Effect of Protein Supplement Timing on Strength, Power and Body Compositional Changes in Resistance-Trained Men

Jay R. Hoffman, Nicholas A. Ratamess, Christopher P. Tranchina, Stefanie L. Rashti, Jie Kang, and Avery D. Faigenbaum.

The College of New Jersey, Ewing, NJ 08628-0718

Running head: Protein Timing

Send Correspondence to:

Jay R. Hoffman, Ph.D., FACSM, FNSCA

Department of Health and Exercise Science

The College of New Jersey

PO Box 7718

Ewing, New Jersey 08628

Tel: 609-771-2287

Fax: 609-637-5153

hoffmanj@tcnj.edu

Abstract

The effect of 10-weeks of protein supplement timing on strength, power and body composition was examined in 33 resistance-trained men. Subjects were randomly assigned to either a protein supplement provided in the morning and evening (AM/PM; n = 13), or provided immediately prior to and immediately post workouts (PRE/POST; n = 13). In addition, seven subjects agreed to serve as a control (CTR) group and did not use any protein or other nutritional supplement. During each testing session subjects were assessed for strength (one repetition maximum [1-RM] bench press and squat), power (5 repetitions performed at 80% of 1RM in both the bench press and squat exercise) and body composition (DEXA). A significant main effect for all three groups in strength improvement was seen in 1RM bench press (120.6 ± 20.5 kg vs. 125.4 ± 16.7 at week 0 and week 10 testing, respectively) and 1RM squat (154.5 ± 28.4 kg vs. 169.0 ± 25.5 at week 0 and week 10 testing, respectively). However, no significant between group interactions were seen in 1RM squat or 1-RM bench press. Significant main effects were also seen in both upper and lower body peak and mean power, but no significant differences were seen between groups. No changes in body mass or body fat % were seen in any of the groups. Results indicate that the time of protein supplement ingestion in resistance-trained athletes during a 10-week training program does not provide any added benefit to strength, power or body compositional changes.

Key Words: Sport Nutrition, Ergogenic Aid, Athletes, Weight Training

Introduction

It is well accepted that strength/power athletes have a protein requirement that may be at least twice that of the sedentary individual, and perhaps 30 – 50% greater than the endurance athlete (Lemon et al., 1992; Tarnopolsky et al., 1992). The greater protein need seen in these athletes is thought to enhance the recovery and remodeling processes of muscle fibers that have been damaged or disrupted during resistance exercise (Tipton et al., 2004). Recent investigations have reported a reduction in muscle damage, attenuation of force decrements, and an enhanced recovery from resistance exercise in individuals using protein and/or amino acid supplements (Kraemer et al., 2006; Ratamess et al., 2003). A recent area of focus in studies examining protein supplementation has become the timing of protein consumption in regards to the workout.

Studies examining the acute effect of protein ingestion have demonstrated that ingestion occurring close to the workout (e.g. immediately before or within an hour post-exercise) significantly enhances muscle protein synthesis rate and muscle protein accretion when compared to when ingestion is delayed for longer periods of time (Rasmussen et al., 2000; Tipton et al., 1999; 2001). These results suggest that protein supplement timing may be of critical importance in stimulating muscle adaptations that occur during prolonged training. However, there are only a limited number of studies that have examined the effect of protein timing in prolonged training studies.

The effect of timing of the protein ingestion in training studies is not clear. Several investigations have shown that protein ingestion occurring before and immediately after resistance exercise is a potent stimulus for muscle size and performance gains compared to carbohydrate only supplements in young (approximately 19 – 23 years) previously trained

(Hoffman et al., 2007) or untrained individuals (Anderson et al., 2005; Willoughby et al., 2006), while, no change was seen in muscle mass or strength following 12 weeks of supplementation in untrained elderly men (Candow et al., 2006). The differences between these studies are not clear, but may be attributed to differences in the endocrine response to resistance exercise between young and older men (Kraemer et al., 1999). Only a limited number of studies have actually compared various protein timing strategies. Esmarck and colleagues (2001) examined the effect of protein timing in untrained elderly subjects (74.1 ± 1 yrs) during a 12-week resistance training program. Subjects consumed a protein supplement (10 g protein, 7 g carbohydrate and 3 g of fat) immediately after or 2-hr following each resistance exercise session (three times per week). Results showed that muscle cross-sectional area and individual muscle fiber area increased significantly in the subjects that consumed the supplement immediately post-exercise, but muscle fiber area did not change in those subjects consuming the supplement 2-hr following each training session. In a study on young (21 – 24 years) recreationally trained male bodybuilders, consumption of a supplement containing protein (40 g of whey isolate) and carbohydrate (43 g of glucose) immediately before and after resistance exercise sessions resulted in significantly greater gains in lean body mass, increases in cross-sectional area of type II fibers and increases in contractile protein content compared to subjects consuming the protein/carbohydrate supplement in the morning and evening (Cribb and Hayes, 2006).

The examination of protein timing has generally used untrained or recreationally trained subjects. The understanding of how protein timing affects resistance-trained athletes is limited. Thus, the purpose of this study was to examine the role of protein timing on resistance trained athletes participating in a 10-week off-season conditioning program.

Materials and Methods

Subjects:

Thirty-three male strength and power athletes volunteered for this study. Following an explanation of all procedures, risks and benefits each subject gave his informed consent to participate in this study. The Institutional Review Board of the College approved the research protocol. Subjects were not permitted to use any additional nutritional supplementation and did not consume anabolic steroids or any other anabolic agents known to increase performance for the previous year. Screening for anabolic steroid use and additional supplementation was accomplished via a health questionnaire filled out during subject recruitment.

Subjects were randomly assigned to either a protein supplement group provided in the morning and evening (AM/PM; n = 13; 19.6 ± 1.3 y; 183.4 ± 5.1 cm; 102.3 ± 18.9 kg) or provided immediately prior to and immediately post workouts (PRE/POST; n = 13); 19.9 ± 1.3 y; 183.4 ± 5.1 cm; 95.1 ± 14.4 kg). To compare the effect of supplementation to no supplementation, seven subjects agreed to serve as a control group (CTR; n = 7; 20.7 ± 1.1 y; 179.4 ± 9.4 cm; 100.1 ± 27.2 kg) and did not use any protein or other nutritional supplement. Most of the subjects (30/33) were athletes from the college's football team with at least 2 years (5.9 ± 1.8 y) of resistance training experience. The remaining subjects competed in power lifting and were randomly assigned to one of the three groups. All groups performed the same resistance training program for 10 weeks. The training program was a 4-day per week, split routine (see Table 1) that was supervised by laboratory personnel. All subjects completed a daily training log, which was collected by research investigators on a weekly basis.

[Place Table 1 here]

Testing Protocol:

Subjects reported to the Human Performance Laboratory (HPL) on two separate occasions. The first testing session occurred prior to the onset of protein supplementation (Week 0), and the second testing session occurred at the conclusion of the 10-week supplementation program (Week 10). All testing sessions occurred at the same time of day.

Body Composition

Body composition was determined using whole body-dual energy x-ray absorptiometry (DEXA) scans (Prodigy™; Lunar Corporation, Madison, WI). Total body estimates of percent fat, bone mineral density and bodily content of bone, fat and non-bone lean tissue was determined using company's recommended procedures and supplied algorithms. All measures were performed by the same technician, and the intraclass correlation coefficient for BMD was $R = 0.99$. Quality assurance was assessed by daily calibrations and was performed prior to all scans using a calibration block provided by the manufacturer.

Strength Measures

During each testing session, subjects performed a 1-repetition maximum (1-RM) strength test for the squat and bench press exercises. The 1 RM tests were conducted as described by Hoffman (2006). Each subject performed a warm-up set using a resistance that was approximately 40-60% of his perceived maximum, and then performed 3-4 subsequent attempts to determine the 1-RM. A 3 – 5 minute rest period was provided between each lift. No bouncing was permitted for the bench press exercise, as this would have artificially boosted strength results. Bench press testing was performed in the standard supine position: the subject lowered an Olympic weightlifting bar to mid-chest level and then pressed the weight until his elbows were fully extended. The squat exercise required the subject to rest an Olympic weightlifting bar across the trapezius at a self-chosen location. The squat was performed to the parallel position (that was closely monitored by research staff), which was achieved when the greater trochanter of the femur was lowered to the same level as the knee. The subject then lifted the weight until his knees were extended.

Power Measurements

Upper and lower body power during the bench press and squat exercise was measured with a Tendo™ Power Output Unit (Tendo Sports Machines, Trencin, Slovak Republic). The Tendo™ unit consists of a transducer that was attached to the end of the barbell which measured linear displacement and time. Subsequently, bar velocity was calculated and power was determined when bar load was manually input. Both peak and mean power output were recorded for each repetition and set, and used for subsequent analysis. Power analyses were performed with each subject performing five repetitions at 80% of their 1-RM in both exercises. Order of exercise testing was randomly determined. Test retest reliabilities for these power measurements have been established in our laboratory to be $R > 0.92$.

Dietary Recall

Three-day dietary records were completed during the week prior to the onset of the study and during week 9 of the study. Subjects were instructed to record as accurately as possible everything they consumed during the day including the supplement, and between meal and late evening snacks. FoodWorks Dietary Analysis software (McGraw Hill, New York, NY) was used to analyze dietary recalls.

Supplement Schedule

The protein supplement was in liquid form and consisted of 42 g of a proprietary blend of protein (enzymatically hydrolyzed collagen protein isolate, whey protein isolate, and casein protein isolate), 2 g of carbohydrate and 0 g of fat. Laboratory analysis of the supplement reported by the company (IDS Sports, Oviedo, FL, USA) showed that it contained 3.6 g of leucine, 3.0 g of isoleucine, 1.4 g of valine, 5 g of alanine, 3.0 g of arginine, 2.3 g of aspartic acid, 4.0 g of glutamic acid, 9.1 g of glycine, 2.3 g of lysine, 2.0 g of phenylalanine, 5.8 g of proline, 1.2 g of serine, 1.0 g of tyrosine, 0.9 g of threonine, 0.9 g of methionine, 0.4 g of cystine, 0.3 g of tryptophan, and 0.2 g of histidine. Each supplement was prepackaged in a spherical tube. Subjects were required to consume either the supplement or placebo twice per day for the entire 10-week training period. Subjects in AM/PM reported to the HPL upon awakening and in the evening for their supplement. Subjects in PRE/POST reported to the HPL immediately prior to their workout for their pre-exercise supplement and returned immediately after their workout for their post-exercise supplement. On non-workout days, subjects in PRE/POST reported at a similar time of the day (as used for their workouts) for their supplement. Following consumption of Friday's second supplement ingestion, subjects received their weekend supply of protein. Subjects were required to return all tubes to the HPL during Monday's initial supplement ingestion. Compliance for protein ingestion was greater than 97% for the 10-week study.

Urine Measurements

Twenty-four hour urine volumes were collected at weeks 0 and 10 to assess urinary urea nitrogen excretion and determine nitrogen balance. Nitrogen balance was estimated using the formula: nitrogen balance = total nitrogen intake – (urinary urea nitrogen + 4) (Benotti and Blackburn, 1979; Isley et al, 1983; Wright 1980). All urinary urea nitrogen measures were determined with an Analox GM7 enzymatic metabolite analyzer (Analox Instruments USA, Lunenburg, MA). All samples were run in duplicate with a mean intra-assay variance of < 5%.

Statistical Analysis

Statistical evaluation of the data was accomplished by a 3 (group) x 2 (time) repeated measures analysis of variance. In addition, Δ week 0 – week 10 comparisons between groups in performance measures were analyzed with a one-way analysis of variance. In the event of a significant F- ratio, LSD post-hoc tests were used for pairwise comparisons. A criterion alpha level of $p \leq 0.05$ was used to determine statistical significance. All data are reported as mean ± SD.

Results

Average daily dietary intakes for week 0 and 10 are shown in Table 2. No significant changes in caloric intake ($p = 0.70$), carbohydrate intake ($p = 0.73$), or fat intake ($p = 0.73$) were seen in any group, and no differences between the groups in these measures were noted either. A significant ($p < 0.05$) increase in daily protein intake (both absolute and relative to body mass) was seen in AM/PM, but not PRE/POST or CTR. Although subjects in PRE/POST increased their relative protein intake by 20%, this change was not statistically different. The protein composition of the diet significantly increased ($p < 0.05$) at 10 weeks in both AM/PM and PRE/POST, and the protein composition of their diets were significantly greater ($p = 0.01$) at this time point than seen in CTR.

[Place Table 2 here]

Urinary nitrogen excretions significantly increased ($p < 0.000$) from week 0 (12.2 ± 5.5 g) to week 10 (21.8 ± 11.2 g) in all groups, reflecting the greater demands of the training program. However, no between group differences were observed. In addition, subjects in all groups were in a positive nitrogen balance during both weeks 0 (18.2 ± 12.6 g), and 10 (12.4 ± 12.3 g), and no significant differences ($p > 0.05$) between groups were seen.

Body compositional changes are shown in Table 3. No significant change in body mass occurred during the 10-week study in any group, and no differences between groups were observed ($p = 0.48$). In addition, no significant changes ($p > 0.05$) in percent body fat, fat mass or lean body mass were seen in any group.

[Place Table 3 here]

Significant improvements ($p < 0.05$) from week 0 to week 10 in 1-RM squat were seen in all three groups (Figure 1), but significant improvements ($p < 0.05$) in 1-RM bench press was seen in AM/PM and PRE/POST only (Figure 2). However, no between group differences ($p > 0.05$) were seen, and Δ comparisons between groups showed no significant differences in either 1-RM squat ($p = 0.67$) or 1-RM bench press ($p = 0.85$).

[Place Figures 1 and 2 here]

Peak power in the squat exercise significantly increased ($p < 0.05$) from week 0 to week 10 in AM/PM (1341 ± 290 W vs. 1503 ± 291 W, respectively) and PRE/POST (1328 ± 245 W vs. 1513 ± 355 W, respectively) but not in CTR (1377 ± 230 W vs. 1397 ± 116 W, respectively). Similarly, mean power in the squat exercise significantly increased ($p < 0.05$) from week 0 to week 10 in AM/PM (692 ± 154 W vs. 756 ± 118 W, respectively) and PRE/POST (711 ± 113 W vs. 775 ± 149 W, respectively) but not in CTR (722 ± 73 W vs. 752 ± 88 W, respectively). No differences between the groups in either peak ($p = 0.88$) or mean power ($p = 0.98$) for the squat exercise were seen.

Peak power in the bench press exercise significantly improved ($p < 0.02$) from week 0 to week 10 for PRE/POST only (683 ± 148 W vs. 733 ± 167 W, respectively), but differences between weeks 0 and 10 were not significant ($p > 0.05$) for AM/PM (641 ± 178 W vs. 683 ± 149 W, respectively) nor CTR (545 ± 132 W vs. 612 ± 126 W, respectively). No significant change

($p > 0.05$) in mean power was seen from week 0 to week 10 in the bench press exercise for either AM/PM (422 ± 107 W vs. 463 ± 84 W, respectively) or PRE/POST (474 ± 83 W vs. 483 ± 91 W, respectively), but a significant improvement ($p = 0.01$) was seen in CTR (398 ± 74 W vs. 463 ± 81 W, respectively). However, no significant differences ($p > 0.05$) between the groups in either peak or mean power for the bench press exercise were observed. In addition, no significant differences ($p > 0.05$) in Δ comparisons between the groups were noted for any of the power measures in either the squat or bench press exercise.

Discussion

The findings of this study were unable to support the benefits of pre and post exercise ingestion of a 42 g protein supplement compared to a morning and evening ingestion of the same protein supplement during 10 weeks of resistance training in resistance trained men. Although both supplement groups significantly increased upper- and lower-body strength and power, no between group differences in any strength or power measure were seen. Furthermore, considering that no differences in strength and power performances were observed between CTR and either of the protein supplement groups, it appears that if dietary protein intake is at or exceeds recommended levels for a strength/power athlete (1.6 $g \cdot kg^{-1}$) that additional protein intake from a supplement, regardless of its timing, may not result in further performance gains. In addition, all groups were in a positive nitrogen balance indicating that protein intakes in this study were sufficient to meet the protein needs of these subjects.

Previous studies from our laboratory demonstrated that protein intakes at or above the recommended levels for strength/power athletes do not augment lean body mass, power or strength gains (Hoffman et al., 2006; 2007). The results from this study confirm those previous results and further indicate that the timing of the protein supplement ingestion does not provide any additional benefit for strength and power gains, and lean tissue accruement in resistance-trained athletes. However, the results of this study are also consistent with previous studies that demonstrated a trend towards greater strength improvements in resistance trained subjects consuming a daily protein intake that was greater than recommended levels for strength power athletes (Hoffman et al., 2006). Although no significant differences were seen in comparisons between groups on strength and power performance, significant improvements in upper body strength and lower body power performance were seen in PRE/POST and AM/PM only. In addition, examination of the six dependent performance variables measured revealed significant improvements over time in only two variables (1-RM squat and mean power for the bench press) for CTR, while significant improvements in five of the six variables (1-RM, peak power and mean power for the squat exercise and 1-RM and peak power for the bench press exercise) measured were seen in PRE/POST and in four of six variables (1-RM, peak power and mean power for the squat exercise and 1-RM for the bench press exercise) in AM/PM. Considering that small, non-significant changes may have important practical significance for competitive athletes, interpretation of results should be performed with appropriate relevance.

Previous studies have shown that protein or essential amino acid ingestion immediately before and/or after a resistance exercise session can significantly increase rate of delivery and uptake of amino acids to skeletal muscle (Tipton et al., 2001), and increase muscle protein synthesis (Tipton et al., 2001; 2004). In addition, whey protein ingestion has been shown to be more effective than casein protein in stimulating muscle protein synthesis when provided immediately following a workout (Bourie et al., 1997). This is thought to be related to differences in amino acid composition (greater concentrations of leucine and isoleucine in whey than casein) and differences in digestive properties of whey and casein protein. Dangin and colleagues (2001) have shown that the rate of absorption of a single serving of whey protein is significantly faster than a similar serving of casein protein. In consideration of these findings, several studies hypothesized that the timing of protein intake during a training regimen could provide a strategic benefit in maximizing muscle growth and performance (Anderson et al., 2005; Candow et al., 2006; Cribb and Hayes, 2006; Esmarck et al., 2001; Hulmi et al., 2008; Williams et al., 2001). Results from these studies, though, have not provided conclusive evidence to support this hypothesis. Although several studies have shown that protein intake close to exercise session is important in maximizing muscle mass and strength gains (Anderson et al., 2005, Cribb and Hayes, 2006; Esmark et al., 2001; Hulmi et al., 2008), other investigations have failed to support this hypothesis (Candow et al., 2006; Williams et al., 2001). However, none of these studies examined experienced resistance-trained athletes. Subjects were either recreationally trained or untrained. This study appears to be the first to examine the effects of protein timing in experienced resistance trained athletes.

Albeit the results of this study suggest that protein timing does not provide significant benefits to lean body mass and muscle performance changes, it needs to be interpreted with some caution. Previous studies examining protein timing have generally used a supplement whose macronutrient composition contained greater carbohydrate content. Tipton and colleagues (1999; 2001), in their acute timing studies, generally used an amino acid to carbohydrate ratio that was approximately 1:6, while studies examining whole protein intake the protein to carbohydrate ratio ranged from of ~1:1 (Cribb and Hayes, 2006) or 1:0.7 (Esmarck et al., 2001). However, the precise ratio that elicits the most effective response is not known. It is likely that the carbohydrate content in protein supplements is important in facilitating transport across intestinal lining and accelerates subsequent uptake by skeletal muscle through activating insulin dependent transport mechanisms. In the present study, the ratio of protein to carbohydrate was 21:1. It is possible that the relatively small carbohydrate content of the supplement delayed the uptake of amino acids into muscle (presumably due to a lower insulin response), thereby missing a potential greater window of adaptation that may exist immediately following a training session.

Another potential limitation of this study was the relatively low caloric content of the subjects. The low energy intakes observed in this study are consistent with previous studies from our laboratory (Hoffman et al., 2006; 2007) and are supported by other studies that indicated that collegiate athletes generally do not meet their nutritional and caloric needs (Cole et al., 2005; Hinton et al., 2004). Caloric intakes should exceed 44 – 50 kcal·kgBM·day $^{-1}$ (American Dietetic Assn, 2000), however the average caloric intake observed in this study (29.1 ± 9.7 kcal·kgBM·day $^{-1}$) were well below these recommended levels and may have affected the ability of these subjects to tolerate high volumes of training that may have enabled these subjects to elicit greater muscle size, power and strength gains. Previous studies have demonstrated the importance of high energy intakes in eliciting significant gains in lean body mass (Roy et al., 1997; Rozenak et al., 2002). Despite elevated protein intakes, the relatively low caloric intake likely limited gains in body mass and lean tissue accruement. However, the elevated protein intakes may have provided an additional benefit for these athletes. Recently Pikosky and colleagues (2008) demonstrated that a high protein intake may offset the effects of an energy deficit. It is possible that despite relatively low energy intakes, the higher protein intake of all three groups may have prevented performance decrements.

In conclusion, results of this study are unable to support the hypothesis that protein timing provides a significant benefit to lean body mass, strength and power improvements in experienced resistance trained athletes. However, considering the relatively low carbohydrate content of the supplement and the low daily caloric intake of the subjects, these results should be interpreted specifically to the parameters measured. Future research appears to be warranted that examines the effect of protein timing in experienced resistance trained athletes with protein supplements containing higher carbohydrate content, and in subjects consuming a much higher daily energy intake.

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Table 1: 10-Week Resistance Training Program

Days 1/3	Weeks 1 – 5 (Sets x Reps)	Weeks 5 – 10 (Sets x Reps)
High Pull	-	4 x 4 -6
Bench Press	4 x 8 – 10	4 x 6 - 8
Incline Bench Press	3 x 8 – 10	3 x 6 - 8
Incline Flys	3 x 8 – 10	3 x 6 – 8
Seated Shoulder Press	4 x 8 – 10	-
Dumbbell Shoulder Press/ Behind the Neck Shoulder Press	-	4 x 6 - 8
Lateral Raises/Dumbbell Front Raise	3 x 8 - 10	3 x 6 - 8
Triceps Pushdowns	3 x 8 – 10	3 x 6 – 8
Tricep Pushdowns/ Dumbbell Extensions	3 x 8 – 10	3 x 6 - 8
Partner Neck Exercise	2 x 10	3 x 10
Days 2/4		
Squat	4 x 8 – 10	4 x 6 – 8
Dead Lift/Romanian Dead Lift	4 x 8 – 10	3 x 6 - 8
Dumbbell Lunge/ Dumbbell Step Ups	3 x 8 – 10	3 x 6 - 8
Leg Curls	3 x 8 – 10	-
Standing Calf Raises	4 x 8 – 10	3 x 6 – 8
Pull-ups	3 x max	
Lat Pulldown	4 x 8 – 10	4 x 6 – 8
Seated Row	4 x 8 – 10	4 x 6 – 8
Dumbbell Biceps Curls	4 x 8 – 10	4 x 6 – 8
Trunk and Abdominal Routine	3 x 10	3 x 10

All exercises performed to a repetition maximum range. Lines with two exercises required athlete to perform the first exercise during the first training session and the second exercise during the second training session.

Table 2: Average Daily Dietary Intake

Variable	Group	Week 0	Week 10
Kcal	AM/PM	2860 ± 864	2862 ± 800
	PRE/POST	3060 ± 1258	2738 ± 1018
	CTR	2904 ± 750	2919 ± 533
Kcal·kgBM	AM/PM	28.4 ± 9.2	28.6 ± 9.0
	PRE/POST	32.3 ± 13.2	28.6 ± 11.4
	CTR	30.5 ± 9.5	31.0 ± 8.9
CHO (g)	AM/PM	275 ± 98	257 ± 85
	PRE/POST	327 ± 134	319 ± 124
	CTR	297 ± 81	291 ± 104
Protein (g)	AM/PM	144 ± 34	229 ± 72*, **
	PRE/POST	175 ± 102	204 ± 55
	CTR	157 ± 53	146 ± 49
Protein ($g \cdot kg^{-1}$)	AM/PM	1.40 ± 0.22	2.28 ± 0.78*
	PRE/POST	1.80 ± 0.98	2.16 ± 0.67
	CTR	1.67 ± 0.70	1.58 ± 0.72
Fat (g)	AM/PM	113 ± 72	100 ± 47
	PRE/POST	115 ± 63	81 ± 33
	CTR	115 ± 54	110 ± 35
% CHO	AM/PM	41.0 ± 13.0	38.0 ±15.2
	PRE/POST	47.2 ± 10.2	42.9 ±8.0
	CTR	44.7 ± 15.5	44.1 ±13.5
% Protein	AM/PM	20.8 ± 4.7	31.5 ± 9.6*,**
	PRE/POST	23.0 ± 7.5	31.6 ± 10.7*,**
	CTR	24.5 ± 7.1	18.8 ± 3.6
% Fat	AM/PM	32.1 ± 13.3	28.6 ±11.0
	PRE/POST	27.6 ± 8.1	24.2 ± 4.9
	CTR	30.7 ± 15.6	31.0 ±6.1

* $p < 0.05$, significant difference between Week 0 and Week 10; ** $p < 0.05$, significantly different than CTR.

Table 3: Anthropometric and Performance Changes during 10 Weeks of Protein Supplementation

Variable	Group	Week 0	Week 10
Body Mass (kg)	AM/PM	102.3 ± 18.9	102.0 ± 18.5
	PRE/POST	95.1 ± 14.4	96.3 ± 14.1
	CTR	100.1 ± 27.2	100.4 ± 27.7
Body Fat (%)	AM/PM	24.9 ± 10.2	23.0 ± 8.5
	PRE/POST	18.4 ± 6.3	18.0 ± 6.6
	CTR	21.7 ± 9.7	21.7 ± 8.2
Lean Body Mass (kg)	AM/PM	75.1 ± 5.8	77.2 ± 6.4
	PRE/POST	77.1 ± 8.7	78.3 ± 8.2
	CTR	76.6 ± 13.3	77.0 ± 14.3
Fat Mass (kg)	AM/PM	27.2 ± 16.2	24.8 ± 13.3
	PRE/POST	18.0 ± 8.5	18.0 ± 8.9
	CTR	23.5 ± 17.0	23.4 ± 14.8

Figure Legends

Figure 1: 1-RM Squat Performance. * = $p < 0.05$ between week 0 and week 10.

Figure 2: 1-RM Bench Press Performance. * = $p < 0.05$ between week 0 and week 10.

Figure 1

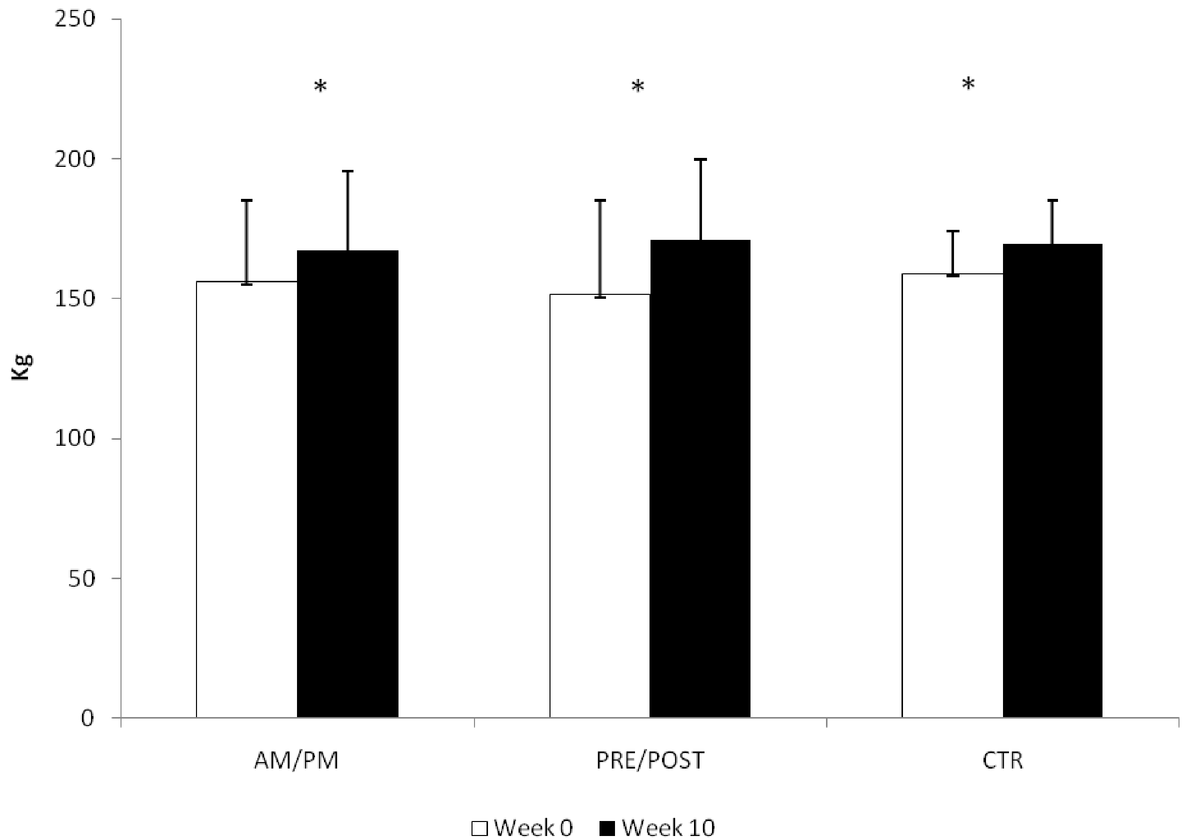

Figure 2