

The Effect of Whey Isolate and Resistance Training on Strength, Body Composition, and Plasma Glutamine

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Different dietary proteins affect whole body protein anabolism and accretion and therefore, have the potential to influence results obtained from resistance training. This study examined the effects of supplementation with two proteins, hydrolyzed whey isolate (WI) and casein (C), on strength, body composition, and plasma glutamine levels during a 10 wk, supervised resistance training program. In a double-blind protocol, 13 male, recreational bodybuilders supplemented their normal diet with either WI or C (1.5 gm/kg body wt/d) for the duration of the program. Strength was assessed by 1-RM in three exercises (barbell bench press, squat, and cable pull-down). Body composition was assessed by dual energy X-ray absorptiometry. Plasma glutamine levels were determined by the enzymatic method with spectrophotometric detection. All assessments occurred in the week before and the week following 10 wk of training. Plasma glutamine levels did not change in either supplement group following the intervention. The WI group achieved a significantly greater gain ($P < 0.01$) in lean mass than the C group (5.0 ± 0.3 vs. 0.8 ± 0.4 kg for WI and C, respectively) and a significant ($P < 0.05$) change in fat mass (-1.5 ± 0.5 kg) compared to the C group ($+0.2 \pm 0.3$ kg). The WI group also achieved significantly greater ($P < 0.05$) improvements in strength compared to the C group in each assessment of strength. When the strength changes were expressed relative to body weight, the WI group still achieved significantly greater ($P < 0.05$) improvements in strength compared to the C group.

Key Words: protein supplement, lean mass, body fat loss

Some (8, 37) but not all (33) studies indicate that a higher protein intake (approximately 1.5 to 2 times the current Recommended Daily Allowance) is advantageous for muscle and strength development during resistance training. Bodybuilders and other strength athletes widely use protein supplements to achieve high protein intakes (up to 3 times the RDA) (23, 27). Aside from quantity, certain types of protein

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affect whole body protein anabolism and accretion (4, 11, 12) and therefore, have the potential to affect muscle and strength development during resistance training (22). The type of protein consumed may influence results from resistance training due to variable speeds of absorption, differences in amino acid profiles, unique hormonal response, or positive effects on antioxidant defense (22).

Whey is a protein that generally contains a higher concentration of essential amino acids than other protein sources (7), and has rapid absorption kinetics (4, 11, 12). Supplementation results in a higher blood amino acid peak and stimulation of protein synthesis compared to casein (the other major bovine milk protein) (4, 11, 12). The consumption of a whey protein meal provides a higher postprandial leucine balance and net protein gain in young and older men compared to an isonitrogenous casein meal (11). Due to its favorable effect on protein metabolism and lean body mass (LBM) accretion, whey protein may enhance adaptations from resistance training. During 6 wk of resistance training, whey protein supplementation (1.2 g/kg body weight/d) resulted in an almost two-fold higher gain (2.1 vs 1.2 kg) in LBM compared to a carbohydrate control (8). However, no studies have examined the effects of whey protein supplementation in comparison to other proteins (such as casein) during resistance training, particularly in resistance-trained individuals consuming a high protein intake.

A high protein intake that is commonly consumed by strength athletes may have a negative impact on plasma glutamine (19). A decrease in resting plasma glutamine caused by intense or prolonged exercise may cause immunosuppression that results in a higher incidence of infection (illness) and slower wound healing (19). In athletes, dietary protein intake expressed relative to body mass ($\text{g} \cdot \text{kg}^{-1} \cdot \text{d}^{-1}$) is shown to be significantly inversely related to plasma glutamine concentrations (19). Compared to other athletes (such as runners, swimmers, and cyclists) weight lifters exhibit the lowest plasma glutamine concentrations despite the consumption of a high protein intake (19). A decline in plasma glutamine concentrations has been shown to occur during intense (anaerobic) training programs (15). Therefore, bodybuilders and other strength athletes that characteristically follow high protein diets maybe predisposed to a decline in plasma glutamine concentrations during intense training.

Hydrolyzed whey isolate is a protein supplement that contains the highest concentration of the essential amino acids, including the branched-chain amino acids (BCAA) than other protein sources (9). The BCAA are the major precursors for glutamine synthesis and supplementation is shown to prevent a decline in plasma glutamine that is seen after endurance exercise (2). Supplementation with a rich source of BCAA such as whey isolate may attenuate a decline in plasma glutamine levels that may occur during intense anaerobic exercise training. However, no studies have assessed the effects of protein supplementation on plasma glutamine concentrations during resistance training.

Therefore, the aim of this study was to examine the effects of a hydrolyzed whey isolate (WI) in comparison to casein (C) supplementation on strength, body composition, and plasma glutamine during a 10 wk intense resistance training program. We hypothesized that, compared to C, supplementation with WI would provide greater gains in LBM and strength and/or enhance plasma glutamine values during the resistance training program.

Materials and Methods

Subjects

Nineteen male recreational (not highly trained) bodybuilders commenced this 12-wk study but only thirteen completed all required components (C; $n = 7$, WI; $n = 6$) (six subjects did not finish the program for reasons unrelated to this study). To qualify as subjects the men a) had no current or past history of anabolic steroid use; b) had at least 2 y of resistance-training experience (and submitted a detailed description of their current training program); c) had not ingested any ergogenic supplement for an 8-wk period prior to the start of supplementation; and d) agreed not to ingest any other nutritional supplements, or nonprescription drugs that may affect muscle growth or the ability to train intensely during the study.

All subjects were informed of the potential risks of the investigation before signing an informed consent document approved by the Human Research Ethics Committee of Victoria University and the Department of Human Services, Victoria, Australia. All procedures conformed to National Health and Medical Research Council guidelines for the involvement of human subjects for research. After baseline testing the subjects were matched for maximal strength in three weight training exercises (see strength assessments) and then randomly assigned to either supplement.

Dietary Supplementation

Immediately after all baseline testing, the subjects were given their designated protein supplement, C or WI, in a double-blind procedure. The protein supplement was provided to the subjects in identical, unmarked, sealed containers. The macronutrient content of the supplements were as follows; approximately 90 g protein, 3 g carbohydrate, 1.5 g fat/100 g for WI (VP2 Hydrolyzed Whey Isolate); approximately 90 g protein, 3 g carbohydrate, 1.5 g fat/100 g for C. Supplements were supplied by AST Sports Science, Golden, CO and contained no other performance-enhancing substances. The WI was independently assessed on two separate occasions (Naturalac Nutrition Ltd., Mt. Eden, New Zealand) and met label ingredients on both occasions.

The subjects were instructed to consume 1.5 g of the supplement per kilogram of body weight per day while maintaining their habitual daily diet. The chosen supplement dose was based on previously reported intakes of this population (23, 27). The 1.5 g · kg · d supplement dose was divided into smaller equal servings and consumed throughout the day. For example, an 80 kg subject consumed four 30 g servings per day; one with breakfast, lunch, directly after training, and one final serving was consumed with the evening meal. Subjects were given a container of the supplement at the start of each week and asked to return it empty to verify compliance with the dosing procedure. In addition to having to return the container, the subjects were asked to document the time of day they took the supplement in training diaries provided to them.

Nutritional intake was monitored via written dietary recalls. The subjects were shown how to record nutrient intake and dietary recordings were obtained for 3 d prior to the program. Subsequently, 3 d were also recorded in the first and final week of the supplementation/training program. The recordings obtained during

the supplementation/training program were compared to the recordings taken prior to supplementation. All recordings were assessed using Nutritionist Pro (Axxya Systems, Stafford, TX) software. The following assessments occurred in the week before and immediately after a 10-wk resistance exercise program.

Strength Testing

Strength assessments consisted of the maximal weight that could be lifted once (1RM) in three weight training exercises: barbell bench press, cable pull-down, and barbell squat. The 1RM testing protocols followed that prescribed by the National Strength and Conditioning Association (NSCA) (1). Briefly, the subject's maximal lift was determined within no more than five single repetition attempts following three progressively heavier warm-up sets. Subjects were required to successfully lift each weight before attempting a heavier weight. Each exercise was completed in the same order during pre and post testing. Exercise execution guidelines were defined and adhered to for the successful completion of each lift (1). An NSCA-certified strength and conditioning specialist who was blinded to the groups, supervised all lifts and showed the subjects how to record training data (i.e., lifts performed, repetitions, amount of weight lifted, etc.) in training journals.

Body Composition

Whole-body composition measurements were determined using a Hologic model QDR-4500 dual energy X-ray absorptiometry (DEXA) with the Hologic version V 7, REV F software (Waltham, MA). Quality control calibration procedures were performed on a spine and step phantom prior to each testing session according to procedures previously described (14), and the same licensed operator performed all scans. Body fat percent was calculated by the software by dividing the amount of measured fat mass by total scanned mass (sum of bone mass, fat mass and lean mass). For longitudinal studies in which small changes in body composition are to be detected, whole body scanning with this instrument has been shown to be accurate and reliable (precision errors: 0.8 to 2.8%) (14, 32).

Plasma Glutamine

Blood samples for plasma glutamine analysis were taken by venepuncture without stasis from a vein in the antecubital space following a 6-h fast. After sampling, blood was placed in a lithium heparin tube, mixed, and spun in a centrifuge at 4500 rpm and at 4 °C for 5 min. A 1 mL aliquot of plasma was deproteinized in an equal volume of cold 3M perchloric acid (HClO₄) vortexed, and centrifuged again for 2 min. The supernatant was then neutralized with 20% potassium hydroxide (KOH). This was vortexed, centrifuged again, and the neutralized, deproteinized supernatant stored at -70 °C for subsequent analysis. Plasma glutamine levels were determined by the enzymatic method with spectrophotometric detection (24).

Resistance Training Protocol

Resistance training began the week after all baseline assessments and continued for 10 wk. The resistance training program (Max-OT, AST Sport Science, Golden,

CO) consisted of high-intensity workouts using mostly compound exercises with free weights (Table 1). The primary goal of the program was to increase maximal strength and muscle size. The program closely followed the principles documented by the American College of Sports Medicine for producing effective gains in strength and muscle hypertrophy (20). Training intensity for the program was determined using repetition maximums (RM) from strength tests. Once a designated RM was reached, the subjects were encouraged by the trainer to increase the weight used. This linearly progressive overload program was divided into three phases; preparatory (70 to 75% of 1RM), overload phase-1 (80 to 85% of 1RM), and overload phase-2 (90 to 95% of 1RM). An NSCA-certified strength and conditioning specialist supervised all subjects perform each weight lifting session in a one-to-one or two-to-one fashion. The subjects were given training diaries to record exercises, sets, repetitions performed, and the weight used throughout the program.

Table 1 Max-OT Resistance Training Program

General preparatory phase (weeks 1-2) 2 working sets, 10 to 8-RM (70-75% of 1RM)		
Monday	Wednesday	Friday
Barbell squat	Pull up (body weight)	Flat barbell bench press
Barbell dead lift	One arm row	30° Incline barbell press
45° Leg press	Cable row machine	Standing shoulder press
Leg curl	Barbell arm curl	Dips (body weight)
Abdominal exercise	Abdominal exercise	Abdominal exercise
Overload Phase-1 (weeks 2-4) 2 working sets, 6-RM (80-85% of 1RM)		
Monday	Wednesday	Friday
Barbell squat	Barbell bench press	Barbell dead lift
45° Leg press machine	30° Incline dumbbell press	Wide grip pull up (added wt)
Stiff-leg dead lift	Standing shoulder press	Cable machine row
Calf raise	Dips (with added wt)	Barbell arm curl
Abdominal exercise	Abdominal exercise	Abdominal exercise
Overload Phase-2 (weeks 5-10) 2-3 sets, 4-RM (90-95% of 1RM)		
Monday	Wednesday	Friday
Barbell squat	Barbell bench press	Barbell dead lift
Barbell split-squat	45° Incline dumbbell press	Close grip pull up (added wt)
Stiff-leg dead lift	Standing shoulder press	Barbell row
Calf raise	Close grip bench press	Alternate dumbbell curl
Abdominal exercise	Abdominal exercise	Abdominal exercise

Statistical Analysis

Subject characteristics are reported as means \pm standard deviation. All other values are reported as means \pm standard error. Statistical evaluation of the data was accomplished by using a two-way analysis of variance (ANOVA) with one between groups factor (supplement) and one repeated factor (training). Where an interaction was found, post hoc analysis was performed via *t*-tests. Changes from baseline within each group were assessed by a paired *t*-test while comparisons between the groups were performed by unpaired *t*-tests. In addition, comparisons of the changes made by each group were made using an unpaired *t*-test. A *P* value of less than 0.05 was required for significance.

Results

Subject Characteristics

At baseline there were no differences in the age, training consistency, height, body weight, strength levels, lean mass or fat mass between the two groups (Table 2).

Table 2 Baseline Characteristics

Characteristics	Casein	Whey Isolate
Age (y)	26 \pm 5	27 \pm 7
Height (cm)	177 \pm 4	180 \pm 8
Weight (kg)	79.7 \pm 11.2	84.0 \pm 5.0
Total strength 1RM (kgs)	460 \pm 95	470 \pm 107
Lean body mass (kg)	62.5 \pm 6.4	67.1 \pm 6.5
Fat mass (kg)	14.4 \pm 4.7	13.9 \pm 3.7

Values are means \pm standard deviation of the 13 males who completed all assessments. There were no significant differences between the groups prior to the training/supplementation program.

Dietary Assessments

No differences in energy or protein intake were detected between the groups or within the groups throughout the study (Table 3).

Body Composition

Lean mass and fat mass for WI and C are shown in Table 4 and the changes from pre- to post- shown in Figure 1. There was a significant increase in lean body mass ($P < 0.01$) and a significant decrease in body fat ($P < 0.05$) in the WI group over the 10 wk resistance training period. There was no significant change in lean body mass or body fat over the training period in the C group. The increase in lean body mass was significantly greater ($P < 0.01$) in the WI than in the C group. A significant decrease in body fat was seen ($P < 0.05$) in the WI group compared to the C group following the training period (Figure 1).

Table 3 Dietary Analyses

Variable	Group	Before program	Week 1*	Week 10*
Energy intake (Kcal/kg/d)	C	42.4 ± 4.9	42.3 ± 5.3	41.6 ± 4.3
	WI	41.7 ± 6.8	43.2 ± 6.8	42.3 ± 7.5
Protein (g/kg/d)	C	1.86 ± 0.14	2.06 ± 0.15	2.10 ± 0.10
	WI	1.78 ± 0.18	2.12 ± 0.09	2.11 ± 0.11

Results are means ± standard deviations of 3-d written dietary recalls all participants submitted before the training/supplementation program and during the first and last week of the training program. *Includes energy and protein intake from supplementation. No differences in energy or protein intake were detected between the groups or within the groups throughout the study.

Table 4 Lean Mass and Fat Mass Data (PRE and POST training)

	Whey Isolate	Casein
Lean mass (kg)		
PRE	67.1 ± 2.7	62.5 ± 2.4
POST	72.1 ± 2.8 ^a	63.3 ± 2.3 ^b
Fat mass (kg)		
PRE	13.9 ± 1.5	14.4 ± 1.8
POST	12.5 ± 1.3 ^a	14.5 ± 1.8

Values are mean ± standard error of 13 males. ^asignificant difference between pre- and post- values; ^bsignificant difference between WI and C groups

Strength

Maximal 1-RM in the barbell squat, bench press, and cable pull-down (both absolute and relative to body weight) are shown in Table 5 and the changes from pre- to post- shown in Figure 2. The resistance training program resulted in significant ($P < 0.05$) increases in muscle strength in the three lifting exercises in both the C and WI groups. However, strength improvements were significantly greater ($P < 0.05$) in the WI group for all three exercises assessed compared to the casein group (Figure 2) such that the WI group were significantly stronger ($P < 0.05$) in all exercises than the C group following the training period. When expressed relative to body weight, the strength improvements were still significantly greater ($P < 0.05$) in the WI group for all three exercises assessed compared to the casein group (Figure 3)

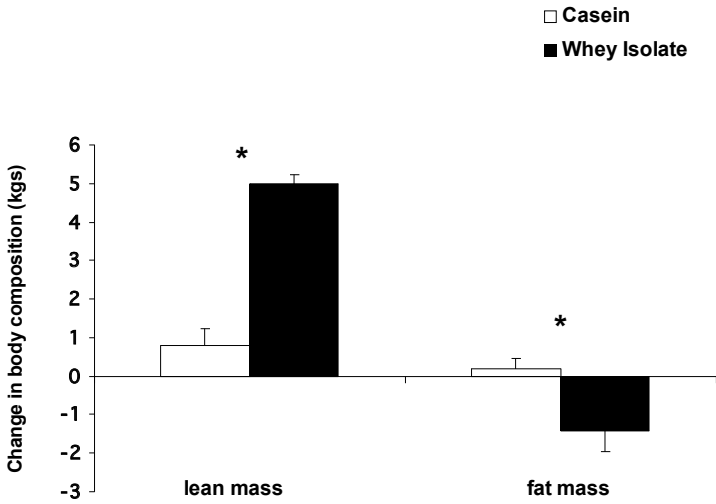


Figure 1 — Body composition changes before and after 10 wk of resistance training and supplementation. Values are means \pm standard error of 13 males (casein = 7; whey isolate = 6). Lean body mass and fat mass was assessed by DEXA in the week immediately before and after the 10 wk resistance training program. *Indicates significant ($P < 0.05$) difference between the two groups.

Table 5 Strength Data (PRE and POST training)

Strength (kgs)	Whey Isolate (kgs)	Casein (kgs)	Whey Isolate (/kg BW)	Casein (/kg BW)
Squat				
PRE	80.2 \pm 7.3	71.0 \pm 4.5	0.94 \pm 0.09	0.91 \pm 0.08
POST	155.5 \pm 6.0	123.2 \pm 8.6	1.79 \pm 0.11	1.54 \pm 0.09*
Bench press				
PRE	84.0 \pm 9.1	87.0 \pm 10.0	1.01 \pm 0.11	1.10 \pm 0.1
POST	132.0 \pm 5.0	105.5 \pm 9.5*	1.51 \pm 0.07	1.31 \pm 0.1*
Pull-down				
PRE	71.7 \pm 6.8	72.0 \pm 5.0	0.85 \pm 0.09	0.90 \pm 0.06
POST	106.8 \pm 3.6	92.7 \pm 5.4*	1.22 \pm 0.04	1.16 \pm 0.04*

Values are means \pm standard error of 13 males. Strength is expressed in absolute terms and also expressed relative to body mass. There was a significant increase in strength in all exercises pre- to post- in both groups. *significant difference between WI and C groups.

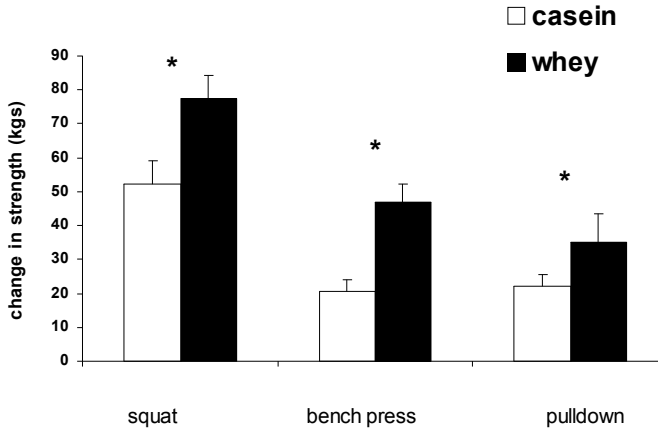


Figure 2 — Strength improvements before and after 10 wk of resistance training and supplementation. Values are means \pm standard error of 13 males (casein = 7; whey isolate = 6). Strength (1RM) was assessed in three exercises (barbell squat, barbell bench press, cable pull-down) the week immediately before and after a 10 wk resistance training program. *Indicates significant ($P < 0.05$) difference in strength improvements between the two groups.

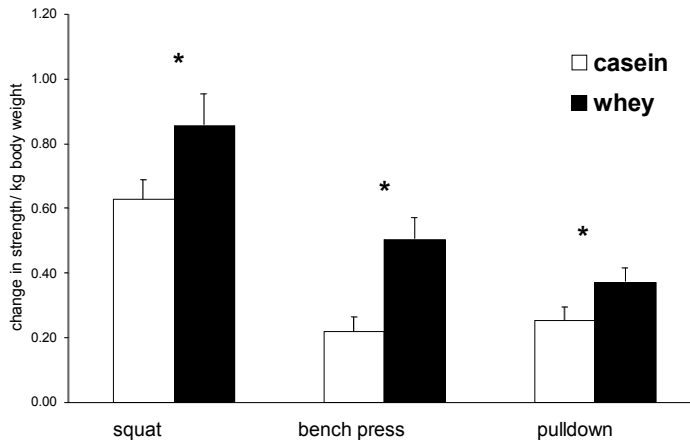


Figure 3 — Strength improvements relative to body weight before and after 10 wk of resistance training and supplementation. Values are means \pm standard error of 13 males (casein = 7; whey isolate = 6). Strength changes are expressed relative to kilograms of body weight in the three exercises. *Indicates significant ($P < 0.05$) difference in strength improvements between the two groups.

Plasma Glutamine

There were no significant effects of either training or supplementation on plasma glutamine levels for the C and WI groups (Table 6).

Table 6 Plasma Glutamine Values

	Whey Isolate	Casein
Plasma glutamine		
PRE	0.76 ± 0.24	0.57 ± 0.24
POST	0.66 ± 0.19	0.63 ± 0.33

Values are mean ± standard error of 13 males. Glutamine values are expressed as (mmol/L). There were no significant changes in plasma glutamine from the training/supplementation program.

Discussion

Using two groups of matched, resistance-trained males, this study demonstrated that whey isolate (WI) provided significantly greater gains in strength, LBM, and a decrease in fat mass compared to supplementation with casein (C) during an intense 10 wk resistance training program. Neither supplement had an effect on plasma glutamine levels. However, when interpreting the results, the following aspects should be considered.

One limitation of this study was the low subject number of the groups. It is possible the differences in the group's results could be (at least partly) attributed to the attrition of subjects. Another important factor that may have confounded our results was the mean weight of the groups in their initial make-up. Although there was no statistical difference in energy or protein intake between the two groups, nor was there a statistically significant difference in starting body weight, the mean weight of the subjects in the WI group was approximately 4.5 kg greater than the C group at the start of the study. On a per kilogram per day basis (see Tables 2 and 3) the WI group consumed approximately 250 kcal/d more than the C group throughout the study. This energy difference could have accounted for at least some of the difference in lean mass gains between the two groups. Studies by Butterfield (9), Calloway (10), and Todd (36) have demonstrated that by increasing energy intake, nitrogen balance is improved. Moreover, Todd et al. (36) demonstrated that increased energy intake and exercise actually increased utilization of the available protein. To help clarify the importance of the effect of body weight on the strength differences observed, the strength changes were expressed as absolute (Figure 2) and relative to body weight (Figure 3). In both instances, the strength improvements were still significantly greater ($P < 0.05$) in the WI group for all three exercises assessed compared to the C group.

To our knowledge, this is the first study that has directly compared the effects of WI and C supplementation on body composition and strength changes during a structured, supervised resistance training program using experienced subjects. Demling and DeSanti (13) completed an open trial that compared the effects of whey protein supplementation (60 g/d) to a casein-based meal replacement product on body composition and strength changes during a 12-wk resistance training program. In this study, a group of overweight, sedentary individuals followed a calorie-restricted diet during the exercise program. While a greater decrease in fat mass and increase in LBM was seen in the group given the meal replacement, the product contained added vitamins, minerals, amino acids, carbohydrate, and a number of proteins, including whey. Therefore, it is difficult to attribute the results

obtained from this product to one particular nutrient source. Only one study has examined the effects of whey protein supplementation in comparison to casein in healthy adults ($n = 20$), but this investigation did not involve exercise training (21). In this study, after the 10 wk supplementation period (20 g/d), the whey group demonstrated a decrease in body fat percentage (but maintained body weight) and an improvement in anaerobic performance, without taking part in an exercise program (21). A study on rodents has shown that supplementation with whey (alpha lactalbumin) during 6 wk of exercise training resulted in better improvements in body composition compared to supplementation with casein or carbohydrate (5). The rodents fed a whey protein meal before daily exercise showed greater lean mass and less fat mass post-training compared to rodents fed an equivalent amount of casein or carbohydrate (5). The consumption of whey protein (but not casein or carbohydrate) preserved lipid oxidation in the hours during and after exercise, suggesting a greater utilization of body fat for fuel (5). The results of our study and the results of others that have directly compared the effects of whey protein to casein (5, 21) suggest that whey protein has a greater capability to augment body composition changes during exercise. However, the exact mechanism(s) behind these improvements is unclear.

A high stimulation of protein synthesis is one essential mechanism to the development of muscle hypertrophy, along with a decreased rate of protein breakdown (30). A high concentration of essential amino acids in the blood also acts synergistically to enhance the anabolic response of resistance training by stimulating a higher increase in protein synthesis (34) and reduce protein breakdown (3). Generally, whey protein supplements contain a higher dose of the essential amino acids than casein and other protein sources (44 to 48 g/100 g protein for WI vs. 34 to 35 g/100 g for C) (7). In addition, whey and casein appear to differ in their capacity to present their amino acids to tissues (4, 11, 12, 35). Studies that have assessed the digestion-absorption characteristics of these two protein supplements show that generally, whey is rapidly absorbed and provides a higher (albeit transient) increase in blood amino acid concentrations and stimulation of protein synthesis (for up to 2 h) compared to an equivalent or larger dose of casein (4, 11, 12). A single bout of resistance training can influence protein metabolism for up to 36 h (30). Therefore, it is tempting to suggest that repeated doses of whey protein consumed throughout the day may interact with resistance-exercised muscles to provide a higher anabolic response and better muscle mass accretion over the longer term. However, a recent study has shown that casein is capable of stimulating muscle anabolism after resistance exercise equally as effectively (if not slightly better) than whey (35). This research (35) directly examined whey and casein's acute impact on protein metabolism after resistance training exercise and showed that a 20 g bolus dose of either protein resulted in similar increases in muscle protein net balance and net muscle protein synthesis despite different patterns of blood amino acid responses. Therefore, the data obtained from acute response studies do not appear to provide a connection to our results. In addition, the effects of repeated doses of either protein combined with resistance training on whole body protein metabolism over the course of a day, days, or weeks is not known. The contrast of our results to the data from acute response studies highlight the need for future investigations to establish a link between acute metabolic perturbations and long-term adaptations in muscle and strength development.

Aside from differences in essential amino acid concentrations and absorption kinetics, whey protein and casein differ in their concentration of cysteine. The amino acid cyst(e)ine (cysteine and its disulfide twin cystine) is thought to play a key role in the regulation of whole body protein metabolism as well as underlie improvements in body composition (i.e., an increase in LBM and/or a decrease in fat mass) (16, 18). WI contains a three- to four-fold higher concentration of cyst(e)ine compared other protein sources, including casein (7). An abundant supply of cyst(e)ine in the blood is necessary for hepatic catabolism of cyst(e)ine into protons and sulfate; a process that inhibits carbamoylphosphate synthesis (the first and rate limiting step of urea biosynthesis) (16). This process down-regulates urea production, promotes glutathione synthesis, and shifts whole body nitrogen disposal in favor of preserving the muscle amino acid pool (16). In humans, whey protein supplementation is shown to augment this pathway (21, 29) and provide an improvement in body composition without exercise, whereas casein supplementation was shown not to provide this effect (21). In rodents, whey protein feeding is shown to augment this pathway of protein metabolism in a dose-dependant manner (26). Therefore, WI's ability to provide better improvements in body composition during resistance training maybe at least partly due to its greater contribution of cyst(e)ine to the diet.

Aside from amino acid profiles and absorption characteristics, the processing methods used during the manufacture of a protein supplement (i.e., degree of isolation and or hydrolyzation) may have an impact on muscle anabolism (22). A number of studies have shown that the same nitrogen load is absorbed faster when delivered as hydrolyzed protein peptides rather than as whole protein or free amino acids (25). Similarly, some studies have reported an increase in nitrogen incorporation into tissue protein in animals fed hydrolyzed whey peptides compared with those receiving the same amount of nitrogen as whole protein or free amino acids (6, 31). In humans a partially hydrolyzed whey protein was shown to be absorbed faster and induced a high rate of protein synthesis compared to casein (a whole protein) (4, 11, 12). However, whether hydrolyzation has a practical beneficial effect such as faster muscle mass accretion or improved recovery from exercise is not clear as it has not been adequately studied (25). The greater strength and LBM gains seen in our study by the group that consumed the hydrolyzed (short chain peptide) WI compared to casein (a whole protein) suggests that the differences in the manufacture of the proteins may have been a contributing factor, although to what extent is unclear.

Compared with unsupervised training, the supervision of resistance training programs by qualified personnel is shown to provide a greater rate and magnitude of training load increases, which in turn promotes greater strength gains (28). One of the strengths of our investigation was the supervision of all the subject's training sessions by qualified instructors. In our study, the subjects were supervised as in a personal training scenario (a one-to-one, or two-to-one fashion). This not only ensured there were no differences in training variables (such as volume, frequency, duration, and intensity or load), it resulted in substantial improvements in 1RM strength in each assessment. The large changes in 1RM strength seen in these resistance-trained individuals can be explained by the fact that although the subjects had been training consistently prior to the study for at least 2 y, none had ever received professional coaching or personal training by a qualified instructor. Therefore, the

large changes in 1RM strength in both groups primarily reflect an improvement in lifting skill and ability to perform each lift in compliance with the strict exercise execution guidelines. However, this certainly does not alter the fact that the instructors were blinded to the subjects supplement and the strength increases in all three exercises were significantly greater with WI supplementation than casein. Dietary strategies that may promote improvements in functional strength have important implications for an aging population and others that are prone to muscle wasting such as cancer, HIV, and cardiac rehabilitation patients.

One important consideration of our study that perhaps makes it unique compared to most other supplementation studies was the implementation of a supplement dose that is characteristic of many strength athletes, and the impact this had on the subject's daily protein intake. Prior to supplementation, the eating patterns of the subjects were characteristic of most athletes who undertake resistance training programs, i.e., they consumed a high energy/protein intake and frequent, mixed macronutrient meals over the 24 h period (23). However, the addition of a large supplement dose ($1.5 \text{ g} \cdot \text{kg} \cdot \text{d}$) resulted in only a small increase in daily protein intake, i.e., from $1.86 \text{ g} \cdot \text{kg} \cdot \text{d}$ before the study to $2.10 \text{ g} \cdot \text{kg} \cdot \text{d}$ in week 10 for C and 1.76 to $2.11 \text{ g} \cdot \text{kg} \cdot \text{d}$ for WI (Table 3). Therefore, it is apparent that the subjects substituted a large portion of their habitual daily protein (and calorie) intake with the protein supplement. Why the subject's daily protein intakes did not change substantially when the supplement was added to the diet is not clear. Perhaps as the subjects believed that the supplement would be of benefit to their bodybuilding results, they may have subconsciously reduced their nutritional intake from other sources to ensure compliance (i.e., consume all their supplement servings each day). Another explanation may be a satiety effect that has been observed from protein supplementation, particularly whey (17). To our knowledge, the effects of replacing a large portion of protein in the daily diet with one particular source, such as WI, particularly in athletic individuals undertaking an intense resistance training program has not been investigated. Even when taking into consideration the limitations of this study, the differences between the groups in body composition and strength after the training program were quite dramatic. One possible explanation for these changes could be that one group replaced a large portion of their daily protein intake with a protein source that contained a rich source of essential amino acids and added a high concentration of cysteine to the diet. Over a period of weeks this may have resulted in a better increase in LBM during intense resistance training. Although we did not assess absorption characteristics or amino acid kinetics in this study, our results are consistent with those theories. Based on our results, further studies involving cellular and/or molecular investigations are currently being completed by our laboratory.

In conclusion, two matched groups of males were used to examine the effects of whey isolate and casein supplementation ($1.5 \text{ g} \cdot \text{kg} \cdot \text{d}$) during a 10 wk resistance training program. Results showed that while neither supplement had an effect on plasma glutamine values, the group that consumed whey isolate demonstrated a significantly greater gain in lean body mass and strength. This group also experienced a significant decrease in fat mass compared to the casein group, which showed no change in fat mass after the 10 wk training period. To our knowledge, this is the first study that has examined the effects of whey isolate and casein supplementation during a structured, progressive overload program that was supervised on a

one-to-one basis by qualified personnel. While it is possible that whey isolate is a superior protein to casein for enhancing the chronic adaptations of resistance training, our study does not allow for a definitive conclusion and thus emphasizes a need for further research in this area.

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