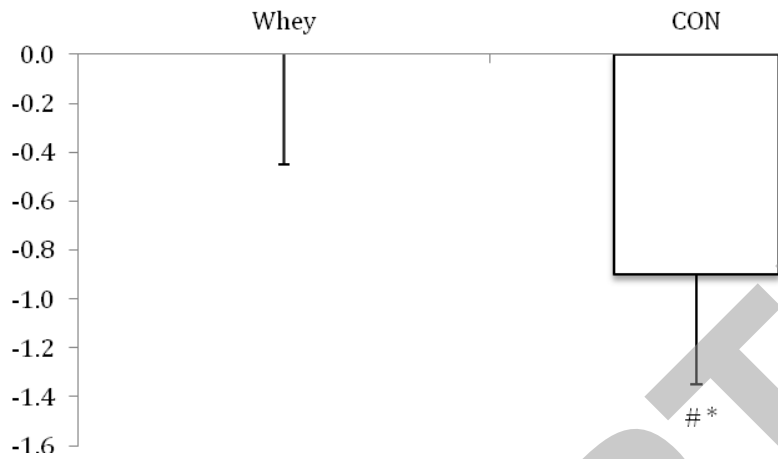


Figure 3: Change in lean body mass between whey and control groups following 8 week study period. * Different from comparison group, $p < 0.05$; # Different from pre within group, $p < 0.05$.

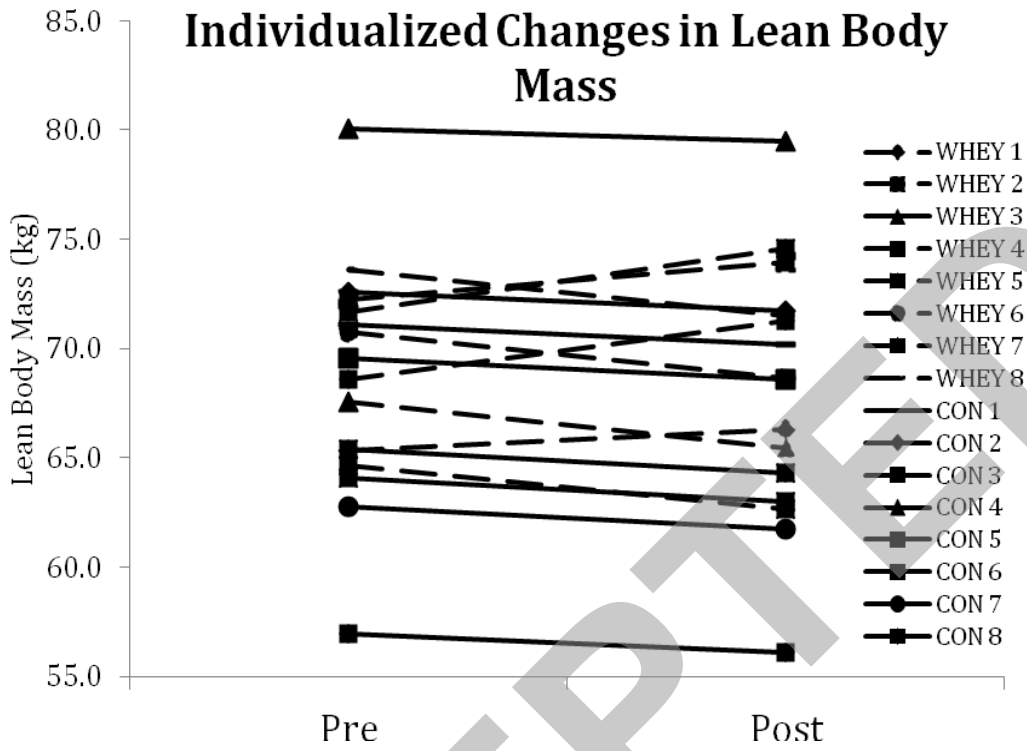


Figure 4: Change in lean body mass of whey and control groups following 8 week study period.

Fat Mass Change

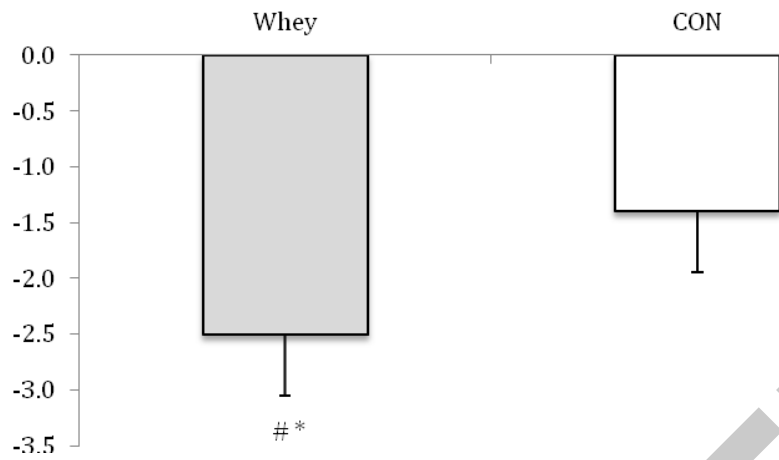


Figure 5: Change in fat mass between whey and control groups following 8 week study period. * Different from comparison group, $p < 0.05$; # Different from pre within group, $p < 0.05$.

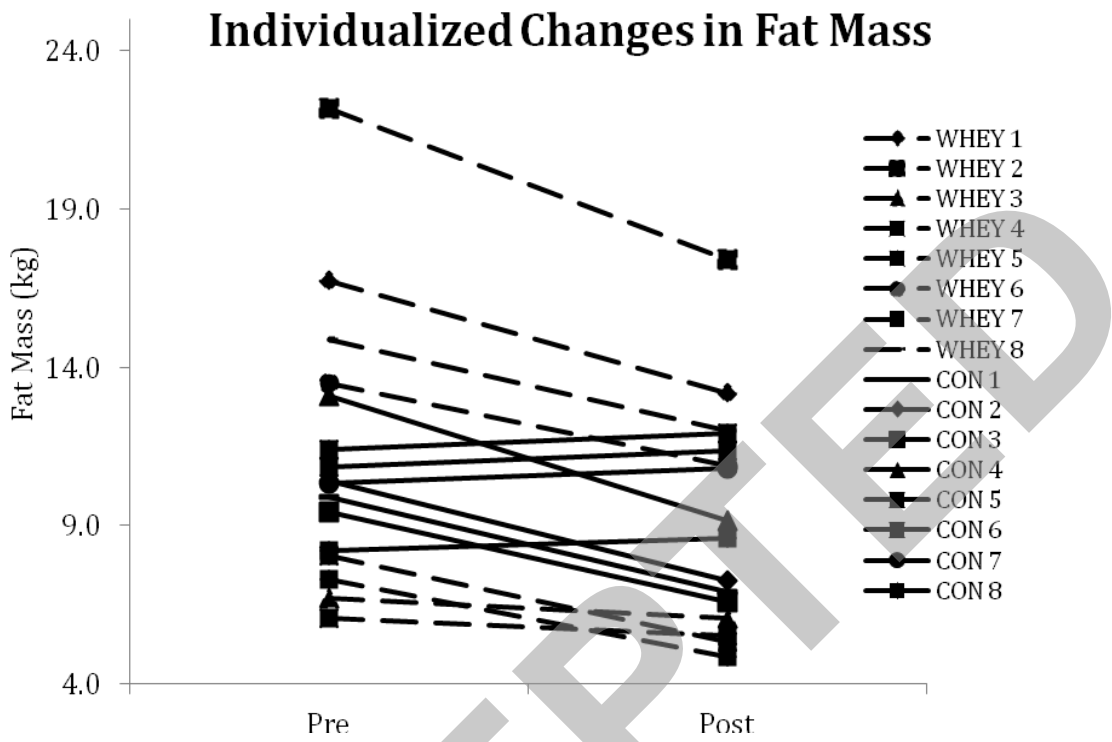


Figure 6: Change in fat mass of whey and control groups following 8 week study period.

Change in Strength

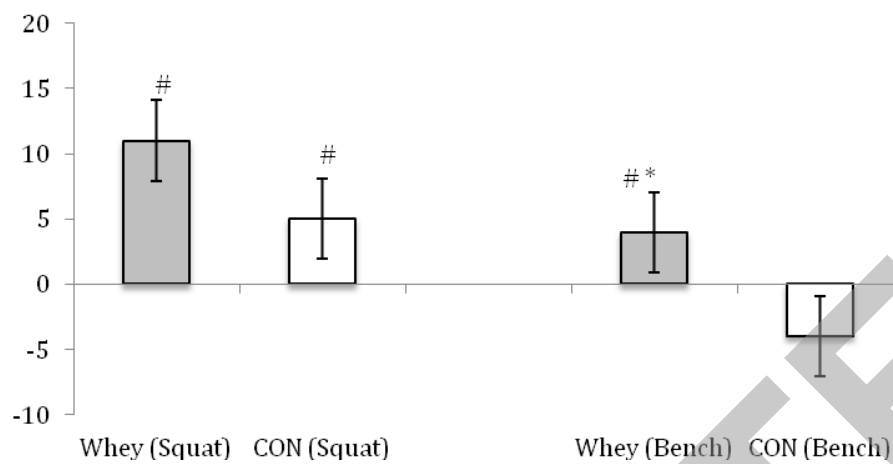


Figure 7: Change in upper and lower body strength between whey and control groups following 8 week study period. * Different from comparison group, $p < 0.05$; # Different from pre within group, $p < 0.05$.

Repetitions to Fatigue

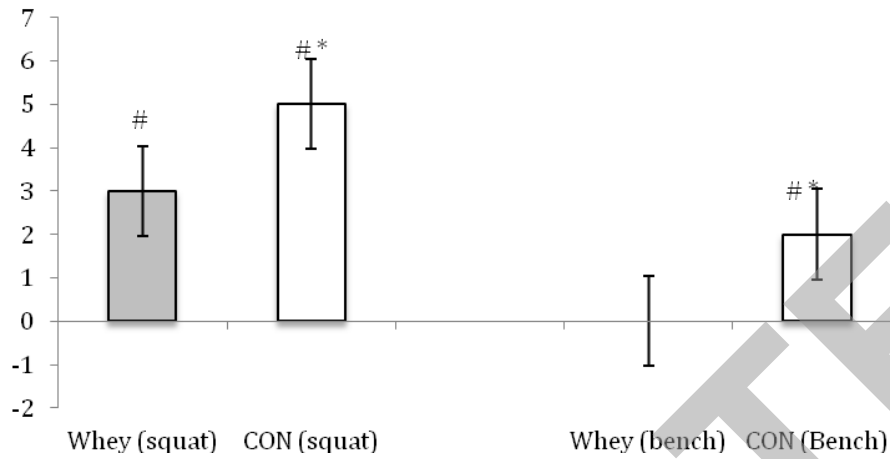


Figure 8: Change in upper and lower body strength between whey and control groups following 8 week study period. * Different from comparison group, $p < 0.05$; # Different from pre within group, $p < 0.05$.