The Effects of Beef, Chicken, or Whey Protein After Workout on Body Composition and Muscle Performance

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Abstract

Sharp, MH, Lowery, RP, Shields, KA, Lane, JR, Gray, JL, Partl, JM, Hayes, DW, Wilson, GJ, Hollmer, CA, Minivich, JR, and Wilson, JM. The effects of beef, chicken, or whey protein after workout on body composition and muscle performance. *J Strength Cond Res* 32(8): 2233–2242, 2018—The purpose of this study was to determine the effects of postworkout consumption of beef protein isolate (Beef), hydrolyzed chicken protein (Chx), or whey protein concentrate (WPC), compared with a control on body composition and muscle performance during 8 weeks of resistance training. Forty-one men and women were randomized into 4 groups: WPC (m = 5, f = 5; age [years] = 19 ± 2, height [cm] = 171 ± 10, mass [kg] = 74.60 ± 14.19), Beef (m = 5, f = 5; age [years] = 22 ± 4, height [cm] = 170 ± 7, mass [kg] = 70.13 ± 8.16), Chx (m = 5, f = 6; Age [years] = 21 ± 2, height [cm] = 169 ± 9, mass [kg] = 74.52 ± 13.83), and Maltodextrin (control) (m = 4, f = 6; age [years] = 21 ± 2, height [cm] = 170 ± 9, mass [kg] = 73.18 ± 10.96). Subjects partook in an 8-week periodized resistance training program. Forty-six grams of protein or a control were consumed immediately after training or at similar times on off-days. Dual-energy x-ray absorptiometry was used to determine changes in body composition. Maximum strength was assessed by 1 repetition maximum for bench press (upper body) and deadlift (lower body). Power output was measured using cycle ergometer. Whey protein concentrate (52.48 ± 11.15 to 54.96 ± 11.85 kg), Beef (51.68 ± 7.61 to 54.65 ± 8.67 kg), and Chx (52.97 ± 12.12 to 54.89 ± 13.43 kg) each led to a significant increase in lean body mass compared with baseline ($p < 0.0001$), whereas the control condition did not (53.14 ± 11.35 to 54.19 ± 10.74 kg). Fat loss was also significantly decreased at 8 weeks compared to baseline for all protein sources ($p < 0.0001$; WPC: 18.70 ± 7.38 to 17.16 ± 7.18 kg; Beef: 16.43 ± 5.71 to 14.65 ± 5.41 kg; Chx: 17.58 ± 5.57 to 15.87 ± 6.07 kg), but not the control condition (16.29 ± 7.14 to 14.95 ± 7.72 kg). One repetition maximum for both deadlift and bench press was significantly increased for all treatment groups when compared with baseline. No differences in strength were noted between conditions. Overall, the results of this study demonstrate that consuming quality sources of protein from meat or WPC lead to significant benefits in body composition compared with control.

Key Words supplementation, muscle hypertrophy, strength training

Introduction

The benefits of additional protein consumption, beyond normal dietary protein intake, for people of all ages participating in resistance training are well documented (2,10,11,16). After consumption, proteins are digested into their constituent amino acids, which provide the building blocks of skeletal muscle. It has been suggested that protein requirements for resistance-trained athletes is higher than normal individuals as extra protein/amino acids are necessary for maintenance of skeletal muscle tissue and performance. In fact in the 1980s and the early 90s, researchers demonstrated that total protein needs were 50–175% greater in athletes than sedentary controls (9). However, there are a number of variables beyond total protein intake that must be considered when selecting proteins including the quality and source of the protein. In general, quality is determined by the essential amino acid (EAA) content of the protein. Overall, research has shown that animal and dairy-based products contain the highest percentage of EAAs and result in greater protein synthesis and muscle hypertrophy after resistance training than

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a vegetarian protein-matched control, which typically lack one or more EAAs (3,6,16).

Although a majority of research in sport has compared dairy to maltodextrin and plant-based proteins, much less is known regarding the impact of meat-based protein sources on skeletal muscle adaptations (3,6,16). Previous work has shown 30 g of meat protein to be efficient in stimulating mixed-muscle fractional synthesis in both young and elderly subjects (15). To date, research has yet to investigate the effects of dairy protein as compared to various meat-based protein sources during a resistance training program. Therefore, the purpose of this study was to compare the effects of whey protein concentrate (WPC), isolated beef protein (Beef), hydrolyzed chicken protein (Chx), and a Maltodextrin control group on body composition, muscle performance, perceived recovery, and gastrointestinal symptoms in resistance-trained individuals during periodized resistance training combined with high-intensity interval training. We hypothesize that different animal protein sources (46 g) consumed after training bouts improve resistance training and body composition adaptations relative to a control group after an 8-week periodized resistance training protocol.

Methods

Experimental Approach to the Problem

To investigate the effects of different protein sources on body composition and functional performance, a double-blind, parallel, controlled trial was conducted in which subjects were randomly divided into 4 groups: WPC, isolated beef protein (BeefISO; Essentia Metabolic Proteins, Ankeny, IA, USA), hydrolyzed chicken protein (MyoCHX; Essentia Metabolic Proteins), and Maltodextrin (control). Subjects were stratified based on dependent variables in the following order: lean body mass (LBM) ($p = 0.9904$), fat mass (FM) ($p = 0.9903$), strength (1 repetition maximum [1RM] deadlift: $p = 0.8283$; 1RM bench press: $p = 0.9763$), and power output ($p = 0.8402$) such that baseline values for these parameters were not statistically different across groups. All subjects were required to undergo identical training protocols for 8 weeks. Subjects consumed their supplement immediately after workout and at similar times on non–workout days. A blinded researcher before and after the 8-week protocol collected measures of body composition, strength, and power at the same time of the day.

Subjects

A total of 41 subjects (men, $n = 19$; women, $n = 22$) aged 18–30 years were recruited from The University of Tampa's campus and volunteered for the study. The WPC group consisted of 5 men and 5 women; the isolated beef protein (Beef) group consisted of 5 men and 5 women; the hydrolyzed chicken protein (Chx) group consisted of 5 men and 6 women; and the control group consisted of 4 men and 6 women (Table 1). All subjects reported at least 2 years of previous experience in weight lifting programs. All subjects agreed to refrain from additional resistance or cardiovascular training not prescribed by the researchers for the duration of the study. We adopted the select inclusion criteria as followed: nonsmoker, no protein or amino acid supplementation, no anabolic or catabolic, or any other ergogenic acids and finally any substance known to influence the variables investigated in this study. Each subject was informed of the inherent risks and benefits and signed an informed consent form before participating in the study. The methods and test assessments used in this study were approved by the University of Tampa Institutional Review Board.

Procedures

Diet and Supplementation. Subjects worked individually with a dietitian on a weekly basis. Subjects were prescribed an individually based diet. The dietitian used the Mifflin St. Jeor equation for each subject to determine their caloric needs based on the LBM of the individual. The recommended diet consisted of 50% carbohydrates, 25% fat, and 25% protein. Total calories and macronutrients were matched between treatment groups. Poststudy analysis revealed that individuals consumed diets that resulted in 48% carbohydrates, 29% fat, and 23% protein. There were no statistical differences in total calories or macronutrients between groups. Subjects tracked their daily intakes using MyFitnessPal (MyFitnessPal, Inc., San Francisco, CA, USA).

In addition to dietary recommendations, subjects consumed a 46 g bolus of their respective treatment condition (WPC, Chx, Beef, or Maltodextrin) after workout before

Table 1. Baseline subject characteristics.*

Characteristic	WPC ($n = 10$)	Beef ($n = 10$)	Chx ($n = 11$)	Control ($n = 10$)
Age (y)	19 ± 2	22 ± 4	21 ± 2	21 ± 2
Height (cm)	171.45 ± 10.04	169.93 ± 7.13	169.03 ± 9.11	170.43 ± 8.67
Body mass (kg)	74.60 ± 14.19	70.13 ± 8.16	74.52 ± 13.83	73.18 ± 10.96

*Results are presented as mean ± *SD*.

Table 2. Training protocol.*

Sets, repetitions, and intensity					
	Wk #	1 and 5	2 and 6	3 and 7	4 and 8
Weight training	Hypertrophy	4 sets/15 reps 60–90 s rest	4 sets/12 reps 60–90 s rest	4 sets/10 reps 60–90 s rest	4 sets/8 reps 60–90 s rest
	Strength	5 sets/5 reps @80% 1RM 3–5 min rest	5 sets/4 reps @85% 1RM 3–5 min rest	5 sets/3 reps @90% 1RM 3–5 min rest	5 sets/2 reps @92.5% 1RM 3–5 min rest
Interval training	Sprints	3 × 10 s 60 s rest	3 × 10 s 45 s rest	4 × 10 s 60 s rest	4 × 10 s 45 s rest

Wk 1–4 exercise selection				
Monday	Tuesday	Wednesday	Thursday	Friday
Leg press Romanian deadlift Incline DB press Pronated lat pull-down Shoulder press BB curl Close grip bench press	Wingate sprints	Leg extension Leg curl DB fly Straight arm pull-down Lateral fly DB curl Rope pressdown	Wingate sprints	Bench press Deadlift Front squat BB over head press BB row

Wk 5–8 exercise selection				
Monday	Tuesday	Wednesday	Thursday	Friday
Back squat Romanian deadlift DB neutral grip bench press Bilateral DB row Shoulder press EZ bar curl EZ bar skullcrusher	Wingate sprints	Reverse lunge Single leg bridge DB chest fly Supinated lat pull-down Hammer curl DB triceps extension	Wingate sprints	Bench press Deadlift Front squat BB over head press BB row

*1RM = 1 repetition maximum; DB = dumbbell; BB = barbell.

leaving the laboratory and at similar times on non–workout days. All shakes were consumed under the supervision of a blinded researcher. To maintain control and blinded conditions, this researcher was the only person handling and distributing the supplementation to the subjects. This individual had no part in data collection, training, or poststudy analysis. Individuals were provided the supplement in the form of a shake, which were labeled "A," "B," "C," and "D."

Body Composition. A whole body dual-energy x-ray absorptiometry (DXA) (Hologic, Bedford, MA, USA) scan was used to measure body composition. Lean body mass (LBM) and fat mass (FM) were determined for the total body with the subject laying in a supine position with the knee extended and instructed not to move for the entire duration of the scan (~10 minutes). Results from each scan were uploaded and accessed on a computer directly connected to the DXA device. All DXA scans were conducted before and after the completion of the study, and each subject was required to fast overnight (10 hours) before the DXA scan. Each participant was given an appointment sheet including the date and time of their scan with the date and time to stop consuming food and drink for compliance purposes. All scans were analyzed by the same researcher who was blinded to treatment conditions. The coefficient of variation (CV) for body composition was 1.5%.

Training Protocol. All subjects participated in an 8-week periodized resistance training protocol consisting of 2 hypertrophy-oriented sessions and 1 strength-oriented session. During the training protocol, each subject performed resistance exercise 3 $d \cdot wk^{-1}$ (M, W, and F). Monday and Wednesday was full-body hypertrophy and Friday was full-body strength. The rest period between sets was set at 1–

Table 3. Dietary data.

Group	Kcal ($g \cdot kg^{-1}$)	CHO ($g \cdot kg^{-1}$)	Fat ($g \cdot kg^{-1}$)	PRO ($g \cdot kg^{-1}$)
WPC	34.6 ± 4.6	4.1 ± 0.5	1.0 ± 0.1	2.2 ± 0.3
Beef	35.4 ± 3.7	4.1 ± 0.6	1.1 ± 0.1	2.2 ± 0.2
Chx	34.3 ± 4.1	4.1 ± 0.5	1.1 ± 0.2	2.1 ± 0.3
Control	35.1 ± 3.1	4.3 ± 0.4	1.1 ± 0.1	2.0 ± 0.2

2 minutes for hypertrophy and 3–5 minutes for strength. Total volume over the trial for all hypertrophy- and strength-oriented sessions was calculated by obtaining the product of sets, repetitions, and total weight lifted for all subjects. Tuesday and Thursday consisted of low volume and high intensity interval training on a Monark cycle ergometer. The resistance load for all Wingate sessions was set at 7.5% of body mass. All training sessions were supervised by a trained research assistant. The training protocol was identical between groups and is further explained in Table 2. Subjects were restricted to only the exercise activity used in this protocol for the duration of their participation in the study.

Strength and Power Measures. Before the training protocol, all subjects completed 2 familiarization sessions to practice and familiarize with the following assessments: 1RM bench press, 1RM deadlift, and Wingate anaerobic peak power (PP). Strength was assessed via 1RM testing in the bench press and deadlift movements. Observation and load prescription were performed by a trained tester that was certified by the National Strength and Conditioning Association (NSCA-CSCS). Loads were increased incrementally until maximal load or failure at a given load was reached. Briefly, subjects performed a general warm-up and a specific warm-up consisting of 3 sets. During the first set, subjects performed 10 repetitions with 50% of their predicted 1RM. For the second set, they performed 5 repetitions with 70% of the predicted 1RM. In the third set, subjects perform 1 repetition with 90% of their predicted 1RM. After the completion of warm-up sets, subjects rested for 3 minutes. Then, each subject had as many as 5 attempts to achieve their 1RM load with 3–5 minutes rest between each attempt.

Anaerobic power was assessed via Monark Wingate cycle ergometry (Monark, Vansbro, Sweden). During the cycling test, the volunteer was instructed to cycle against a predetermined resistance (7.5% of body mass) as fast as possible for 10 seconds. The saddle height was adjusted for each individual to produce a 5–10° knee flexion while the foot was in the low position of the central void. A standardized verbal stimulus was provided to the participant. Power output was recorded in real time by a computer connected to the Monark standard cycle ergometer (Monark model 894e, Vansbro, Sweden) during a 10-second sprint test. Peak power was recorded using Monark Anaerobic test software (Monark Anaerobic Wingate Software, Version 1.0; Monark). The CV for Wingate PP was 3.5%.

Perceptual Measures. The perceptual measures collected using a Perceived Recovery Status Scale (PRS). Ratings of perceived recovery were collected at the beginning and the end of every week. The PRS scale consisted of a scalar representation numbering from 0 to 10. Visual descriptors of "very poorly recovered," "adequately recovered," and "very well recovered" for perceived recovery were

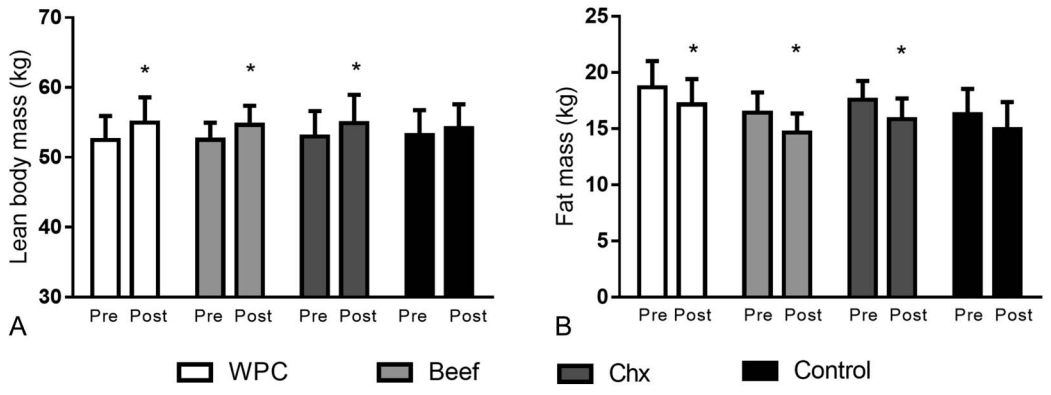

Figure 1. The combined 8-week effects of resistance training with WPC, Beef, Chx or Control on lean body mass (A) and fat mass (B). *Indicates within-group differences ($p < 0.05$).

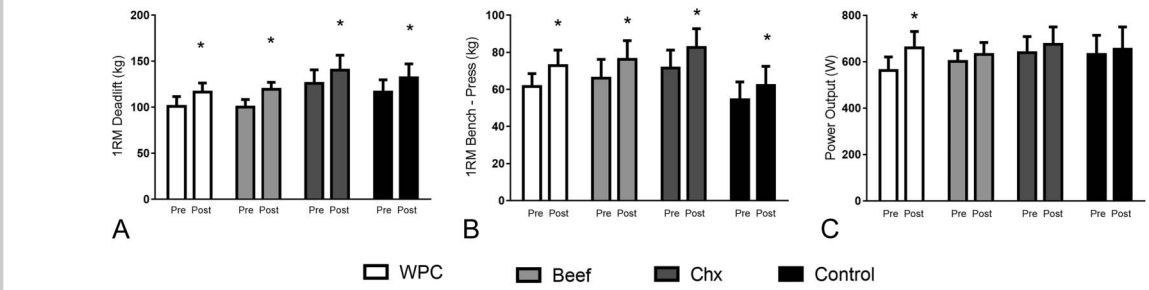

Figure 2. The combined 8-week effects of resistance training with WPC, Beef, Chx or control on deadlift 1RM (A), bench press 1RM (B), and power output (C). *Indicates within-group differences ($p < 0.05$). 1RM = 1 repetition maximum.

presented at numbers 0, 5, and 10, respectively. Subjects were asked to identify their level of perceived recovery after warming-up, before performing the training protocol.

Gastrointestinal Symptoms. At the midpoint of every week, subjects completed the Gastrointestinal Symptom Rating Scale (GSRS) survey before training (14). The survey contained 15 questions which were rated on a seven-point Likert scale with visual anchors ranging from "very serve discomfort" to "no discomfort at all" to track digestive side effects associated with supplementation. The factor analysis used in this study stratified the questions into 3 scales: abdominal pain (abdominal discomfort, hunger pains, and nausea); indigestion symptoms (abdominal distension, acid reflux, heartburn, and increased flatus); bowel dysfunction (diarrhea, constipation, loose stools, hard stools, and incomplete evacuation).

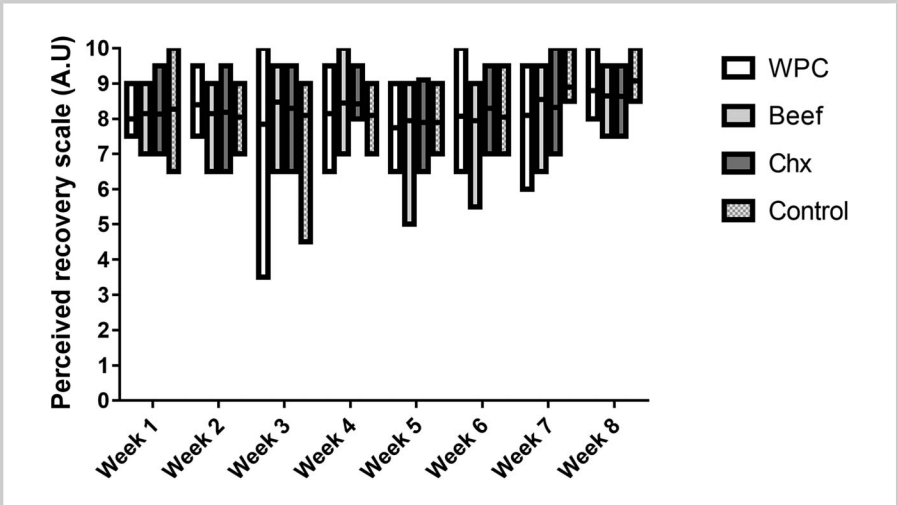

Figure 3. The combined 8-week effects of resistance training with WPC, Beef, Chx, or control on perceived recovery. WPC = whey protein concentrate.

Blood Analysis. Blood draws were obtained via venipuncture techniques of an antecubital vein in the forearm according to standard procedures by a trained phlebotomist following a 10-hour overnight fast. All subjects donated a blood sample of approximately 15mL for analysis in the morning to control for diurnal variations. Whole blood was collected, transferred into appropriate tubes for obtaining serum and plasma, and subsequently centrifuged at 1,500 g for 15 min at 4°C. Resulting serum and plasma were then aliquoted and stored at −80°C until further analysis.

Statistical Analyses

After a visual inspection of boxplots to identify outliers, a normality test (i.e., Shapiro Wilk) confirmed the normality of the data. A 2-way analysis of variance (ANOVA) with repeated measures was performed for all dependent variables assuming time (baseline, post-8 weeks) and group (WPC, Control, Chx, and Beef) as fixed factors. Whenever a significant F value was obtained, a post hoc with Tukey's adjustment was performed for multiple comparisons. For some selected variables, which were not normally distributed (e.g., PRS and some blood markers), we used Friedman 2-way ANOVA. For all analyses, the significance level was set at $p < 0.05$. In addition, mean values and confidence intervals (CIs) of the absolute difference (CI_{diff}) are presented as this approach allows variable change due to supplementation to be investigated, rather than only the

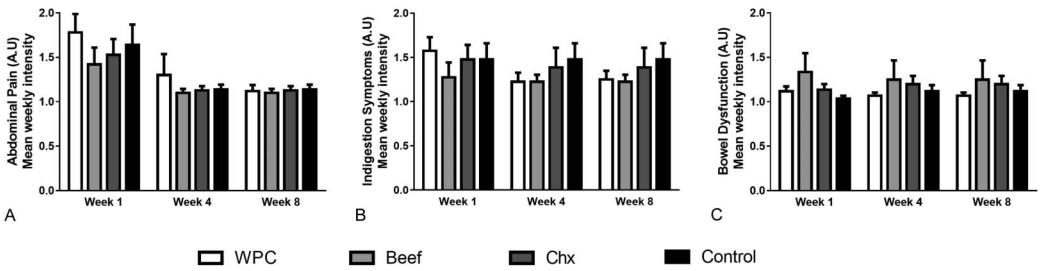

Figure 4. The effects of supplementing with WPC, Beef, Chx, or control on abdominal pain (A), indigestion symptoms (B), and bowel dysfunction (C). WPC = whey protein concentrate.

level of statistical significance. In this regard, the CI includes the value range in which the true population mean of the difference is likely to be contained. Positive and negative CIs that did not cross zero were considered significant. Results are expressed as mean ± *SE*, unless otherwise mentioned. There were no significant sex effects for strength, power, or body composition adaptations; therefore, the data were collapsed.

Results

Volume Load and Macronutrient Intake

There were no between-groups significant differences for total volume (group mean ± *SD*: WPC = 149,766 ± 66,330 kg; Chx = 155,664 ± 58,100 kg; Beef = 140,194 ± 50,357 kg; Malto = 136,472 ± 53,379 kg) ($p = 0.865$). In addition, the compliance for the training protocol was 97%. In regards to nutrition, there were no between-groups significant differences for total calorie intake per day or daily macronutrient distribution (Table 3).

Body Composition

Results for body composition are presented in Figures 1A–B and Table 5. No significant between-groups differences in LBM and FM were detected at baseline ($p > 0.05$). For LBM, a significant main time effect was observed for all experimental groups ($p < 0.0001$) that demonstrated a relative increase ranging from 1.9 to 5.7%. In addition, CI_{diff} revealed that only the control group demonstrated a nonsignificant increase in LBM, control: mean 1.0 kg, 95% CI_{diff}: −0.7 to 2.8 kg, whereas all other experimental

Table 4. Blood safety and lipid profiles.*

	Control	WPC	Beef	Chx
Pre-cholesterol ($mg \cdot dl^{-1}$)	169.5 ± 34.6	168 ± 34.11	174.9 ± 26.06	175.4 ± 32.66
Post-cholesterol ($mg \cdot dl^{-1}$)	177.8 ± 34.7	155.9 ± 32.8	184.2 ± 24.4	179.7 ± 35.52
Pre-HDL ($mg \cdot dl^{-1}$)	70.5 ± 17.3	64 ± 13.03	66.4 ± 15.69	61.36 ± 11.53
Post-HDL ($mg \cdot dl^{-1}$)	71.9 ± 15.1	61.1 ± 13.9	65.3 ± 16.71	60.54 ± 12.73
Pre-triglycerides ($mg \cdot dl^{-1}$)	96.6 ± 22.3	94.7 ± 37.56	106.1 ± 40.57	101.9 ± 30.61
Post-triglycerides ($mg \cdot dl^{-1}$)	98.9 ± 28.44	94.8 ± 39.6	95.1 ± 34.01	90.45 ± 31.86
Pre-AST ($IU \cdot L^{-1}$)	28.6 ± 6.44	24.7 ± 6.67	26.6 ± 6.78	23.5 ± 5.53
Post-AST ($IU \cdot L^{-1}$)	24.4 ± 5.23	20.8 ± 2.67	24 ± 7.69	22.5 ± 5.22
Pre-ALT ($IU \cdot L^{-1}$)	24.5 ± 6.69	23.4 ± 2.95	21.4 ± 5.11	21.3 ± 6.73
Post-ALT ($IU \cdot L^{-1}$)	18.8 ± 5.76	21.9 ± 3.96	21.5 ± 7.7	21.9 ± 4.66
Pre-glucose ($mg \cdot dl^{-1}$)	91.8 ± 8.43	90.3 ± 8.07	87.2 ± 6.82	87.4 ± 8.49
Post-glucose ($mg \cdot dl^{-1}$)	92.8 ± 8.09	91.1 ± 7.64	86.8 ± 4.63	86.7 ± 7.16
Pre-BUN ($mg \cdot dl^{-1}$)	16.9 ± 4.44	14.5 ± 2.62	15.3 ± 2	16.5 ± 2.63
Post-BUN ($mg \cdot dl^{-1}$)	15.6 ± 3.2	15 ± 3.26	15.1 ± 2.64	15.1 ± 3.41
Pre-Cr ($mg \cdot dl^{-1}$)	0.969 ± 0.17	0.986 ± 0.22	0.981 ± 0.11	0.987 ± 0.15
Post-Cr ($mg \cdot dl^{-1}$)	1.00 ± 0.18	0.982 ± 0.2	0.994 ± 0.11	1.02 ± 0.15
Pre-BUN/Cr ratio	17.6 ± 2.57	15.8 ± 2.58	16.7 ± 2.66	16.6 ± 2.76
Post-BUN/Cr ratio	15.55 ± 2.98	16.5 ± 3.3	16 ± 3.09	14.8 ± 2.29

*$mg \cdot dl^{-1}$ = milligrams per deciliter; $IU \cdot L^{-1}$ = international unit per liter; BUN = blood urea nitrogen; Cr = creatinine; HDL = high density lipoprotein; AST = aspartate aminotransferase; ALT = alanine aminotransferase; CHO = carbohydrate; PRO = protein.

Table 5. Body composition and muscle performance results.

Group	LBM (kg)		FM (kg)		Deadlift 1RM (kg)		Bench press 1RM (kg)		Peak power (W)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
WPC	52.48 ± 10.89	54.96 ± 11.48*	18.71 ± 7.38	17.18 ± 7.18†	101 ± 34	116 ± 32‡	62 ± 22	73 ± 26‡	563 ± 181	661 ± 221‡
Beef	52.53 ± 7.67	54.65 ± 8.61†	16.43 ± 5.71	14.65 ± 5.41*	101 ± 27	119 ± 25‡	66 ± 32	76 ± 32‡	601 ± 148	632 ± 164
Chx	52.97 ± 12.12	54.89 ± 13.43†	17.58 ± 5.57	15.87 ± 6.07*	126 ± 49	141 ± 54‡	71 ± 32	83 ± 34‡	639 ± 228	675 ± 247
Control	53.14 ± 11.35	54.96 ± 10.74	16.29 ± 7.14	14.95 ± 7.72	117 ± 42	132 ± 48‡	64 ± 27	71 ± 37‡	631 ± 262	655 ± 300

*Significantly different from pretest ($p < 0.01$).
†Significantly different from pretest ($p < 0.05$).
‡Significantly different from pretest ($p < 0.0001$).
1RM = 1 repetition maximum; LBM = lean body mass; FM = fat mass.

groups significantly increased LBM; WPC: mean 2.4 kg, 95% CI_{diff}: 0.6 to 4.3 kg; Chx: mean 1.9 kg, 95% CI_{diff}: 0.1 to 3.6 kg; Beef: mean 2.1 kg, 95% CI_{diff}: 0.2 to 3.9 kg with no differences between conditions.

A significant main time effect was observed for FM in all experimental groups ($p < 0.0001$), with a relative decrease ranging from −10.8 to −6.6%. However, the control group did not significantly decrease FM, control: mean −1.3 kg, 95% CI_{diff}: −2.7 to 0.05 kg, whereas each of the protein groups resulted in significant decreases in FM over the course of the study; WPC: mean −1.5 kg, 95% CI_{diff}: −2.9 to −0.2 kg; Chx: mean −1.7 kg, 95% CI_{diff}: −3.0 to −0.3 kg; Beef: mean −1.7 kg, 95% CI_{diff}: −3.1 to −0.4 kg.

Maximum Strength and Muscle Power

Results for maximum strength and muscle power are presented in Figures 2A–C. No significant between-groups differences in 1RM deadlift, 1RM bench press, and PP were detected before the experimental period ($p > 0.05$). A significant main time effect was observed for 1RM deadlift in all experimental groups ($p < 0.0001$) with a relative increase ranging from 11.6 to 19.3%. In addition, CI_{diff} revealed that all experimental groups had significant increases in 1RM deadlift; control: mean 15.7 kg, 95% CI_{diff}: 6.9 to 24.5 kg; WPC: mean 15.6 kg, 95% CI_{diff}: 6.6 to 24.2 kg; Chx: mean 12.1, 95% CI_{diff}: 6.3 to 23.0 kg; Beef: mean 19.3 kg, 95% CI_{diff}: 10.5 to 28.1 kg with no differences between conditions.

A similar response was observed for 1RM bench press as a significant main time effect was detected for all experimental groups ($p < 0.0001$) with a relative increase ranging from 11.4 to 17.6%. Furthermore, CI_{diff} revealed that all experimental groups had significant increases in 1RM bench press; control: mean 7.3 kg, 95% CI_{diff}: 3.0 to 12.0 kg; WPC: mean 10.9 kg, 95% CI_{diff}: 6.2 to 15.6 kg; Chx: mean 11.4 Kg, 95% CI_{diff}: 6.6 to 15.6 kg; Beef: mean 10.0 kg, 95% CI_{diff}: 5.3 to 14.7 kg, with no differences between conditions.

For PP, a quite different response was observed, despite a significant main time effect detected for all experimental groups ($p < 0.0001$) demonstrating a relative increase ranging from 3.7 to 17.2%. The CI_{diff} revealed that only the WPC group had significant increases in power output; WPC: mean 97.3 Watts (W), 95% CI_{diff}: 45.2 to 149.5 W. However, control, Chx, and Beef groups did not have significant increases in power measurements; control: mean 23.0 W, 95% CI_{diff}: −28.1 to 76.0 W; Chx: mean 35.6 W, 95% CI_{diff}: −13.9 to 85.3 W; Beef: mean 30.4 W, 95% CI_{diff}: −21.6 to 82.6 W.

Perceptual Measures

Results for the PRS are presented in Figure 3. No significant between-groups differences were detected before the experimental period ($p > 0.05$). Despite some higher interval individual values in data time points, all groups ranged between moderately recovered and well recovered (e.g., range 7.0–9.2 A.U) throughout the experimental period. No significant within or between-groups differences ($p > 0.05$) were observed at any time throughout the study.

Gastrointestinal Symptom Rating Scale

Results for the GSRS are presented in Figures 4A–C describing abdominal pain, indigestion, and bowel dysfunction, respectively. No significant between-groups differences were detected before the experimental period ($p > 0.05$). All participants reported "no discomfort at all" to "minor discomfort" for the 3 symptom clusters selected (i.e., abdominal pain, indigestion symptoms, and bowel dysfunction) throughout the experimental period. There were no significant within or between-groups differences ($p > 0.05$).

Blood Measures

There were no within- or between-groups differences ($p > 0.05$) in any of the investigated health biomarkers (glucose, blood urea nitrogen [BUN], creatinine [Cr], and Cr/BUN ratio), lipid markers (cholesterol, triglycerides, high density lipoprotein [HDL]), and hepatic markers (aspartate aminotransferase [AST], alanine aminotransferase [ALT]). The data is represented in Table 4.

Discussion

The purpose of this study was to investigate the effects of postexercise WPC, beef, and chicken protein consumption compared with a maltodextrin control on body composition, muscle strength, and power after 8 weeks of periodized resistance training combined with high-intensity interval training. The primary finding in this study was that protein supplementation, irrespective of source, improved body composition relative to the control; further demonstrating that the 2-servings of protein (46 g) postworkout improved body composition results. Our findings partially support our purposed hypothesis that whey or meat protein (46 g) after training can improve body composition and resistance training–induced adaptations. These results suggest that choice of protein did not impact muscular strength outcomes, as all quality protein sources (WPC, Beef, and Chx) demonstrated significant improvements in maximum strength, however, not significantly greater than control. In addition, only WPC significantly increased muscle power output. All experimental groups demonstrated a significant increase in LBM and a significant decrease in FM, whereas neither of these effects were seen in the control.

These findings underscore the importance of consuming protein postworkout, but also indicate that similar improvements in body composition profiles (i.e., increase LBM and decrease FM) should be expected if an athlete consumes beef protein, chicken protein, or whey protein despite limited research comparing different animal protein sources on body composition. Our findings are in agreement with past research from Hartman et al. (6) who demonstrated that enriching the diet with additional high-quality protein via consumption of fat-free fluid milk after resistance training was the only condition to promote a significant increase in lean mass and fat loss than did consumption of soy or carbohydrate in young, novice, male weightlifters.

To our knowledge, our study is the first to investigate the effects of different animal protein sources on resistance-trained college-aged men and women. Protein supplements derived from meat can provide high amounts of EAAs as a standard serving of 113.4 g (4 oz) lean beef or chicken provides 10–15 g EAAs in total. In this regard, our experimental conditions received an adequate amount of EAAs in which translated into positive adaptations on body composition profiles compared with the carbohydrate control condition. Supporting this contention, other studies have demonstrated the importance of consuming EAA to stimulate muscle protein synthesis (4,7). These previous findings suggest that the total composition of a protein supplement should be considered (including amino acid composition and peptide and other nutrient abundance) when choosing a postworkout protein source. Therefore, the aforementioned outcomes suggest that performing resistance training followed by high-quality protein supplementation augments LBM and attenuates FM as it was observed in our experimental groups.

Regarding muscle functional performance, the results of this study demonstrated that all groups were able to increase muscle strength after an 8-week periodized training program. Previous studies have demonstrated greater or similar strength gains for protein supplementation compared with carbohydrate control groups regardless of training status (1,18). For instance, Andersen et al. (2005) reported that countermovement jump and peak torque during slow isokinetic muscle contractions increased similarly in both protein and carbohydrate groups. Thus, our findings are in agreement with previous research that demonstrated no added benefit of protein supplementation on muscle functional performance when compared with a control (carbohydrate) condition despite significantly greater gains in LBM. However, a reasonable explanation for those similar strength gains observed in this study might be associated with the volume load used herein. To investigate the effects of different protein sources compared with carbohydrate group on morphological and functional performance, we recruited trained individuals with a minimal training experience of ~2 years. Moreover, it is important to mention that all conditions totaled a high and similar volume load (i.e., ~140,000 kg) which has been suggested to be a robust predictor of strength gains for both men and women (13).

In regards to power output, quite a different response was observed, indicating that only the WPC group had significant increases in power output (+97.3 W). It is difficult to determine why only the WPC group improved more than other conditions. Furthermore, there is a paucity of studies investigating the effects of dairy and different animal protein sources on power output. Thus, future studies addressing the effects of different supplemental proteins on power output in resistance-trained individuals is warranted.

In addition, this study sought to investigate the effect of different protein sources on perceived recovery compared with a carbohydrate control condition. However, there were no significant differences between groups on perceived recovery response. It has been demonstrated that protein functions as an agent to remodel and recover damaged muscle tissue (12). Nonetheless, in this study, regardless of protein source (e.g., WPC, beef, or chicken), the important role of protein to recover muscle damage did not aid in one's perception of recovery when compared with the control group.

Furthermore, this study investigated the impact of different protein sources on possible gastrointestinal side effects relating to abdominal pain, indigestion, and bowel dysfunction using the GSRS. These side effects could have indicated improper digestion of the protein supplement, which could negatively affect muscle performance and recovery. There were no between or within-group differences throughout the duration of the study indicating that the experimental groups did not receive any potential side effects compared with the control.

This study supports the notion that protein supplementation supports muscle protein accretion in athletes. The mechanism behind this is likely related to increases in muscle protein synthesis as previously documented (8). A unique outcome of this article is that we found no effect of protein source on muscle protein accretion, suggesting that as long as athletes consume large quantities of protein, the source is not as relevant. This is consistent with previous research which suggests a "threshold" for anabolic benefits of protein supplementation that may peak as low as 20 grams (11). It is possible that at suboptimal protein doses (i.e., 10 g), the protein quality would be of more relevance. This requires further investigation.

Practical Applications

These results suggest that differences in protein sources are of less relevance when the protein quantity is high (46 g) and comes from either meat or dairy-based sources. Furthermore, subjects in this study did not report significant gastrointestinal distress from any treatment. These results reinforce the importance of postworkout protein supplementation. Individuals looking to optimize body composition should consume ample protein postworkout, but the source of protein can be self-selected by the individual's preference. For instance, those who have dairy and or lactose intolerances can opt for animal protein sources that are free of these allergens and attain similar body composition and muscular adaptations.

In contrast to body composition changes, there was no treatment effect for strength adaptations. The WPC group was the only condition to significantly increase power output. These performance outcomes require further investigation to elucidate the mechanism of action. Future research should also examine adaptations in highly trained athletes.

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