

Research article

The Effects of Pre- and Post-Exercise Whey vs. Casein Protein Consumption on Body Composition and Performance Measures in Collegiate Female Athletes

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Abstract

Two of the most popular forms of protein on the market are whey and casein. Both proteins are derived from milk but each protein differs in absorption rate and bioavailability, thus it is possible that each type of protein may contribute differently to the adaptations elicited through resistance training. Therefore, the purpose of this study was to investigate the potential effects of ingestion of two types of protein in conjunction with a controlled resistance training program in collegiate female basketball players. Sixteen NCAA Division III female basketball players were matched according to body mass and randomly assigned in a double-blind manner to consume 24 g whey protein (WP) (N = 8, 20.0 ± 1.9 years, 1.58 ± 0.27 m, 66.0 ± 4.9 kg, 27.0 ± 4.9 %BF) or 24 g casein protein (CP) (N = 8, 21.0 ± 2.8 years, 1.53 ± 0.29 m, 68.0 ± 2.9 kg, 25.0 ± 5.7 %BF) immediately pre- and post-exercise for eight weeks. Subjects participated in a supervised 4-day per week undulating periodized training program. At 0 and 8 weeks, subjects underwent DXA body composition analysis, and at 0 and 8 weeks underwent one repetition maximum (1RM) strength, muscle endurance, vertical jump, 5-10-5 agility run, and broad jump testing sessions. Data were analyzed using repeated measures ANOVA, and presented as mean ± SD changes from baseline after 60 days. No significant group x time interaction effects were observed among groups in changes in any variable ($p > 0.05$). A significant time effect was observed for body fat (WP: -2.0 ± 1.1 %BF; CP: -1.0 ± 1.6 %BF, $p < 0.001$), lean mass (WP: 1.5 ± 1.0 kg; CP: 1.4 ± 1.0 kg, $p < 0.001$), fat mass (WP: -1.3 ± 1.2 kg; CP: -0.6 ± 1.4 kg, $p < 0.001$), leg press 1RM (WP: 88.7 ± 43.9 kg; CP: 90.0 ± 48.5 kg, $p < 0.001$), bench press 1RM (WP: 7.5 ± 4.6 kg; CP: 4.3 ± 4.5 kg, $p = 0.01$), vertical jump (WP: 4.1 ± 1.8 cm; CP: 3.5 ± 7.6 cm, $p < 0.001$), 5-10-5 (WP: -0.3 ± 0.2 sec; CP: -0.09 ± 0.42 sec, $p < 0.001$), and broad jump (WP: 10.4 ± 6.6 cm; CP: 12.9 ± 7.1 cm, $p < 0.001$). The combination of a controlled undulating resistance training program with pre- and post-exercise protein supplementation is capable of inducing significant changes in performance and body composition. There does not appear to be a difference in the performance-enhancing effects between whey and casein proteins.

Key words: whey, casein, protein, females, body composition, performance

Introduction

In response to resistance training, an individual experiences muscle activation and damage that stimulates protein turnover (Campbell et al., 2007; Kerksick and

Leutholtz, 2005; Wilson and Wilson, 2006). If the body is lacking sufficient levels of amino acids, both pre- and post-exercise, the result is a negative protein balance, leading to detrimental side-effects such as muscle wasting and delayed exercise recovery (Biolo, 1995; Phillips, 1999; 2002). It is essential that athletes consume sufficient amounts of protein while also appropriately timing their protein consumption in order to experience a positive nitrogen balance and eventual muscle hypertrophy (Campbell et al., 2007; Kerksick and Leutholtz, 2005). A large number of athletes and exercisers have turned to protein supplements to meet these excess demands on the body. With varying amounts of information given to this population, including information that may be false or misleading, it is important for researchers to test various protein timing options, all possible types of proteins, and to utilize all populations as test subjects.

Many studies have been performed proving the positive impact of protein consumption pre- and post-exercise. Benefits of protein timing include: muscle maintenance and hypertrophy, improved exercise recovery, improved body composition and enhanced immune function during periods of intense training (Andersen et al., 2005; Cribb, 2006; Esmarck et al., 2001; Flakoll et al., 2004; Hulmi et al., 2005; Kerksick and Leutholtz, 2005; Willoughby et al., 2007). The International Society of Sports Nutrition (ISSN) (Campbell et al., 2007) position stand on protein and exercise further documents the benefit of protein consumption pre- and post-exercise.

In addition to timing, type of protein consumed has also been shown to affect the overall benefits experienced by athletes and measured by researchers. Numerous types of protein are utilized by athletes, including whey, casein, milk, and soy- or egg-based varieties and each type possesses a varying level of amino acid bioavailability upon consumption (Campbell et al., 2007; Wilson and Wilson, 2006). According to the ISSN position stand, whey and casein proteins have the greatest bioavailability when compared to protein alternatives, although it is unclear whether one type provides any greater benefits over the other (Campbell et al., 2007). These two forms of protein are both milk-derived protein substrates, but the amino acid availability differs in absorption time, composition, and length of time upon consumption. Whey protein is water soluble and is quickly digested in the body, earning it the "fast protein" title. Amino acids are quickly

available in large quantities after consumption of whey protein (Campbell et al., 2007; Wilson and Wilson, 2006). Alternately, the consumption of a casein supplement results in a slower availability of amino acids, labeled a “slow protein.” Casein is water insoluble and coagulates, resulting in a slow-release mechanism of amino acids that is sustained at increased levels in the body for a longer period of time (Campbell et al., 2007; Wilson and Wilson, 2006). This difference between whey and casein proteins could affect the response seen in conjunction with training.

To determine if any one protein type is more beneficial than another, more studies should be performed. Therefore, the purpose of this study is to investigate the potential anabolic effects of whey and casein protein ingestion in conjunction with a controlled resistance training program using collegiate female, anaerobic athletes. This is a particularly important investigation as no studies utilizing college-level female athletes have been performed to assess the role of dietary protein supplementation on training adaptations. Due to the frequent use of protein supplements in sport, additional data on the true effects in females is needed.

Methods

Experimental approach to the problem

A randomized, double-blind study was used to compare the effects of consuming casein versus whey protein before and after exercise for eight weeks on resistance-trained (> 1 years) NCAA Division III female basketball players. The following dependent variables were assessed to determine training-induced differences based on the two protein groups: one-repetition maximum (1RM) bench press, 1RM leg press, vertical jump, broad jump, 5-10-5 time, and body composition. Subjects were instructed not to change their standard dietary habits. No control group was used due to the documented positive effects of protein and training reported in other studies. Since this relationship had previously been established and the intent of the current study was to determine whether differences between the whey and casein protein supplements exist, omitting a control group was deemed acceptable.

Subjects

Sixteen NCAA Division III female basketball players were matched according to body mass and randomly assigned, in a double-blind fashion, to either a whey (WP; $n = 8$, 20.0 ± 1.9 years, 1.58 ± 0.27 m, 66.0 ± 4.9 kg, 27.0 ± 4.9 %BF) or casein (CP; $n = 8$, 21.0 ± 2.8 years, 1.53 ± 0.29 m, 68.0 ± 2.9 kg, 25.0 ± 5.7 %BF) protein group. All procedures were approved by the University Institutional Review Board for Human Subjects and the subjects signed an informed consent prior to any testing. Subjects were excluded if they had any known disease or disorder including: metabolic disorders, heart/cardiopulmonary diseases, diabetes, thyroid disease, hypogonadism, hepatorenal disease, musculoskeletal disorders, neuromuscular/neurological diseases, autoimmune diseases, cancer, peptic ulcers, or anemia. Subjects were also excluded if

they were taking any drug, medication, or supplement that could interfere with the results of the study, or if they had any absolute or relative contraindication for exercise testing or prescription as outlined by the American College of Sports Medicine.

Because this study tested the effects of the supplement on resistance trained athletes, all subjects had been resistance training consistently for the preceding 12 months, and were participating in collegiate-level anaerobic athletics.

Supplementation protocol

The WP group consumed 24 g of Optimum Nutrition 100% Whey Gold Standard protein (Optimum Nutrition, Inc., Aurora, IL) which consisted of 120 calories, 1 g of total fat, 4 g of total carbohydrates, and 24 g of protein in a single scoop serving, whereas the CP group consumed 24 g of Optimum Nutrition 100% Casein protein (Optimum Nutrition, Inc., Aurora, IL) with 120 calories, 1 g of total fat, 3 g of carbohydrates, and 24 g of protein in a single severing scoop, 30 minutes before and immediately after each training session for eight weeks. Supplements were prepared in powder form and packaged in generic bottles for double-blind administration. Protein was mixed with 10 fl oz. of water in each athlete's individual shaker bottle at every time point. Research assistants monitored supplement ingestion in the Human Performance Lab (HPL).

Baseline testing

All subjects participated in a familiarization session, health history questionnaire, and were scheduled for baseline testing times. Following the familiarization session, subjects recorded food intake on dietary record forms for four days. Subjects were instructed to refrain from exercise for 48 hours and to fast for 12 hours prior to the scheduled baseline testing appointment. Subjects reported to the HPL where they underwent body composition and bone density testing determined by a Hologic™ Discovery dual energy x-ray absorptiometer (DXA; Bedford, MA). Subjects lay in a supine position on the DXA exam table in a pair of shorts or gown for roughly 7 minutes while a low dose of radiation scanned the subject's entire body to determine fat, muscle, and bone mass.

Performance testing

Performance testing occurred on two separate days and all tests were supervised by lab assistants experienced in conducting strength/anaerobic exercise tests using standard procedures. Day 1 consisted of 5-10-5, vertical jump, and broad jump in that order. Subjects warmed up for five minutes prior to testing. A 5-10-5 agility run was used to assess anaerobic performance. The subjects started at the middle cone with a cone five yards to the right and five yards to the left. The participants performed a 5-yard side shuffle from the middle cone to the right cone, a 10-yard side shuffle to the left-most cone, followed by a pivot and 5-yard sprint to the right, ending at the middle cone. Time from start to finish was manually measured with a stopwatch and recorded. Subjects also performed a vertical jump test using the VERTEC (Sports Imports,

Columbus, OH) vertical jump assessment tool. Participants were given four attempts on the VERTEC and the best of the four attempts was recorded. Following the vertical jump test, athletes were given 10 minutes of rest before beginning testing for broad jump. A standing broad jump test was completed using a long jump mat with 0.5 inch increments and the best of three attempts was recorded.

Day 2 consisted of bench press and leg press tests to assess strength as well as muscular endurance. Subjects warmed-up on the dynamic, Hammer Strength bench press with 2 sets of 8 – 10 repetitions at approximately 50% of anticipated maximum. Participants then performed successive 1RM lifts starting at about 70% of anticipated 1RM and increased by 5 – 10 lbs until reaching a 1-RM. For a successful lift, the participant must have kept their head and hips on the bench, both feet on the ground, and they must have touched the bar to their chest before returning the bar to the start position. After resting for five minutes, participants completed maximal repetitions at 65% of established 1RM. Participants were instructed to complete as many repetitions as possible while maintaining proper form, touching their chest with the bar to signal the end of the lowering phase, and without resting between each repetition. The test-to-test reliability for bench press in our lab is 0.997. Subjects then rested for 10 minutes before warming up on the 45° Hammer Strength, plate-loaded leg press (2 sets of 8 – 10 repetitions at approximately 50% of anticipated maximum). Subjects then performed successive 1-RM lifts on the leg press starting at about 70% of anticipated 1-RM and increased by 10 – 25 lbs until reaching a 1-RM. Participants were required to keep both feet flat on the foot platform and to lower the weight until the knees were at 90°, and to maintain a constant rhythm without resting after repetitions. Subjects again rested for five minutes and completed maximal repetitions at 65% of 1RM. Both 1RM protocols were followed as outlined by the National Strength and Conditioning Association (Bachle and Earle, 2008). The test-to-test reliability for leg press is 0.974 in our lab. Before leaving the lab, subjects were assigned to a protein group and given a workout protocol to be com-

pleted at designated times.

Training protocol

Subjects participated in a periodized anaerobic resistance-training program four days per week throughout the entire eight-week training period. The program incorporated two upper- and two lower-extremity workouts per week (Table 1). In addition to strength training, three days per week the athletes also participated in sport specific conditioning, agility, jumping, and sprint work (Table 2). These workouts consisted of 30-40 minutes of skill and conditioning related work. All training was performed under the supervision of the principal investigators and trained HPL research assistants.

Assessment schedule

All baseline assessments were repeated at the completion of the combined training and supplementation period, including dietary intake, body composition, power, and strength.

Statistical analysis

Analysis of variance (ANOVA) for repeated measures univariate tests were used to analyze data utilizing the SPSS 12.0 for Windows software package (SPSS Inc., Chicago, IL). Data was considered statistically significant when the probability of type I error was 0.05 or less. Values are represented as mean \pm SD.

Results

Both groups experienced significant improvements in body composition, strength, and anaerobic performance when consuming either protein supplement pre- and post-exercise. However, no significant effects were observed between groups in changes in any variable ($p > 0.05$).

Body composition

Both the casein and the whey protein supplemented groups experienced a marked decrease in body fat over the course of the eight week study (WP: -2.0 ± 1.1 %BF; CP: -1.0 ± 1.6 %BF, $p < 0.001$). Similarly, lean mass

Table 1. Resistance training protocol.

	Exercise	Sets x Reps (Week 1-4)	Sets x Reps (Week 5-8)
Monday	Squat	1 x 15	3 x 12
	Incline	1 x 15	3 x 12
	Hang Clean	1 x 15	3 x 12
	Shoulder Complex	1 x 15	3 x 12
	Lunge	1 x 15	3 x 12
	EZ Curls	3 x 15	
Tuesday	Squat Jumps	3 x 30	
	Weighted Lunges	3 x 12	
	Lateral Jumps	2 x 50	
	Twist/Cable Rotation	3 x 20	
	Stability Pushups	3 x 15	
Thursday	Squat	1 x 15	3 x 12
	RDL	1 x 15	3 x 12
	Push Jerk	1 x 15	3 x 12
	BW Lunge 4-way	1 x 15	3 x 12
	Row	1 x 15	3 x 12
	French Press	3 x 15	

Table 2. Agility and conditioning protocol.

	Agility	Conditioning	Etc.
Monday	Ladder 1 x 2		PB Russian Twist
	Rope 1 x 2		PB Leg Curl
	Dot 1 x 2		PB Lateral Role
			PB Crunch
			PB Reverse Crunch
			PB Knee Tuck
Tuesday			PB Bridge
			Elbow Bridge
	18 Meter Shuttle		150 Foot contacts
	4-minute Drill		Jumping
	Ladder Sprints		
Thursday		Interval 20 minutes	Stretch
		Long Run 45 minutes	3-way Bridge
Friday			Crunches
	Ladder 2		PB Russian Twist
	Rope 2		PB Leg Curl
	Dot 2		PB Lateral Role
			PB Crunch
			PB Reverse Crunch
		PB Knee Tuck	
		PB Bridge	
		Elbow Bridge	

increased in both groups (WP: 1.5 ± 1.0 kg; CP: 1.4 ± 1.0 kg, $p < 0.001$), while fat mass decreased in both groups (WP: -1.3 ± 1.2 kg; CP: -0.6 ± 1.4 kg, $p < 0.001$). Overall, both supplements appear to have been beneficial to the body composition of all athletes, regardless of the type of protein consumed.

Strength

Casein and whey supplement groups both experienced statistically significant strength gains between the onset and the culmination of the study for both 1RM leg press (WP: 88.7 ± 43.9 kg; CP: 90.0 ± 48.5 kg, $p < 0.001$) and 1RM bench press (WP: 7.5 ± 4.6 kg; CP: 4.3 ± 4.5 kg, $p = 0.01$). There was no significant between-group difference in strength gains.

Power and agility

Both study groups experienced improved performance in all three power and agility tests, including increased height on the vertical jump (WP: 4.1 ± 1.8 cm; CP: 3.5 ± 7.6 cm, $p < 0.001$), increased distance on the broad jump (WP: 10.4 ± 6.6 cm; CP: 12.9 ± 7.1 cm, $p < 0.001$), and decreased time to completion on the 5-10-5 shuttle run (WP: -0.3 ± 0.2 sec; CP: -0.09 ± 0.42 sec, $p < 0.001$).

Discussion

This study found no significant difference in type of protein consumption on overall performance gains during an eight week undulating resistance training and conditioning program. These findings were similar to those seen by Tipton et al. (Tipton et al., 2004), who tested femoral arteriovenous blood samples for leucine and phenylalanine concentrations in study participants consuming either a placebo, a casein supplement, or a whey supplement one hour post leg-extension exercise bout. The

groups consuming the protein supplements experienced a positive net amino acid balance, although it was achieved through different expressions of leucine and phenylalanine in the blood. The overall result indicated that the total protein synthesis response after consuming either a whey or casein protein supplement post-exercise was beneficial, and that neither supplement displayed a significantly superior response.

Although the current study seems to verify the Tipton et al. study, other studies have implied that one of the two proteins have resulted in greater net gains in amino acid uptake. A study published by Dangin et al. (2001) suggested that the sustained, seven-hour increase in blood leucine levels after the consumption of a mixed casein meal provided a more beneficial positive nitrogen balance than the faster, but shorter availability, of amino acids following a mixed whey meal. However, in a second study by Dangin et al. (2003), results showed that whey protein exhibited more beneficial protein uptake capabilities in older men compared to younger men after consuming mixed meals. Researchers surmised that the availability of leucine and amino acids presented by the "fast" whey protein provided greater bioavailability in the elderly than the mixed meal of "slow" casein protein. Though interesting and surely valuable, neither of Dangin's studies evaluated the effects of protein consumption post-exercise. The uptake of proteins could be influenced by the effects of muscle damage incurred during a bout of strength training, which would have equalized the benefit of whey and casein proteins. Additionally, the present study analyzed the effects in young, female athletes and their responses might be very different from those of men.

Similarly, a 2006 study (Cribb et al., 2006) investigated the effects of whey versus casein on strength and body composition. Thirteen body builders ingested 1.5

g·kg⁻¹ of body weight (BW) per day of either whey or casein protein for 10 weeks. The findings revealed that the whey group had greater gains in strength (squat: +75.3 kg whey vs. +52.2 kg casein, bench press: +48 kg whey vs. +18.5 kg casein, and cable pull-down: +35.1 kg whey vs. +20.7 kg casein) and lean body mass (5.0 ± 0.3 kg for whey and 0.8 ± 0.4 kg for casein), when compared to the casein group. Considering this study included exercise, it is once again suggested that the results from the current study differed because of gender.

In addition to information on the effects of protein-type and its impact on exercise response, the present study also added to the body of knowledge regarding the benefits of protein consumption and exercise. Like many other studies (Andersen et al., 2005; Borsheim et al., 2002; Campbell et al., 2007; Esmarck et al., 2001; Falvo et al., 2005; Flakoll et al., 2004; Hartman et al., 2007; Hulmi et al., 2005; Karp et al., 2006; Kerksick and Leutholtz, 2005; Kreider, 1999; Kreider et al., 2003; Rankin et al., 2004; Rasmussen et al., 2000; Shirreffs et al., 2007; Tipton et al., 1999; Willoughby et al., 2007), the evidence of improvements in body composition, strength, power and agility highlight the benefit of appropriately timed protein ingestion in conjunction with a strength-training program. This seems to be the case for males and females alike. One additional benefit of this study is its applications to the female athlete population. Most other studies regarding protein consumption and exercise have been performed on men; therefore the confirmation of positive body composition and performance enhancements of protein consumption on the female athlete population is an important step toward rounding out the body of knowledge.

Conclusion

Although the finding from the current study were statistically significant and improved the overall knowledge of protein supplementations and female athletes, more studies comparing the consumption of whey and casein protein pre- and post-exercise are needed to further determine if and/or how the two protein types differ in promoting hypertrophy and improving anaerobic performance. These studies should be performed on men and women, trained and untrained, as well as different age groups, as it appears that results may vary depending on the demographic of the study population.

Practical applications

The combination of a controlled undulating resistance training program with pre- and post-exercise protein supplementation had a significant impact on performance and body composition factors for both whey protein and casein protein groups. There does not appear to be a difference in the performance enhancing effects of whey versus casein proteins, and both prove to be beneficial to athletic performance in female athletes for both strength and body composition.

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Key points

- Females can experience and increase in performance makers from consuming protein after resistance training.
- Females can have a decreased body fat composition when ingesting protein with daily resistance training and conditioning.
- There was no significant difference in performance markers between whey and casein.

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